Zmluva
o poskytnutí finančných prostriedkov na spolufinancovanie projektu výskumu a vývoja ENIAC č. ....

Poskytovateľ:	**Ministerstvo školstva, vedy, výskumu a športu SR**
sídlo:	Stromová 1, 813 30, Bratislava
zastúpený štatutárnym orgánom:	Eugenom Jurzycom ministrom
osoba oprávnená rokovať v odborných veciach:	Marta Cimbáková
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Fax:	02/59102620
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IČO:	00 164 381
Bank. spojenie:	Štátna pokladnica, č. účtu 7000065236/8180

(ďalej len „poskytovateľ“)

Príjemca:	**POWERTEC s.r.o.**
sídlo:	Drotárska 6385/19a, 811 04, Bratislava
zastúpený štatutárnym orgánom:	Martinom Donovalom konateľom
osoba oprávnená rokovať v odborných veciach:	Martin Donoval
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peňažný ústav:	Tatra banka a.s.
číslo účtu :	2923863663/1100
Zapísaný:	V obchodnom registri Okresného súdu Bratislava I, vložka č. 56298/b

(ďalej len „príjemca “)

Preambula

Nariadením Rady (ES) č. 72/2008 z 20. decembra 2007 bol založený spoločný európsky technologický podnik ENIAC (ďalej len „spoločný podnik“) na podporu spoločných európskych výskumných a vývojových aktivít v oblasti nanoelektroniky.

Slovenská republika sa prihlásila za člena spoločného podniku listom podpredsedu vlády a ministra školstva SR zo dňa 12. decembra 2008 a zaviazala sa alokovať každoročne v rozpočtovej kapitole Ministerstva školstva SR prostriedky štátneho rozpočtu Slovenskej republiky vo výške 500 000 EUR za účelom spolufinancovania účasti organizácií výskumu a vývoja v Slovenskej republike v projektoch výskumu a vývoja spoločného podniku (ďalej len „projekt spoločného podniku“).

Na základe dohody o správe č. ENIAC-ED-27-09 uzavretej medzi spoločným podnikom a Ministerstvom školstva SR, ktorá je neoddeliteľnou súčasťou tejto zmluvy v Prílohe 1, sa Ministerstvo školstva, vedy, výskumu a športu SR stalo národným financujúcim orgánom, ktorý zabezpečuje poskytovanie prostriedkov štátneho rozpočtu Slovenskej republiky na spolufinancovanie účasti organizácií výskumu a vývoja v Slovenskej republike v projektoch spoločného podniku.

Čl. 1
Predmet zmluvy

1) Poskytovateľ a príjemca uzatvárajú túto zmluvu podľa Čl. 13 ods. 6 písm. b) Štatútu spoločného podniku ENIAC, ktorý je neoddeliteľnou súčasťou Nariadenia Rady (ES) č. 72/2008 z 20. decembra 2007, ktorým sa zakladá spoločný podnik ENIAC (ďalej len „štatút spoločného podniku“).

2) Poskytovateľ a príjemca sa dohodli na predmete zmluvy na základe technickej špecifikácie Technical Anex Energy for a green society: From sustainable harvesting to SMART distribution. Equipments, materials, design solutions and their applications (ďalej len „technická špecifikácia“), ktorá bola schválená spoločným podnikom dňa 16. 12. 2010 a je v Prílohe 2 k tejto zmluve, ktorá je jej neoddeliteľnou súčasťou.

3) Predmetom zmluvy je poskytnutie 99 900 EUR (slovom deväťdesiatdeväťtisíc deväťsto EUR) z prostriedkov štátneho rozpočtu Slovenskej republiky poskytovateľom príjemcovi na zabezpečenie spolufinancovania riešenia projektu spoločného podniku s názvom “Energia pre zelenú spoločnosť: Od trvalého získavania energie k jej SMART distribúcii. Prístroje, materiály, návrhové riešenia a ich aplikácie“, ktorého riešenie bolo schválené na základe výberového konania uskutočneného spoločným podnikom k 3. výzve pre verejnú súťaž ním vyhlásenej v roku 2010 a potvrdené technickou špecifikáciou.

4) Doba riešenia projektu spoločného podniku je stanovená v technickej špecifikácií schválenej spoločným podnikom.

5) Poskytovateľ zabezpečuje spolufinancovanie riešenia projektu spoločného podniku počas celej doby jeho riešenia, ktorá je 36 mesiacov.

6) Príjemca sa zaväzuje zabezpečiť riešenie projektu spoločného podniku s názvom: “Energia pre zelenú spoločnosť: Od trvalého získavania energie k jej SMART distribúcii. Prístroje, materiály, návrhové riešenia a ich aplikácie“, (“Energy for a green society: From sustainable hrvesting to SMART distribution. Equipments, materials, design solutions and their applications“)

   počas celej doby jeho riešenia od: 01/06/2011 do: 31/05/2014.

7) Špecifikácia projektu spoločného podniku (zoznam riešiteľov a ich kapacít viazaných na riešenie projektu, použitia prostriedkov štátneho rozpočtu Slovenskej republiky poskytnutých poskytovateľom vrátane charakteristiky, cieľov projektu v jednotlivých rokoch jeho riešenia a výstupov) je uvedená v Prílohe 3, ktorá je neoddeliteľnou súčasťou zmluvy.

Čl. 2
Poskytovanie a použitie prostriedkov

1) Financovanie projektu spoločného podniku sa uskutočňuje podľa Čl. 13 štatútu spoločného podniku.

2) Spoločný podnik podľa Čl. 13 ods. 6 písm. a) štatútu spoločného podniku poskytuje príjemcovi na spolufinancovanie riešenia projektu spoločného podniku prostriedky zo svojho rozpočtu vo výške 16,7 % z celkových oprávnených nákladov na riešenie projektu spoločného podniku.

3) Poskytovateľ poskytuje príjemcovi, ktorý je podnikateľom podľa zákona č. 513/1991 Zb. (Obchodný zákonník) v znení neskorších predpisov na spolufinancovanie riešenia projektu spoločného podniku prostriedky štátneho rozpočtu Slovenskej republiky vo výške 33,3 % z celkových oprávnených nákladov na riešenie projektu spoločného podniku.

4) Oprávnenými nákladmi na riešenie projektu spoločného podniku, ktoré financuje poskytovateľ z prostriedkov štátneho rozpočtu Slovenskej republiky, sú náklady podľa § 17 ods. 2 až 5 zákona č. 172/2005 Z. z. o organizácii štátnej podpory výskumu a vývoja a o doplnení zákona č. 575/2001 Z. z. o organizácii činnosti vlády a organizácii ústrednej štátnej správy v znení neskorších predpisov v znení zákona č. 233/2008 Z.z. a v znení zákona č. 40/2011 Z.z., a rozpočet projektu spoločného podniku hradený z prostriedkov štátneho rozpočtu Slovenskej republiky je špecifikovaný príjemcom v časti C. Prílohy 3 k tejto zmluve.

5) Príjemca si za účelom poskytnutia prostriedkov štátneho rozpočtu Slovenskej republiky poskytovateľom a ich transparentného čerpania zriadi osobitný účet (ďalej len „účet príjemcu“).

6) Poskytovateľ poskytuje prostriedky štátneho rozpočtu Slovenskej republiky na účet príjemcu v jednotlivých rozpočtových rokoch riešenia projektu spoločného podniku podľa rozpisu celkových oprávnených nákladov uvedených v Prílohe 4 k tejto zmluve, ktorá je jej neoddeliteľnou súčasťou.

7) V prvom rozpočtovom roku riešenia projektu spoločného podniku poskytovateľ poskytne prostriedky štátneho rozpočtu Slovenskej republiky na účet príjemcu na základe oficiálneho oznámenia spoločného podniku o ukončení technického rokovania k projektu spoločného podniku.

8) V každom ďalšom rozpočtovom roku riešenia projektu spoločného podniku poskytovateľ poskytuje prostriedky štátneho rozpočtu Slovenskej republiky na účet príjemcu na základe dvoch dodatkov k tejto zmluve. Prvým dodatkom, začiatkom rozpočtového roka, poskytne poskytovateľ príjemcovi 50 percent prostriedkov štátneho rozpočtu Slovenskej republiky určených na spolufinancovanie v príslušnom rozpočtovom roku na základe

kontroly použitia prostriedkov štátneho rozpočtu Slovenskej republiky poskytnutých príjemcovi v predchádzajúcom rozpočtovom roku, ktorú vykonáva poskytovateľ. Druhým dodatkom uzatvoreným až na základe výsledkov monitorovania a technického auditu projektu spoločného podniku, ktoré vykonáva spoločný podnik poskytne poskytovateľ príjemcovi zvyšných 50 percent prostriedkov štátneho rozpočtu Slovenskej republiky určených na spolufinancovanie v príslušnom rozpočtovom roku.

9) Ak v prvom rozpočtovom roku riešenia projektu spoločného podniku sú prostriedky štátneho rozpočtu Slovenskej republiky poskytnuté poskytovateľom omeškane na účet príjemcu voči termínu začatia riešenia projektu spoločného podniku, ktorý je záväzne stanovený spoločným podnikom v „technickej špecifikácii“, z dôvodu omeškania podpísania zmluvy medzi príjemcom a poskytovateľom alebo medzi príjemcom a spoločným podnikom, môže príjemca na financovanie projektu spoločného podniku použiť vlastné prostriedky, ktoré si potom refunduje z prostriedkov vedených na účte príjemcu.

10) Rovnako v ďalších rozpočtových rokoch riešenia projektu spoločného podniku, ak poskytovateľ poskytne prostriedky štátneho rozpočtu Slovenskej republiky na účet príjemcu omeškane, môže príjemca počas meškania použiť na riešenie projektu spoločného podniku vlastné prostriedky, ktoré si potom refunduje z prostriedkov vedených na účte príjemcu.

11) Príjemca môže prostriedky štátneho rozpočtu Slovenskej republiky poskytnuté poskytovateľom na účet príjemcu použiť iba na stanovený účel.

12) Príjemca zodpovedá za hospodárenie s prostriedkami štátneho rozpočtu Slovenskej republiky poskytnutými poskytovateľom na účet príjemcu a je povinný pri ich použití zachovávať hospodárnosť, efektívnosť a účelnosť ich použitia.

13) Výnos, ktorý vznikol z účtu príjemcu, je podľa § 7 ods. 1 písm. m) zákona č. 523/2004 Z. z. o rozpočtových pravidlách verejnej správy a o zmene a doplnení niektorých zákonov v znení neskorších predpisov v spojení s Metodickým usmernením Ministerstva financií Slovenskej republiky číslo MF/7415/2005-421 príjmom štátneho rozpočtu Slovenskej republiky.

14) Výnosom určeným na vykonanie odvodu, sú prostriedky, ktoré zostali na účte príjemcu po odpočítaní celého poplatku za vedenie účtu príjemcu od úrokov pripisovaných bankou.

15) Lehota na vykonanie odvodu výnosov z prostriedkov štátneho rozpočtu Slovenskej republiky vedených na účte príjemcu na účet poskytovateľa je do 31.3. nasledujúceho rozpočtového roka.

16) Ak riešenie projektu spoločného podniku vyžaduje zaobstaranie tovarov, služieb a prác, príjemca je povinný v cene pre ich zaobstaranie zohľadniť najlepší pomer kvality a výšky ceny.

17) Príjemca pri zaobstarávaní tovarov, služieb a prác z prostriedkov štátneho rozpočtu Slovenskej republiky vedených na účte príjemcu musí postupovať podľa zákona

č. 25/2006 Z. z. o verejnom obstarávaní a o zmene a doplnení niektorých zákonov v znení neskorších predpisov.

Čl. 3
Práva a povinnosti

1) Príjemca a poskytovateľ zodpovedajú za včasné a riadne plnenie si povinností podľa tejto zmluvy.

2) Príjemca je povinný všetky náklady súvisiace s riešením projektu doložiť prehľadom o výške, spôsobe a účele čerpania finančných prostriedkov, vypracovaných podľa skutočných nákladov na riešenie projektu a platných usmernení a pokynov poskytovateľa v termíne do 31. januára nasledujúceho rozpočtového roka.

3) Príjemca je povinný uchovávať všetky dokumenty a doklady, vrátane účtovných dokladov, týkajúcich sa projektu spoločného podniku najmenej počas piatich rokov nasledujúcich po roku, kedy skončí doba spolufinancovania projektu spoločného podniku poskytovateľom.

Čl. 4
Kontrola

1) Monitorovanie a kontrolu riešenia projektu spoločného podniku vykonáva spoločný podnik podľa Čl. 7 ods. 3 písm. j) a k) štatútu spoločného podniku.

2) Poskytovateľ akceptuje závery vyplývajúce z monitorovacích správ a výsledkov kontroly riešenia projektu spoločného podniku vykonaných spoločným podnikom.

3) Poskytovateľ je oprávnený vykonať pre svoje potreby finančnú kontrolu podľa zákona č. 502/2001 Z. z. o finančnej kontrole a vnútornom audite a o zmene a doplnení niektorých zákonov v znení neskorších predpisov počas trvania zmluvného vzťahu medzi ním a príjemcom ako aj po jeho ukončení, a to aj v prípade odstúpenia od zmluvy.

4) Príjemca je povinný pri výkone kontroly alebo auditu dodržiavať ustanovenia § 14 ods. 2 a § 35 ods. 8 zákona č. 502/2001 Z. z. o finančnej kontrole a vnútornom audite a o zmene a doplnení niektorých zákonov v znení neskorších predpisov.

Čl. 5
Odstúpenie od zmluvy

1) Poskytovateľ má právo odstúpiť od zmluvy, ak

   a) si príjemca neplní povinnosti stanovené v tejto zmluve,

   b) riešenie projektu spoločného podniku má závažné chyby, ktoré zistil spoločný podnik pri monitorovaní a kontrole riešenia projektu spoločného podniku, alebo také chyby, že čas na ich odstránenie by do značnej miery znehodnotil cieľ riešenia projektu spoločného podniku,

c) spoločný podnik odstúpi od zmluvy medzi ním a príjemcom z ďalších dôvodov stanovených v zmluve medzi ním a príjemcom,

d) dôjde k zrušeniu spoločného podniku.

2) Ak poskytovateľ odstúpi od zmluvy medzi ním a príjemcom z dôvodov podľa Čl. 5 ods. 1 písm. a) až c) tejto zmluvy, má právo požadovať vrátenie všetkých prostriedkov štátneho rozpočtu Slovenskej republiky ním poskytnutých príjemcovi.

3) Ak poskytovateľ odstúpi od zmluvy medzi ním a príjemcom z dôvodov podľa Čl. 5 ods. 1 písm. d), má právo požadovať vrátenie časti prostriedkov štátneho rozpočtu Slovenskej republiky, ktoré boli použité príjemcom po termíne zrušenia spoločného podniku.

4) Príjemca má právo odstúpiť od zmluvy v prípade, ak si poskytovateľ neplní povinnosti stanovené v tejto zmluve.

Čl. 6
Sankcie

1) Príjemca je povinný prostriedky štátneho rozpočtu Slovenskej republiky neoprávnene použité na iný účel než účel stanovený v predmete zmluvy vrátiť na príjmový účet poskytovateľa.

2) Príjemca je povinný vrátiť na príjmový účet poskytovateľa aj finančné prostriedky štátneho rozpočtu Slovenskej republiky z dôvodov uvedených v Čl. 5 ods. 3.

3) Sankcie za porušenie finančnej disciplíny príjemcom pri hospodárení s prostriedkami štátneho rozpočtu Slovenskej republiky sa riadia § 31 zákona č. 523/2004 Z. z. o rozpočtových pravidlách verejnej správy a o zmene a doplnení niektorých zákonov.

Čl. 7
Vlastnícke práva k predmetu zmluvy

Vlastnícke práva k výsledkom riešenia projektu spoločného podniku sa riadia podľa ustanovení Čl. 23 štatútu spoločného podniku.

Čl. 8
Záverečné ustanovenia

1) Príjemca a poskytovateľ sa zaväzujú bezodkladne navzájom sa písomne informovať o zmenách identifikačných údajov uvedených v zmluve a akýchkoľvek iných zmenách a skutočnostiach, ktoré by mohli mať vplyv na práva a povinnosti vyplývajúce z tejto zmluvy v lehote najneskôr do 30 kalendárnych dní.

2) Zmeny a doplnenia zmluvy môžu byť vykonané len prostredníctvom písomných dodatkov podpísaných obidvoma zmluvnými stranami.

3) Zmluva je vyhotovená v šiestich origináloch, pričom každá zo zmluvných strán obdrží po tri exempláre.

4) Zmluva nadobúda platnosť dňom podpísania oprávnenými zástupcami zmluvných strán a účinnosť dňom nasledujúcom po dni zverejnenia.

5) Prílohy k zmluve sú:
   a) Príloha 1: Dohoda o správe č. ENIAC-ED-27-09 uzavretá medzi spoločným podnikom a Ministerstvom školstva SR
   b) Príloha 2: Technická špecifikácia projektu - Technical Anex Energy for a green society: From sustainable harvesting to SMART distribution. Equipments, materials, design solutions and their applications
   c) Príloha 3: Špecifikácia projektu spoločného podniku
   d) Príloha 4: Rozpis celkových prostriedkov štátneho rozpočtu Slovenskej republiky na financovanie oprávnených nákladov projektu spoločného podniku v jednotlivých rozpočtových rokoch jeho riešenia

V Bratislave dňa

....	....
Eugen Jurzyca	Martin Donoval
minister	konateľ

Príloha č.1 k zmluve

Eniac JOINT UNDERTAKING

DOHODA O SPRÁVE MEDZI SPOLOČNÝM PODNIKOM ENIAC A MINISTERSTVOM ŠKOLSTVA SLOVENSKEJ REPUBLIKY

1. Zmluvné strany

Tento materiál ustanovuje dohodu medzi spoločným podnikom ENIAC (ďalej len „Spoločný podnik“) a Ministerstvom školstva Slovenskej republiky (ďalej len „Národný financujúci orgán“), ktoré ustanovila Slovenská republika v súlade s čl.3 ods. 4 a čl. 12 a ods. 3 štatútu Spoločného podniku, ktorý je prílohou Nariadenia rady (EK) č. 72/2008 z 20. decembra 2007, a ktorým sa zakladá „Spoločný podnik ENIAC[1]“. Dohodou sa stanovujú vzťahy medzi Spoločným podnikom a národnými financujúcimi orgánmi určenými členskými štátmi ENIAC pre administratívne zabezpečenie implementácie projektov a poskytovanie verejných prostriedkov.

2. Rozsah

Táto dohoda detailne stanovuje požiadavky kladené na obidve straty za účelom implementácie projektov vybraných Spoločným podnikom. Je potrebné ju vykonávať v súlade s Nariadením rady (EK) č. 72/2008, ktorým sa zakladá „Spoločný podnik ENIAC“, výzvami Spoločného podniku na predkladanie návrhov projektov, rozpočtovými pravidlami Spoločného podniku podľa potreby a s členstvom Slovenskej republiky v Spoločnom podniku.

Táto dohoda je záväzná pre Spoločný podnik a Národný financujúci orgán ustanovený Slovenskou republikou.

3. Výklad tejto dohody

Národná financujúci orgán je povinná zabezpečiť výklad požiadaviek vyplývajúcich z tejto dohody a konať tak, aby umožnila implementácia projektov a poskytnutie verejných prostriedkov tak, ako je to stanovené v článku 12 odsek 3 štatútu Spoločného podniku.

Na zamedzenie nečestnému konaniu a podvodom je potrebné riadiť sa podľa Nariadenia Rady (EK, Euratom) č. 2988/95 zo dňa 18. decembra 1995 o ochrane finančných záujmov Európskych spoločenstiev[2], Nariadenia Rady (EK, Euratom) č. 2185/96 zo dňa 11. novembra 1996 týkajúceho sa

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[1] OJ L 30. 4.2.2008, str. 21
[2] Ú. v. EÚ L 312, 23.12.1995, str. 1

kontrol na mieste a previerok uskutočňovaných Komisiou za účelom ochrany finančných záujmov Európskych spoločenstiev proti podvodom a iným nečestným konaniam[3] a Nariadenia (EK) č. 1073/1999 Európskeho parlamentu a Rady týkajúceho sa prešetrovaní ukončených Európskym úradom pre boj proti podvodom[4].

Výrazy, ktoré sa použijú v tomto materiáli, majú rovnaký význam ako v Nariadení Rady (EK) č. 72/2008, ktorým sa zakladá „Spoločný podnik ENIAC“, vo výzvach Spoločného podniku na predkladanie návrhov projektov a v rozpočtových pravidlách Spoločného podniku.

4. Národné zmluvy o grantoch

a) **Komunikácia o oprávnenosti národných kritérií**

Národný financujúci orgán zabezpečí komunikáciu so Spoločným podnikom ohľadom oprávnenosti národných kritérií a iných zákonných a finančných požiadaviek platných pre každú výzvu na predkladanie návrhov projektov za účelom zostavenia národných zmlúv o grantoch s riešiteľmi projektu. Tieto kritériá a požiadavky budú predložené Spoločnému podniku ešte pred zverejnením výzvy na predloženie návrhov projektov Spoločnému podniku, a do 30 dní od požiadavky výkonného riaditeľa.

Odsúhlasené oprávnené národné kritéria budú v zmysle predchádzajúceho odseku začlenené do výzvy na predloženie návrhov projektov Spoločnému podniku.

Národný financujúci orgán uzatvorí zmluvy o grantoch s riešiteľmi projektov v súlade s vlastnými vnútroštátnymi predpismi s prihliadnutím na:

(a) iba kritériá oprávnenosti, ktoré boli uvedené vo výzve alebo vo všetkých ďalších aktualizáciách výzvy;

(b) iné zákonné a finančné požiadavky na zostavenie národných zmlúv o grantoch, ktoré stanovujú národné zákony a predpisy, a ktoré boli odkonzultované so Spoločným podnikom v uzávierke podľa predchádzajúceho odseku.

b. Výber návrhov projektov

Spoločný podnik je zodpovedný za hodnotenie a výber návrhov projektov a za pridelenie verejných prostriedkov riešiteľom projektu podľa na výzvy na predkladanie návrhov projektov Spoločného podniku.

Predložené návrhy projektov sú posudzované nezávislými odborníkmi.

Rada verejných orgánov schváli zoznam vybraných návrhov projektov, doplnený údajmi o verejných prostriedkoch (Spoločného podniku a/alebo národného financujúceho orgánu) ako aj odporúčaniami na ďalšiu fázu rokovaní. Výkonný riaditeľ Spoločného podniku oznámi jednotlivým žiadateľom a Národnému financujúcemu orgánu tieto výsledky spoločne s bodovým hodnotením, pripomienkami a prípadnými odporúčaniami na zmeny do 15 dní od uskutočnenia výberu.

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[3] Ú. v. EÚ L 295, 15.11.1996, str. 2
[4] Ú. v. EÚ L 139, 31.05.1999, str. 1

Na základe tejto komunikácie a v zmysle zoznamu vybraných návrhov projektov, ktoré schválila Rada verejných orgánov, začne Spoločný podnik v zastúpení výkonným riaditeľom technické rokovania s cieľom schváliť „Technickú špecifikáciu projektu[5]“ v rámci limitov vyjednávacieho mandátu a finančných zdrojov na riešiteľa projektu podľa rozhodnutia Rady verejných orgánov.

- V prípade, že boli technické rokovania úspešne ukončené, výkonný riaditeľ predloží ich výsledky spoločne s kompletnou príslušnou dokumentáciou riadiacej rade a Národnému financujúcemu orgánu za účelom vypracovania národnej zmluvy o grante.
- V prípade zmien, ktoré nemôže mandát Rady verejných orgánov vopred predpokladať alebo v prípade neúspešných technických rokovaní, výkonný riaditeľ predloží na schválenie Rade verejných orgánov výsledky rokovaní spoločne zo žiadosťou o zmenu projektu. Rozhodnutie Rady verejných orgánov predloží výkonný riaditeľ riadiacej rade a Národnému financujúcemu orgánu spoločne s kompletnou príslušnou dokumentáciou, aby mohla byť vypracovaná národnej zmluva o grante.

Po ukončení rokovaní predloží Spoločný podnik koordinátorovi zvoleného konzorcia na podpis zmluvu o grante Spoločného podniku a prístupové podklady.

c) Vypracovanie národných zmlúv o grantoch

Po ukončení výberového konania a rokovania, ktoré uskutočnil Spoločný podnik, Národný financujúci orgán vypracuje spoločne s riešiteľmi projektov národné zmluvy o grantoch. Národné zmluvy o grantoch budú zostavované v súlade s pravidlami Národného financujúceho orgánu, aj v prípade, že žiadne národné verejné prostriedky nie sú zabezpečené Radou verejných orgánov predovšetkým, čo sa týka kritérií oprávnenosti a iných nevyhnutných finančných a právnych požiadaviek, okrem prípadov kedy nie je možné vypracovať národnú zmluvu o grante z dôvodu nesplnenia národných kritérií oprávnenosti zo strany riešiteľa projektu alebo iných finančných a zákonných požiadaviek.

Finálna schválená „technická špecifikácia projektu“ vyplývajúca z rokovacieho procesu uskutočneného Spoločným podnikom bude rovnaká[6] pre vypracovanie národných zmlúv o grantoch k tomu istému projektu vo všetkých členských štátoch ENIAC.

Dátum začiatku a trvania projektu bude špecifikovaný v „technickej špecifikácii projektu“. Národné zmluvy o grantoch stanovujú oprávnené náklady, ktoré budú poskytované odo dňa začatia riešenia projektu nezávisle od dátumu ich podpísania.

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[5] „Technická špecifikácia projektu“ predstavuje technický materiál, ktorý čo najjasnejšie a stručne popisuje všetky činnosti, aktivity a úlohy, ku ktorým sa účastníci projektu zaviazali a spĺňajú vedecké a výskumné ciele stanovené v zmluvách o grantoch. Východiskom je popis vedeckých/technologických cieľov a pracovných plánov načrtnutých v návrhu projektu, ktoré sa v priebehu hodnotenia a počas ďalších rokovaní o zmluve eventuálne upravia na základe špecifických odporúčaní externých znalcov. Okrem tejto jej právnej záväznosti „technická špecifikácia projektu“ slúži pre príjemcov grantu, Spoločný podnik, Národný financujúci orgán a eventuálne pre externých znalcov ako referenčný údaj, aby mohli efektívne sledovať a kontrolovať napredovanie daného projektu počas celého jeho trvania.

[6] okrem prekladov, ak je to potrebné

Národný financujúci orgán zabezpečí, aby ustanovenia národnej zmluvy o grante boli v súlade s článkom 107 odseku 1 rozpočtových pravidiel ENIAC, ktoré uvádzajú, že ak si riešenie projektu vyžaduje, aby príjemca uskutočnil verejné obstarávanie, musí požiadavku vo výberovom konaní formulovať na základe najlepšej ponúknutej ceny, t.j. vo výberovom konaní ponúkne najlepší pomer ceny a kvality, pričom sa snaží vyhnúť konfliktu záujmov.

Národný financujúci orgán vynaloží maximálne úsilie, aby urýchlil svoje interné postupy na uzatvorenie národných zmlúv o grante. Národná zmluva o grante musí byť podpísaná najneskôr do 30 dní od ukončenia rokovaní, ktoré uskutočnil Spoločný podnik (ENIAC).

Národný financujúci orgán bude informovať Spoločný podnik o podpise národnej zmluvy o grante a kópiu národnej zmluvy o grante predloží Spoločnému podniku do 15 dní odo dňa jej podpisu jej príjemcom.

Následne bude Spoločný podnik informovať Národný financujúci orgán o podpísaní zmluvy o grante medzi Spoločným podnikom a príjemcom a kópiu tejto zmluvy o grante mu predloží do 15 dní odo dňa jej podpisu.

Zmluva o grante Spoločného podniku nadobúda platnosť po pripojení sa minimálne troch neprepojených subjektov, ktoré boli založené v minimálne troch členských krajinách Spoločného podniku v deň pripojenia sa posledného z nich.

d) Technický monitoring

Spoločný podnik je zodpovedný za monitorovanie riešenia projektu v súlade s „Technickou špecifikáciou projektu„.

Konzorcium predloží Spoločnému podniku svoju technickú správu(y)[7] a výstupy v termínoch, ktoré sú na predloženie správ stanovené v „Technickej špecifikácii projektu“ a zmluve o grante uzavretej medzi Spoločným podnikom a riešiteľmi projektu.

Spoločný podnik poskytne technické správy a výsledky technického hodnotenia riešenia projektu ním vykonané Národnému financujúcemu orgánu do 15 dní po ich schválení a potvrdení výkonným riaditeľom.

Technické hodnotenie riešenia projektu vypracované Spoločným podnikom zohľadní v prípade potreby špecifické požiadavky danej krajiny navrhnuté Národným financujúcim orgánom, ktoré Národný financujúci orgán potrebuje pre akceptovanie úhrady nákladov príjemcov grantov.

Národný financujúci orgán nebude požadovať ďalšie dodatočné technické správy okrem tých, ktoré požaduje Spoločný podnik.

Správy, ktoré sú predkladané Spoločnému podniku, sú vyhotovené v anglickom jazyku.

[7] Technická správa pozostáva z prehľadu o napredovaní prác pre dosiahnutie cieľov projektu, vrátanie úspechov a dosiahnutí míľnikov a výstupov stanovených v „Technickej špecifikácii projektu“ a rozdielov medzi očakávanými a skutočne zrealizovanými činnosťami. Technická správa(y) obsahuje aj informácie o riadení (manažovaní) projektu a upravenú verziu plánov pre jeho využívanie a zverejňovanie.

e) **Finančný monitoring/Platby**

Národný financujúci orgán spracuje požiadavky na úhradu nákladov príjemcov grantov v ich vlastnom jazyku podľa vlastných postupov danej krajiny a zohľadní výsledky technického monitoringu, ktorý uskutočnil Spoločný podnik. Zabezpečí, aby boli nároky platné a náklady oprávnené a v súlade s národnou zmluvou o grante. Všetky ostatné potrebné kontrolné činnosti spadajú do kompetencie Národného financujúceho orgánu.

Prípadne Národný financujúci orgán zrealizuje platby z prostriedkov štátneho rozpočtu priamo príjemcom podľa národných zmlúv o grantoch.

Národný financujúci orgán potvrdí Spoločnému podniku výšku akceptovaných nákladov, iných finančných alebo zmluvných oblastí týkajúcich sa plnenia národnej zmluvy o grante a prípadne aj každú platbu uskutočnenú voči príjemcovi grantu. Národný financujúci orgán pošle toto potvrdenie Spoločnému podniku do 15 dní od jeho realizácie. Národný financujúci orgán zabezpečí realizáciu finančného a zmluvného monitoringu výlučne v zmysle národných predpisov a postupov.

Príslušne Spoločný podnik zrealizuje úhradu svojho príspevku príjemcom grantu do 30 dní od dňa prijatia hore uvedeného potvrdenia od Národného financujúceho orgánu.

Národný financujúci orgán bude zabezpečovať evidenciu platieb príjemcom grantov. Národný financujúci orgán obdrží informácie o príslušnom finančnom monitoringu vykonanom Spoločným podnikom.

Spoločný podnik a Národný financujúci orgán súhlasia s poskytovaním si dôkazov o platbách uskutočnených pri plnení príslušných zmlúv o grantoch predložením kópie prevodného príkazu na žiadosť druhej strany.

Každá strana upovedomí druhú stranu o prípade, že dôjde k zdržaniu alebo zníženiu platby v dôsledku neuspokojivého konania príjemcu alebo z iného dôvodu zdržania platby najneskôr do 15 dní od jeho zistenia.

5. Právo na zaplatenie

Každá strana upovedomí písomne druhú stranu hneď ako zistí, že príjemca porušil zmluvu o grante uzavretú s touto stranou ako aj povinnosť použiť prostriedky štátneho rozpočtu na vopred stanovený účel. V prípade grantov, ktoré podliehajú právu na zaplatenie, je nevyhnutné uchovávať dokumenty zodpovedajúce uplatňovaniu tohto práva (napr. dohody a záznamy o platbách) po dobu eventuálneho vymáhania.

6. Dodatky a ukončenie zmlúv o grantoch

Je v zodpovednosti každej strany upozorniť druhú stranu, že považuje jej konanie za neadekvátne a chce v platbách grantov uskutočniť zodpovedajúcu zmenu pre ich pokračovanie na základe dodatku alebo ukončiť zmluvu o grante.

V prípade že je potrebné v „ Technickej špecifikácii projektu“ uskutočniť podstatnú zmenu, Spoločný podnik bude informovať Národný financujúci orgán o účele dodatku. Národný financujúci orgán predloží Spoločnému podniku špecifické požiadavky svojej krajiny najneskôr do 15 dní od získania tejto informácie. Novú „Technickú špecializáciu projektu“ prerokuje Spoločný podnik po zohľadnení všetkých požiadaviek Národného financujúceho orgánu. Spoločný podnik oznámi Národnému financujúcemu orgánu aktualizovanú verziu „Technickej špecifikácie projektu“ do 15 dní od ukončenia tohto rokovania.

Akýkoľvek iný dodatok „Technickej špecifikácie projektu“ prerokuje Spoločný podnik, ktorý oznámi Národnému financujúcemu orgánu zmenu „ Technickej špecifikácie projektu“ do 15 dní od ukončenia tohto rokovania.

Do 15 dní je Spoločný podnik zodpovedný informovať Národný financujúci orgán o akejkoľvek zmene alebo ukončení zmluvy o grante medzi Spoločným podnikom a príjemcom.

Do 15 dní je Národný financujúci orgán zodpovedný informovať Spoločný podnik o akejkoľvek zmene alebo ukončení zmluvy o grante medzi Národným financujúcim orgánom a príjemcom.

7. Audity – kontroly

Spoločný podnik bude u príjemcov verejných finančných prostriedkov Spoločného podniku uskutočňovať kontroly na mieste a finančné audity. Tieto kontroly a audity bude vykonávať buď priamo Spoločný podnik alebo Národný financujúci orgán v mene Spoločného podniku na základe žiadosti Spoločného podniku. Národný financujúci orgán môže na vykonanie kontrol a auditov menovať externý orgán, ktorý tak urobí v jeho mene. Národný financujúci orgán je oprávnený uskutočniť u príjemcov prostriedkov štátneho rozpočtu iné kontroly a audity, v prípade že to považuje za nevyhnutné a Spoločný podnik oboznámi s ich výsledkami.

Obidve strany sa budú vzájomne informovať o začatí ako aj o výsledkoch všetkých kontrol a auditov ustanovených v zmysle predchádzajúceho odseku, a to do 15 dní.

8. Politika práv duševného vlastníctva

Pre účely národných zmlúv o grantoch v rámci tejto zmluvy a bez toho, aby boli dotknuté pravidlá hospodárskej súťaže Spoločenstva, prednosť majú ustanovenia o duševnom vlastníctve schválené Nariadením Rady (EK) č. 72/2008 pred vnútroštátnymi predpismi, pravidlami o poskytovaní grantov alebo projektami súvisiacimi s duševným vlastníctvom.

9. Dôverné informácie

Všetky informácie, ktoré príslušná strana získa v súvislosti s touto dohodou, sa budú považovať za dôverné a každá strana súhlasí, že:

(a) bude dôverné informácie chrániť zodpovedajúcim a adekvátnym spôsobom v súlade s platnými odbornými štandardami;

(b) bude dôverné informácie používať a reprodukovať len na účely stanovené v tejto dohode;

(c) nebude zverejňovať alebo iným spôsobom poskytovať dôverné informácie iným osobám ako tým, ktoré tieto informácie potrebujú na splnenie účelu stanoveného v tejto dohode.

Predchádzajúci odsek sa nebude vzťahovať na informácie,

(a) ktoré sú verejne známe; alebo

(b) ktoré prijímacia strana už pozná;

(c) keď je zverejnenie dôverných informácií požadované národným zákonom.

10. Administratívne záležitosti

Zúčastnené strany tejto dohody si budú uchovávať a aktualizovať zoznam kontaktných osôb zodpovedných za vybavovanie záležitostí týkajúcich sa tejto dohody.

Obidve strany sa budú vzájomne informovať o iných osobách, ktoré sú zodpovedné za príslušnú uzavretú zmluvu o grante.

Kompletná komunikácia medzi stranami sa uskutočňuje v anglickom jazyku[8].

Kompletná písomná komunikácia medzi zúčastnenými stranami tejto dohody bude prípadne uvádzať názov zmluvy a identifikačné číslo (Národného financujúceho orgánu /alebo Spoločného podniku). Každá strana bude druhej strane odpovedať na otázky týkajúce sa tejto dohody najneskôr do 7 pracovných dní. V prípade, že druhá strana nedostane žiadnu odpoveď ani do 15 dní, bude sa to považovať za kladnú odpoveď.

11. Práva kontroly Európskej komisie, OLAF a Dvora audítorov

V súvislosti s touto dohodou zabezpečia obidve strany uplatňovanie kontrolných práv Európskej komisia, Európskeho úradu pre boj proti podvodom a/alebo Dvora audítorov podľa článku 12 odseku 5 a článku 12 odseku 6 Nariadenia rady (EK) č. 72/2008.

12. Riešenie sporov

Súd prvého stupňa alebo odvolací súd, Súdny dvor Európskych spoločenstiev má výlučnú súdnu právomoc pri riešení súdnych sporov medzi Spoločným podnikom a Národným financujúcim orgánom, ktoré sa týkajú výkladu, uplatnenia alebo platnosti tejto dohody.

13. Trvanie dohody

Táto dohoda nadobudne platnosť v deň jej podpísania oboma stranami dohody a bude platná počas obdobia členstva Slovenskej republiky v Spoločnom podniku. Túto dohodu možno kedykoľvek meniť na základne vzájomného písomného súhlasu zúčastnených strán. Táto dohoda nezahŕňa teraz alebo

[8] V prípade, že je nevyhnutné podpísať pôvodné materiály, ktoré Národná grantová organizácia vyhotovuje v domácom jazyku, Národná grantová organizácia ich predloží spoločne s prekladom do anglického jazyka.

v budúcnosti žiadnu výmenu finančných prostriedkov, ani vytvorenie akéhokoľvek záväzku voči časti akejkoľvek strany na vykonanie úhrady voči inej strane.

Táto dohoda pozostáva z úplnej dohody uzavretej medzi zúčastnenými stranami na stanovený účel a jej úpravy alebo dodatky platia len po uvedení a priložení podpisov obidvoch strán tejto dohody.

Vyhotovené v Bruseli v dvoch kópiách

za Spoločný podnik	za Ministerstvo školstva Slovenskej republiky
vlastnoručný podpis	*vlastnoručný podpis*
Dirk Beernaert	p. Marta Cimbáková
dočasný výkonný riaditeľ	riaditeľka odboru štátnej a európskej politiky vo vede a technike
	Úsek vedy a techniky

ENIAC JOINT UNDERTAKING
TECHNICAL ANNEX

ENERGY FOR A GREEN SOCIETY: FROM SUSTAINABLE HARVESTING TO SMART DISTRIBUTION. EQUIPMENTS, MATERIALS, DESIGN SOLUTIONS AND THEIR APPLICATIONS.

ENIAC Call 2010-1

1 ESSENTIALS

Project acronym	ERG
Project full title	ENERGY FOR A GREEN SOCIETY: FROM SUSTAINABLE HARVESTING TO SMART DISTRIBUTION. EQUIPMENTS, MATERIALS, DESIGN SOLUTIONS AND THEIR APPLICATIONS.
Sub Programme, in order of importance	SP3 - Energy Efficiency - main priority of the project SP5 - Silicon process and integration SP4 - Design Methods and Tools
Version of Technical Annex	4.0
Date of Technical Annex	27/07/2011
Date of approval of Technical Annex by the ENIAC JU[1]:	
Start Date of Project	01/06/2011
Duration of project	36 months
Maximum JU funding	4,293,851 euro
Coordinator	STMicroelectronics S.r.l.
Project coordinator	Dr. Francesco Gennaro
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[1] to be completed by the Joint Undertaking

2 History of Technical Annex later Annex 1 to the JU GA

Version Number	**Date**	**Main changes / Amendment number**	**Description**
1.0	16/12/2010	End of negotiations	
		…	
4.0	27/07/2011	Version for JU GA	
x.y	dd/mm/yyyy	Version for JU GA	
x.y	dd/mm/yyyy	Amendment 1 to the JU GA	
		…	
x.y	dd/mm/yyyy	Version used for Progress Report 1	
		…	
x.y	dd/mm/yyyy	End of project	

3 PUBLISHABLE PROJECT SUMMARY

The research, development and demonstration activities planned for the ERG project focus on the solar energy supply chain, starting form solar cells and proceeding along with innovative energy extraction (harvesting) techniques, high efficiency power conversion and finally managing the energy distribution inside a smart grid, with the target of different classes of applications, from house to small area, as well as application specific "local grid" (healthcare, automotive, etc.).

By considering the full solar energy supply chain, we expect to produce relevant improvements of the industrial state-of-the-art in the efficiency of solar cells, in the optimization of energy generated by photovoltaic systems, in the loss reduction of power converters and, finally, in energy management strategy.

At the initial chain-link of the energy value chain, the project aims to design and develop a set of innovative solar cells. In particular we primarily target the development of ultra-thin (20 micron) Si wafer PV cells, Si hetero-junction cells (tandem/multi-junction and hetero-junction contacts), novel architectures (e.g., back-contact), novel materials (for Si hetero-junctions, ARC, and passivation dielectrics), novel approaches for screen printing and laser processing, with focus to the case of back-contact cells. As a promising low-cost alternative to Si, ERG will pursue the goal of totally printable dye-sensitized-solar-cells (DSSC). This will include (a) printable electrolyte (to replace liquid electrolyte), (b) advanced TiO2 electrode, and (c) counter electrode (to meet high performance DSSC applications). The overall objective is to demonstrate DSSC products for commercial applications.

The next downward chain-link addressed by the project deals with optimization of the energy generated by photovoltaic systems by focusing on power management electronics for silicon cell panels and on micro electromechanical systems for Concentrated Photovoltaic cells (CPV). The complete supply chains will be considered for optimum energy exploitation by Maximum Power Point Tracking (MPPT) and power conversion on module / segment levels for PV and also CPV solar generators. The architecture study will elaborate different profiles of end-users, including direct grid connection, energy storage option and E-mobility support.

As the final chain-link is concerned, the project will develop behavioural models for the individual components of the "Smart Grid". This allows the development of optimal energy dispatching and battery charging algorithms. These algorithms will obtain their input from sensors distributed over the network, with typically, but not exclusive, a wireless communication infrastructure.

A full set of demonstrators, including innovative PV cells, novel conversion systems for PV and CPV inverters, and network demonstrators based on a household application and an industrial application will complete the project deliverables.

4 RELEVANCE AND CONTRIBUTIONS TO THE CONTENT AND OBJECTIVES OF THE CALL

4.1 Relevance

Target activities

The ERG project will develop innovative solutions to enhance the solar **energy value-chain by means of a more efficient energy management from high performance PV cells to power conversion, intelligent drive control, power delivery and interface to smart-grid**. The project targets the transversal **Sub-Programme SP3: Energy Efficiency**.

SP3 deals with the development of innovative technologies and components, which are the basis for new energy efficient products and intelligent power management to allow increased competence in these emerging lead markets in line with the 'sustainability' objective. Efficient generation, distribution and intelligent control of energy can reduce electrical energy consumption in Europe by 20% to 30% until 2020 and CO_2 emission in the same order of magnitude in order to achieve the Kyoto protocol targets and to limit the energy cost increase.

By enforcing the guidelines of the ENIAC AWP 2010 and the MASP roadmap on "Energy Efficiency", the project's streamlines are intended to rely upon the relevant existing projects (i.e. SmartPM) by leveraging its synergy and complementarities. In particular, ERG will push forward the two Grand Challenges:

A. "Sustainable and Efficient Energy Generation – CO_2 Reduction", dealing with renewable solar energy.

B. "Energy Distribution and Management – Smart Energy Grid", to achieve a reliable, flexible, accessible and yet cost-effective power supply.

A. The energy generated by a Photo Voltaic facility is typically available on a non-continuous basis. This implies the need for power conversion (i.e. DC/DC, DC/AC) and sometime local storage buffering before being committed to delivery through the grid. The goal of the project is to further improve the efficiency of the whole supply chain, pushing the efficiency to exceed 20% and reach up to 25% for high performance photovoltaic cells; 20% losses reduction for the AC/DC and DC/DC; 90% battery (slow charge); 91% overall grid.

B. The future "smart energy grid" will be a combined management of incoming power, of distribution of power and of outgoing power at both local (i.e. Urban district, smart city) and global level (i.e. country or even continental wise). This could include also the future bunch of millions of electric batteries belonging to the electrical vehicles plugged-in at home's park lot. The project will develop innovative solution to optimize the local smart grid with regards to power management and co-generation, power consumption, efficiency, as well as real- time energy metering and billing control.

2000-2007: installations of photovoltaic PV panels and wind turbines always exceeded the most optimistic forecasts!

2008/EU-27: new installations based on Renewable Energy exceeded in power the new installations based on fossils! (Ref.: www.EWEA.org, www.EPIA.org).

2009/EU-27: new installations based on Renewable Energy have produced during peak hours more energy than that of the new installations based on fossils!

2009-2013: PhotoVoltaics worldwide growing at 40% CAGR (Ref: www.greentechmedia.com).

2009-2013: PhotoVoltaics in USA growing at 50% CAGR (largest market) (Ref: www.spireCorp.com).

Synergy with other priorities

The technologies and systems developed within the ERG project are linked to other Subprograms for the development of a common technology base. Synergy areas with other priorities are:

- Power management technology and control strategies in relation to **SP1 “Automotive & Transport”**
- High power electronics in relation to **SP6 “Equipment, Materials and Manufacturing”**.

Targeted approach

The ERG approach fulfils the requirements specified in the ENIAC 2010 AWP. In fact:

- It is expected that the topics of the Sub-Programme would be covered by **large scale projects**, with a **broad industrial participation**. A **critical mass is required** to provide solutions that could be widely deployed in the European scenario, and to achieve a large degree of standardization to provide tools and methodologies that can be used also by smaller design companies and reduce costs.
- The cooperation of **user companies** (IDMs, fabless), **design centres, universities and institutes** in the projects will contribute to build a solid electronics design base for Europe and establish standards.

Topics of projects mentioned in the AWP and in close relationship with ERG

Serving the Grand Challenge “”Sustainable and Efficient Energy Generation – CO_2 Reduction”:

- Development of innovative solar cells for higher performance photovoltaic systems.
- Development of optimization methods for energy extraction.
- Efficient power conversion platforms.

Serving the Grand Challenge “Energy Distribution and Management – Smart Energy Grid”:

- Development of innovative smart energy distribution, utilization and management strategies.

Cooperation with other research activities

The project will use existing links of partners to existing projects for re-usage of results and cooperation during project runtime. Especially to be mentioned are projects:

- SmartPM: technology base for high voltage handling (TEL, IFAG, ST, Fraunhofer).
- APOLLON: optic, assembly, tracking of CPV systems (STIAG).
- SmartCoDe: control of energy demands for buildings and neighborhoods (associated partners IFAG, TEL).
- END: Models, Solutions, Methods and Tools for Energy-Aware Design (ST, IFAG).
- THERMINATOR: Modeling, Control and Management of Thermal effects in Electronic Circuits (ST, IFAG, NXP, etc.).

4.2 Measure of success

The expected results of the proposed ERG project are grouped in four areas of interest in which the activity of the project will be focused. By considering the solar energy supply chain, we expect to produce relevant improvements in the efficiency of solar cells, in the optimization of energy generated by photovoltaic systems, in the loss reduction of power converters and finally in energy management and distribution strategy, as listed in the following table.

Innovative solar cells	**Optimization method for energy extraction**	**Efficient power conversion**	**Smart Energy distribution, utilization and management**
Single junction with hetero-junction contacts with efficiency equal or larger than 20% in standard conditions (1 sun, AM1.5G spectrum, 25 °C) with short circuit current equal or larger than 39 mA/cm^2 and open circuit voltage equal or larger than 680 mV. Silicon cells for concentration PV with a target series resistance of 25mΩcm^2 or lower and, efficiency at least 20% at 100suns and up to 25% peak efficiency. Ultra-thin Si wafer PV cells with efficiency of approximately 20% and thickness in the range 20 - 50 μm. 30 $\times$ 30 cm^2 DSSC module for commercial equipment charging applications with an expected active area efficiency of 7%.	Reducing the current cost of the average concentrator area (such as mirrors) from the current 150 to 110 €/m^2. Development of a “smart junction box” for advanced energy extraction at panel level including DC/DC converter with embedded novel MPPT algorithm. Increase in energy production up to 30% and better maintenance.	Increased efficiency in power conversion by avoiding large shadowing effect and by intelligent handling of failures. Reduction of energy losses by 20% in the supply chain. Demonstration of the gained efficiency by using prototype systems for PV and CPV converters.	Development of novel energy dispatching and battery charging algorithms and implementation of wireless network infrastructure for smart grid operation. Enhanced Mean Satisfaction Degree of final users up to 80-85%. Increased efficiency of the battery charging process of 10% with respect traditional systems. Demonstration of the fully integrated infrastructure and software for a large scale distribution grid and an industrial micro-grid.

5 R&D INNOVATION AND TECHNICAL EXCELLENCE

5.1 Concept and objectives

By the end of 2008, total world energy consumption was approximately 15TWh while the PV installed capacity was 16GW. To make a significant contribution to worldwide energy demand, the industry needs to move from gigawatts of production to terawatts. The historic rate of growth for PV since 1975 has been 30% per year, and in the last decade the growth has been close to 40%.

At the beginning the demand consisted in utility and government grid-connected demonstration projects, and in the off-grid market. The strong growth rate observed in recent years is due to subsidies, initially in Japan, Germany and California, later reinforced in Germany thanks to the Feed-in Tariff (FiT) law, soon followed by similar laws in many other European countries.

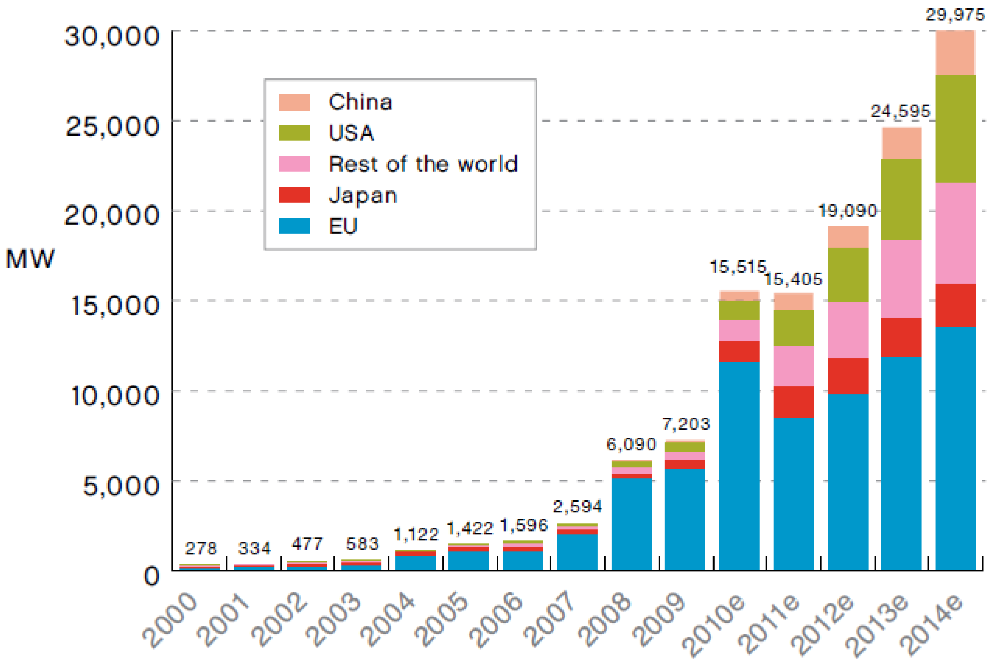

Figure 1 – PV Installation evolution with regional divisions, including short term forecast (Source: iSupply April 2010).

PV technology is dominated by silicon, in the form of crystalline and multi-crystalline modules. Recently the thin film technology has acquired more and more momentum, thanks, from one side, to the huge advancements mainly in the CdTe, with contributions of amorphous-Si and CIGS technologies, and on the other side, to a silicon feedstock supply shortage which affected the module cost of crystalline and multi-crystalline Si in the period 2004-2008. The shortage period has ended, producing a strong decline in the price of silicon modules. This is indeed also attributed to a massive entrance of strong Chinese producers and the reduction of the European FiT.

The expectation of the PV exponential growth for the next and the following decades, as required by the 20-20-20 objective and the general EU policies, creates new formidable technological challenges. These in turns require substantial developments in the field of energy harvesting and distributed generation, efficient power conversion and power management.

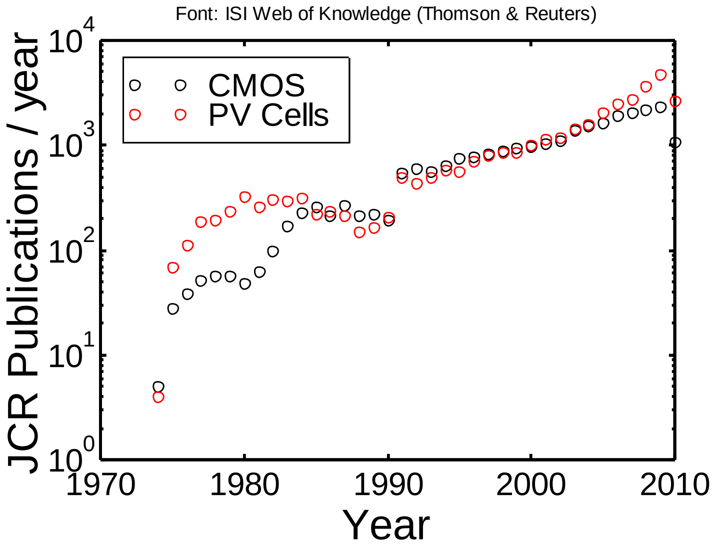

Figure 2 – Time evolution of the number of JCR Publications per year in the area of CMOS and of PV cells (Source: ISI Web of Knowledge)

This requirement is very well mirrored by the rapid growth of research articles published in the area of photovoltaic technology, which indicates the huge sector growth in the last few years both from the technological / scientific side and from the industrial / economic side.

In this highly competitive context, the ERG project focuses on the whole solar energy supply chain, starting from solar cells and proceeding along with innovative energy harvesting techniques, high efficiency power conversion and finally managing the energy distribution inside a smart grid, with the target of different classes of applications, from house to small area, as well as application specific “local grid”.

As far as the photovoltaic cell technology is concerned, Silicon remains the most important material in the near-medium term, while in a longer term view other approaches such as organic PV or hybrid such as dye-sensitized-solar cells (DSSC) may become very important. For this reason we have focused our research in these two areas. The first part of our Project (**WP1**) will focus on the realization of innovative crystalline Si solar cells. The areas of activity will concern the design and fabrication of prototype cells, study on novel materials, and innovation in the sector of industrial advanced Si PV cell manufacturing, including processing and characterization tools. The focus subjects will be in the sectors of:

- Ultra-thin Si wafer PV cells
- Si hetero-junction devices (both the case of tandem / multi-junction cells and the case of hetero-junction contacts used only as minority carrier mirrors)
- Novel architectures for Si cells, with emphasis to the case of back-contact cells
- Novel materials (for Si hetero-junctions, ARC, and passivation dielectrics)
- Novel approaches for screen printing and laser processing, with focus to the case of back-contact cells

As quantitative targets for the prototype cells we aim to realize single junction Si cells with efficiencies with hetero-junction contacts equal or larger than 20% in standard conditions (1 sun, AM1.5G spectrum, 25 °C), with short circuit current equal or larger than 39 mA/cm^2 and open circuit voltage equal or larger than 680 mV. We also plan to realize a single junction Si PV cell version with hetero-junction contacts suitable for Concentration PV, able to work above 100 suns, with a target series resistance (for the packaged device, 1 cm $\times$ 1 cm approximate size) of 25 mΩ*cm^2 or lower, with an efficiency of at least 20% at 100 sun and up to 25 % peak efficiency.

In WP1, ultra-thin Si cells will also be investigated, aiming to increase the conversion efficiency and to reduce the thickness of the cell. By implementing advanced light trapping strategies, we will develop ultra-thin Si cells with efficiency approximately of 20%. On the other hand, by reducing the thickness of the cell to the range 20-50 micron, lower costs will be achieved.

Another part of WP1 concerns the development of advanced or modified materials for high performance DSSC toward the goal of totally printable DSSC. This will includes (a) printable electrolyte (to replace liquid electrolyte), (b) advanced TiO_2 electrode and (c) counter electrode to meet high performance DSSC applications. The overall objective is to demonstrate DSSC products for commercial applications. This will include (a) a low-power, low light compatible monitoring DSSC for wireless sensing in PV tracing application, and (b) a 30 $\times$ 30 cm^2 DSSC module for commercial equipment charging applications, with an expected active area efficiency of 7%.

ERG will also develop advanced concepts for PV field configuration. Today's PV power stations are realized connecting several panels in series in order to define a bus voltage large enough for the inverter working modalities. Depending to the total installed power many strings are connected in parallel. This approach is called “Concentrated” because the panels are connected to the converter which is responsible of their power management. The “Distributed” approach is the technique in which the panel power management is made at panel level by “Smart Junction Box” including a DC/DC converter with embedded the MPPT algorithm. Such a technique presents several advantages in terms of increasing in energy production (up to 30%) and also in better maintenance.

Different distributed philosophies are present on the market but they show some limitations from cost or application points of view. In any case several millions of panels are today equipped by smart boxes. The individuation of a distributed architecture overcoming these limits should definitively open the PV market to this innovative solution with large advantages especially for building integrated systems.

The chart in Fig. 1 shows the PV installations in 2009 and the forecasts for the 2010 and 2011 with growth rates close to 100% per year. Translating these pictures in number of PV modules (200W typical) we reach huge numbers, of the order of many tens of Mpanels/Y.

In such context, **WP2** aims to develop advanced methods for energy extraction from PV modules, focusing on novel concepts for MPPT and low cost systems for concentrated PV. In particular the activity will be on:

- micro-electromechanical systems with dedicated electronics for concentrated photovoltaic;
- efficient power conversion at the single PV module level by means of DC/DC converters able to generate a suitable voltage for grid-connected systems;
- building blocks for future converters representing an innovative approach for distributed architecture, allowing maximum power extraction from single PV modules thanks to dedicated MPPT function and high efficiency conversion for low power grid-connected systems.

WP3 is dedicated to the power conversion problem. Actual solutions for conversion for the generated DC power into usual AC systems are dominated by medium and high power systems, which provide the best ratio between cost and performance. In order to increase performance – without sacrificing cost benefits – several approaches are upcoming and using segmented converters for higher efficiencies. The optimum structure size and internal architecture is open to this time and is offering an essential possibility for increased efficiency, for example by avoiding large shadowing effects and by intelligent handling of failures. The goal for energy saving by conversion systems is set to 20% reduction of losses. Each intermediate step of developments will be measured for the contribution of this general target.

The concept of ERG provides basic architecture evaluations to improve the electrical efficiency for a broad range of PV applications by improving and combining all promising options along the complete supply chain, including:

- Solar cells of newest generations
- Technologies with lowest losses
- Converter Schemes with autonomous flexibility
- Storage options for grid protection and E-mobility support
- Low-loss grid connectivity.

WP4 is dedicated to the problem of the power grid architecture. In grids powered by renewable energy sources, like PV, it becomes essential to actively match the load demand with the instantaneous power generation in combination with the available stored energy. Besides an energy flow from source to load in state of the art systems bi-directional communication between source, storage and load become essential. An efficient management strategy can only be implemented when advanced models are available of all components. ERG will develop those models and implement the communication infrastructure for smart grid operation. Demonstrators will include an application of the communication infrastructure and software for a large scale distribution grid and an industrial micro-grid.

5.2 Progress beyond the state-of-the art

<u>WP1 – Innovative solar cells</u>

The theoretical limit of Si photovoltaic (PV) cells under standard AM1.5G irradiation has been evaluated by a number of authors, and the most cited limit value is the Queisser-Shockley estimate of 1961, of about 30% maximum power conversion efficiency of single junction PV cell with a gap of 1.1 eV. This is considered quite close to the “real” limit, also by considering various refinements to the original Queisser-Shockley theory and alternative models that have been proposed so far. From the experimental side, the theoretical limit has been almost reached in the case of the best cells, and in particular in the case of a crystalline silicon solar cell with front / back contacts and with the Passivated Emitter Rear Local diffused (PERL) architecture. These achieved an efficiency of about 25%. The PERL structure is however quite complex and for the industrial exploitation different routes are considered more realistic to achieve the ultimate limits. Let us therefore briefly review the major loss mechanisms operating in a Si cell to understand the reasons for our proposed areas of research.

A source of loss is the minority carrier silicon bulk recombination through defects and by Auger mechanism. However, the lifetime in current state-of-art production silicon ingots is well above 1 ms, and this implies that bulk recombination will not be a major problem. The big issue comes from the passivation of the surfaces and the cell contacting. Ideally the surfaces should be minority carrier mirrors, i.e., no recombination. Shallow diffusions that are passivated with high quality thermal silicon dioxide have J_0 of over 20 fA/cm^2. Real Si PV cells have much larger J_0, and this gives a noticeable impact on lowering the efficiency.

An approach to contacts is to put a hetero-junction with a band-gap larger than silicon between the metal and silicon. If the conduction and valence bands are properly aligned to silicon's, this has the effect of creating a minority carrier mirror. The best developed such contact uses hydrogenated amorphous silicon, such as in the Sanyo HIT cell. For this cell the main processing step consists in depositing a highly doped amorphous hydrogenated silicon film (aSi:H) on top of a thin “buffer” layer of intrinsic aSi:H with controlled low defect density on doped crystalline silicon substrate by using plasma enhanced chemical vapour deposition (PECVD) systems at temperatures below or close to 200 °C. The dark I-V characteristics reveal that the backward current density can be considerably larger than expected. This is due to the high density of interface states originated from plasma damage on the c-Si surface and a high defect state density in the a-Si layer. To reduce the damage at the interface with the c-Si substrate, the deposition conditions of the a-Si layers, coupled to hydrogen plasma treatments or HF etching prior to the deposition to clean the c-Si surface, can improve the whole cell performance. A further improvement of the HIT structure has been demonstrated by introducing a Back Surface Field (BSF) a-Si layer to increase the minority carrier diffusion length and to decrease the rear surface recombination velocity. The BSF is similar to the top a-Si stack, i.e. it is a thin intrinsic a-Si layer and a doped a-Si film. By also texturing the surfaces to increase the internal reflectivity, conversion efficiency goes beyond 20%. The key points of such a structure are the large band-gap and the interface states of the hetero-contacts. In order to increase the band-gap and to implement the exciton quantum confinement between silicon nanostructure embedded in the layer after separation, we will analyze the use of SiN layers. Moreover, to passivate both front hetero-junction emitter and back contact, a doubled sided structure will be investigated, that is Silicon Rich Oxide (SRO). Hetero-junction solar cells based on a-Si:H, SRO and SiN layer will be implemented by means of Inductively Coupled Chemical Vapour Deposition (ICPCVD). Electrical, optical and structural properties of these solar cells will be analyzed to achieve a better efficiency.

Concerning the field of hetero-junction solar cells, we will investigate III-V multi-junction (MJ) solar cells. The current state of the art is a 3 junction concentrator cell based on the Ge/GaInAs/GaInP system[2] with champion device conversion efficiencies of over 40%. Concentrator PV (CPV) systems facilitate increased efficiency with “production” efficiencies of 25% for Si and 35% for III-V currently demonstrated. In order to lower the cost and at the same time to have higher efficiency than single junction Si, III-V 2 junction and 3 junction systems, such as GaAs/GaInP or Ge/GaInAs/GaInP can be developed. However in both cases these cells are 10-100 times more expensive per cell area than Si due to substrate[3] and epitaxy processing costs. Moreover, we need to take into account the toxicity of conventional III-Vs and the abundance of Ge[4]. III-N (AlGaInN) materials are direct band gap, thus efficient emitters and absorbers right the way to their band edge. The spectral range of InGaN varies from the UV (360 nm) to infrared (1.7 μm). Unlike current multi-absorption solar cell materials, e.g. the 3J system based on Ge/GaAs/GaInP, this potentially enables effectively full solar spectrum absorption through only one material system. Furthermore, the performance of III-N power and LED devices grown on Si does not appear to suffer from the large density of crystalline defects as with conventional III-Vs. An additional advantage is the robustness of nitride-based solar cells for high temperature operation[5], which is particularly relevant under high solar concentration in CPV. Several theoretical studies[6,7] have shown that InGaN PV “top” cells can provide considerable (10-15%) efficiency enhancements to conventional structures. Significantly, 2 and 3 junction tandem InGaN/Si cells have theoretical efficiencies of up to 28% and 35%, respectively[8]. This can be increased further to over 40% under optimum concentration, cell temperature control and resistive loss minimisation. In this field we plan to optimize the design for single and multi-junction

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[2] M.A. Green et al, Prog. Photovoltaics: Research and Applications, **17**, 320 (2009)

[3] Ge and GaAs wafers are about 8-10 times more expensive than Si and limited to 8”/200mm diameter

[4] Kurtz, Kurtz_ Technical Report NREL/TP-520-43208 July 2008 Opportunities and Challenges for Development of a Mature Concentrating Photovoltaic Power Industry

[5] G.A. Landis et al, *NASA report* 2005/CP-2005-213431/27

[6] H. Hamzaoui et al, *Sol. Energy Mater. Sol. Cells*, **87**, 595 (2005)

[7] X. Zhang et al, J. Phys. D, **40**, 7335 (2007)

[8] L. Hsu and W. Walukiewicz, *J. Appl. Phys.* **104**, 024507, (2008)

InGaN/Si solar cells. In order to fabricate InGaN/Si solar cell we will make use of metalorganic vapour phase epitaxy (MOVPE) growth. Moreover, the characterization of the designed devices will be performed to test suitability of the proposed structures.

In the field of CPV systems, we propose to implement a breakthrough in packaging to reduce the large costs. Nowadays very expensive materials are used to package this type of cells. We aim to use semiconductor assembly technology which should bring to a reduction in the packaging cost of a factor 2.

The other source of losses is optical. The front surface reflectance cannot be zero, but it can be small. Moreover, other improvements can come by increasing the back surface reflectance. The grid reflection and grid resistance can be addressed by changing the PV cell architecture. In a conventional bulk crystalline silicon solar cell, the emitter is located near the top of front surface and the contacts and the metal grid are on the front. The base contact is instead on the rear surface that is often fully covered by metal. The front grid has to be a trade-off between having low coverage to limit optical losses and high coverage to limit resistive losses.

Current state of the art photovoltaic technology based on crystalline solar cells provides modules with typical conversion efficiency around 17% and cell thickness of 150 microns. The work planned in this field aims to contribute to further development of crystalline-silicon technology targeting at higher conversion efficiencies (by implementing advanced light-trapping strategies) and lower costs (by developing of ultra-thin photovoltaic cells with wafer thickness in the range 20-50 micron obtained by a smart-cut technique and by using advanced low-breakage wafer handling and contact screen printing processes). Advanced low-temperature deposition processes for passivation and anti-reflection coating layers will be also developed.

The back contact cell architecture with both contact of the rear side allows to significantly reducing both shadowing and resistive losses leading to an improvement in cell efficiency. Furthermore, the back contact design has considerable advantage related to easier and cheaper module assembly and to improved aesthetic appearance. On the other hand, the advanced cell structures generally invoke process modifications of which the related costs have to be compensated by the gain in performance and reduced module manufacturing costs.

Back contact cells are divided into three main classes: back-junction (BJ), emitter wrap-through (EWT) and metallisation wrap-through (MWT). In a conventional solar cell, the front grid usually consists of thin parallel lines (fingers) that transport the current to centrally located busbars. The bus-bars are relatively wide and can be used as solder pads to connect to the external leads. In a metallisation wrap-through (MWT) back-contact cell, the emitter is still located near the front surface, but part of the front metallisation grid (bus-bar) is moved from the front to the rear surface. The remaining front surface grid is connected to the interconnection pads on the rear surface by extending it through a number of openings in the wafer. In the emitter wrap-through (EWT) cell, all contacts are on the rear surface but the emitter is still near the front. The connection between the active emitter near the front surface and the emitter contacts on the rear surface is provided by extending the emitter in the walls of holes in the substrate. Finally, in the back-junction (BJ) cell concept, the emitter is no longer located near the front surface, but together with the contacts moved to the rear surface. Extensive TCAD physics-based electro-optical numerical simulation will be performed in order to evaluate the impact of available technological options on the PV cell performance.

In addition, extended experimental characterization will be performed in order to evaluate the performance and the long-term reliability of the fabricated solar cells. Furthermore we will develop advanced non-contact characterization techniques to be integrated in the solar-cells production line in order to have a fast and efficient screening of the single cell during the production of the full module.

DSSC, invented in the early 90s at EPFL by Prof. M. Graetzel, currently stands with 11.2%

certified efficiency, reported on glass based small area cells (1 cm^2). Uncertified efficiencies measured range up to 11.9%, achieving 14-15% efficiency by 2012 on glass substrates is the declared target of most research projects, currently pursued by various research groups. Even if efficiency and lifetime need to be improved, DSSCs present several advantages with respect to conventional solid-state solar cells. The notable among them are its performance at low light levels and increased operating temperatures, both of which are of primary relevance to building integrated PV (BIPV) and the solar cells for vehicles. The solar powered cars need to operate round the year at varying levels of light intensity, without the need to orient the PV panels. The most important factor is not the peak power generated, but the total energy harvested over the illumination period, from January to December, at different geographical locations.

Long term field test data are available from Japan as well on this vital subject. DSSC modules, fabricated by Aisin Seiki in Japan, have been tested with polycrystalline silicon (pc-Si) running for several years. The test results revealed the advantages of the DSSC as compared with silicon modules under outdoor conditions: for equal rating under standard test conditions, the DSSC modules produced 20–30% more energy than poly-crystalline silicon2. Test data published by Aisin Seki (Toyota Group) of Japan as well as by SolarPrint Limited of Ireland are presented below.

These mesoscopic solar cells based on an interpenetrating network or bulk junctions can be fabricated at much lower cost using standard laboratory techniques (spin coating, dip coating, screen printing, etc.) DSSC is the only PV device that separates the two functions of solar light harvesting and charge carrier transport. The conventional PV cells perform both of these operations simultaneously, resulting in stringent demands on the purity of materials and much higher production costs.

With all of its advantages, DSSCs is now approaching maturity to penetrate the PV market. The field of DSSC is only about 20 years old, compared to silicon PV, which have been in existence for over 50 years.

The growing interest in DSSC is verified by the evolution of patents in the field, amounting to about 350 patents on DSSC. The following are some of the leading companies with commercial ambitions for glass-based DSSC: IMRA-Aisin Seiki/Toyota (JP), Sharp (JP), Samsung (Korea), OrionSolar (Israel) and SolarPrint (Ireland). Further, flexible type DSSC prototypes are developed by e.g. Toshiba, DAI Nippon and Peccel Tec. (JP), Corus (UK), Konarka (USA), G24i (UK), Toppan Forms, Leonhard Kurz (D), Mitsubishi (JP) and SolarPrint (Ireland). Several companies are also involved in producing and selling specific DSSC materials and production equipment like Solaronix (Switzerland) and Dyesol (Australia). The most urgent action required for further maturing DSSC on which partners are working are: increasing of efficiency (already 15% by multi-injection stacked DSSC3) especially for plastic substrates, sealing methods for lifetime increasing and to prevent losses of electrolytes4 (also using quasi-solid or ionic liquid electrolytes suitable for other electrochemical devices, as batteries5).

Even though the conversion efficiency at AM1.5 may still be low as compared to other types of PV (silicon, and thin films), DSSC shows remarkable performance of having better conversion efficiency in other lighting conditions. SolarPrint has conducted the comparison between DSSC and silicon cells in many lighting environments and has the following conclusions. First, in the solar spectrum, DSSC outperformed crystalline silicon cell below 400 W/m^2, which is approximately 40% of the full sunlight of AM1.5 condition. Second, in white LED light, DSSC outperforms crystalline solar cell in all lighting intensities within the test range, i.e., from 100 to 10,000 lux.

The target of the leading ERG Partner in DSSC, SolarPrint, is to launch applications in the market which has a relatively small, but nevertheless a substantial growth share in the future. Equally attractive will be its low cost of manufacturing and its environmental friendly processing and materials to be used. Moreover, its potentially viable technology for flexible, light weight and conformal surface contour for applications such as portable devices, on-board charge for automobiles, wireless sensors, garments etc.

An important upcoming application will be Electrification of Road Transport which European Commission has been promoting for next 10-20 years[6]. DSSC can be used to charge automobile directly on board. Light-weight, flexible, conformal DSSC can be installed in the car interior where is directly exposed to sunlight such as dash board. It also can be integrated as part of the automobile exterior which is exposed to direct sunlight. Potentially viable process for DSSC on polymer substrate is the most promising technology to make light-weight, flexible and surface conformal solar cell without compromising for weight increase or appearance athletics. Medium-to-low, diffused light contributes most of the charge for automobile in everyday life.

Indirect charging can be also accomplished by using DSSC to power through the grid.

Independent measurements performed by Aisin Seiki (Toyota Group) of Japanese show consistent observations as what have been found in SolarPrint Limited.

Figure 3 is the comparison of generated power between DSSC and silicon cells in sunny days in different months of the year. Figure 4 is the comparison of power output between DSSC and silicon cell on the roof 30 degrees facing south and north. It is important to note that for cells facing north, DSSC generate 40% more power than silicon.

With the characteristics shown above, DSSC has been demonstrated as a practically useful solar cell for power generations in many applications.

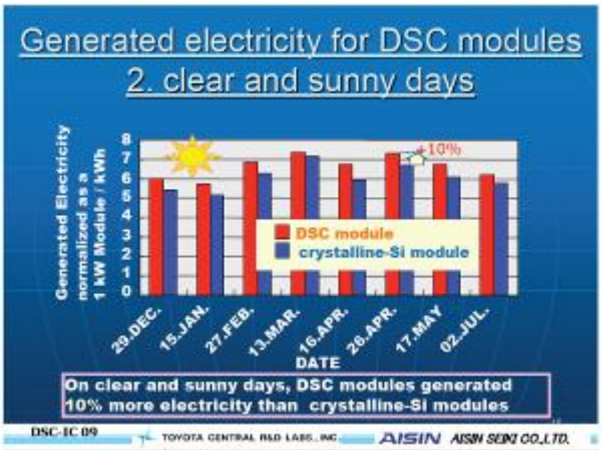


Figure 3 – Generated electricity for DSC modules: clear and sunny days.

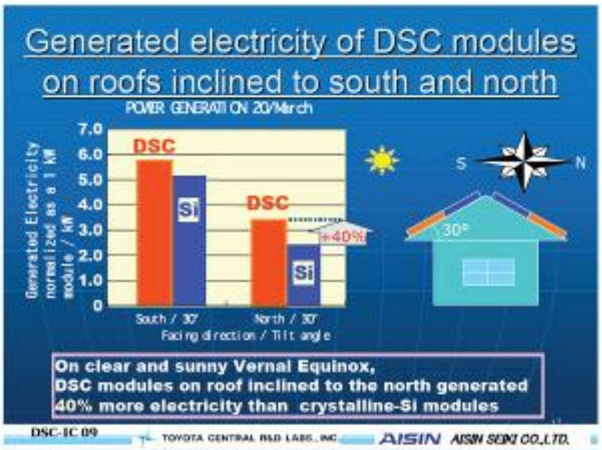


Figure 4 – Generated electricity of DSC modules on roofs inclined to South and North.

Silicon currently represents the most important material in the near-medium term for the photovoltaic field, but in a longer term view organic PV or hybrid dye-sensitized-solar cells (DSSC) may become very important. For this reason the aim in this field is to develop advanced materials for high-performance DSSC products in order to implement a totally printable DSSC processing technology. Moreover we will demonstrate DSSC products for commercial applications.

WP2 – Optimization method for energy extraction

Concerning PV power stations, at the state of the art, they are based on “concentrated” converters. Several panels are connected in series in order to define a bus voltage enough for the inverter working modalities. Depending to the total installed power many strings are connected in parallel. In this approach the converter is responsible of their power management. In this field we aim to develop high efficiency front-end circuits directly integrated with the single photovoltaic cell to implement “distributed” maximum power point tracking (MPPT) and power conversion and management architecture. Since the power budget provided by the single cell is extremely low, strong innovations are required to design circuits able to work efficiently at very low power and voltage. Further, the novel idea is to integrate also the power management with the MPPT and the DC-DC conversion circuits, to manage and combine the power collected from every cell in a modular system perspective.
Concentrated photovoltaic energy production requires the concentration of solar energy in a precise location at low cost. We will cover this issue by designing an optical subsystem based on extensive use of distributed electronic micro-systems for sun tracking and power concentration.

We will develop a “Smart Junction Box” for PV panels able to increase the efficiency of the power distribution outgoing from the Photovoltaic Panels (PVs), due to the reduced contact resistance and consequently the reduced power loss. Dedicated integrated circuits will be inserted in this box in order to control with high efficiency the power converters for distributed architectures. A novel power switch will be also developed, base on a split-gate XtreMOS™ module. Moreover, we will design and develop a dedicated control system for DSSC modules.

In addition we will investigate a novel approach for building block for future converters which allows maximum power extraction from single photovoltaic panel due to a dedicated MPPT function and high efficiency conversion for low power grid-connected systems in the range up to 400W.

WP3 – Efficient power conversion

According to actual tests under realistic conditions (Photon, April 2010, P136) the converter market is showing efficiencies from 89.1% (1KW) to 96.9% (11KW). In other words 3.1% to 10.9% of valuable energy is lost at this stage only, especially for small and medium sized converters.

Every step forward in this stage will directly improve the overall efficiency. Starting from the state of the art, new approaches and architectures for energy conversion will be investigated. The concept of ERG provides basic architecture evaluations to improve the electrical efficiency for a broad range of PV and also for CPV applications by improving and combining all promising options along the complete supply chain which are discussed here. In order to have high efficiency systems, the SOI technology will be evaluated since it allows obtaining very low standby losses for intelligent power control. Innovative converter schemes with autonomous flexibility will be investigated. The aim of this approach is to reduce the power degradation due to effects like shadowing, aging or failure of solar modules. Moreover, the energy storage option for grid protection and E-mobility support will be analyzed.

By combining the energy storage circuits with the sub-module concept, it is possible to reach highly flexible and scalable power supply for mobile applications. In addition, a low-loss grid connectivity will be evaluated. The importance of overall converter efficiency is crucial for the success of European solar industry in order to keep and increase the leading worldwide position.

WP4 - Smart Energy Distribution, Utilization and Management

State of the art of smart energy dispatching strategies for the charging of electrical vehicles (EVs) and energy storage systems are based on the scheduling of the charging process on the basis of negotiation phases between the user and the electric utility in which information about fares, amount of required energy and maximum time available for completing the charging before user drive off are exchanged. However developed algorithms use time-constant charging current, that in the presence of multiple contemporary requests of charging, may lead either to underutilizing the potential grid capacity or grid to collapse. Some variable rate charging algorithms have been also developed, but not taking into account actual relationship between charging rate and system efficiency, leading to poor performances in terms of final user degrees and power dissipation. Clearly, conventional chargers systems do not offer the flexibility in current rate and charging strategies required by the implementation of smart dispatching/charging algorithms.

Concerning energy management in the context of distributed generation, we are targeting the definition of a fully integrated platform based on wireless sensors, from the design of the various Zig-Bee sensor nodes to the software infrastructure for data collection and presentation that leverages a set of widely available and open source software stacks for wireless network operation and data collection. This represents a significant improvement, allowing researchers and designers to focus on the aspects that add more value to the system: the smart management policies on the one hand, and the ultra low-power sensors nodes on the other.

In this context, realistic behavioural models, based on power sources and load profiles, will be introduced for the individual components in the network in order to develop novel energy dispatching and battery charging algorithms that allow the optimal utilization of the electric energy supplied by the energy distribution system and the photovoltaic systems. Sensors distributed over the wireless network infrastructure will provide inputs to such algorithms. For this purpose the goal is to enhance the Mean Satisfaction Degree of final users from the currently achieved value of 67% up to 80-85%. Smart charging algorithms will be proposed with the aim to increase the battery charging process efficiency of 10% compared to standard systems.

Moreover novel performance analysis techniques will be developed leading to obtain fast and accurate metrics of execution times and power consumption for the complete networked electronic system.

A main smart grid demonstrator will be build based on household applications and a smaller one will be focused on industrial/healthcare applications for a large scale commercial smart grid.

6 SCIENTIFIC TECHNICAL APPROACH AND ASSOCIATED WORK PLAN

6.1 Overall strategy and general description

The work in ERG is organized in 4 work packages (WP). ERG also includes two service WPs, not shown in the figure, which cover the activities of Dissemination, Exploitation, IPR management (WPM1), and Project Management (WPM2).

WP1: Innovative Solar Cells ***(Leader: CNR)***

Silicon remains the most important material in the near-medium term, while in a longer term view other approaches such as organic PV or hybrid such as dye-sensitized-solar cells (DSSC) may become very important. For this reason the ERG Project, as far as the photovoltaic cell technology is concerned, is focused in these two areas. The first part of WP1 will concentrate on the realization of innovative crystalline Si solar cells. The areas of activity will concern the design and fabrication of prototype cells, study on novel materials, and innovation in the sector of industrial advanced Si PV cell manufacturing, including processing and characterization tools. The large research Consortium allows facing most if not all of the crucial issues in this area. In fact, the focus subjects will be in the sectors of:

- Ultra-thin Si wafer PV cells
- Si hetero-junction devices (both the case of tandem / multi-junction cells and the case of hetero-junction contacts used only as minority carrier mirrors)
- Novel architectures for Si cells, with emphasis to the case of back-contact cells
- Novel materials (for Si hetero-junctions, ARC, and passivation dielectrics)
- Novel approaches for screen printing and laser processing, with focus to the case of back-contact cells.

Another part of WP1 concerns the development of advanced high performance DSSC cells and modules, toward the goal of a totally printable DSSC, proposing new solutions in terms of materials, including printable electrolyte (to replace the standard liquid electrolyte, and advanced TiO_2 electrode and counter electrode.

Both in the case of advanced Si and of DSSC cells we plan to realize state of the art devices in terms of power conversion efficiency, and to provide effective perspectives for PV cell cost reduction, through the accurate study on novel materials and new PV cell manufacturing technologies.

WP2: Optimization method for energy extraction ***(Leader: ST)***

Starting form efficient solar cells and photovoltaic panels it is mandatory to extract all available power with the highest possible efficiency. This is typically performed by means of dedicated and complex MPPT (Maximum Power Point Tracking) algorithms working at concentrated level of high power inverters able to provide standard AC voltage on the output either for stand-alone or grid-tied applications. The efficiency of this approach is not satisfactory due to several factors, e.g. mismatch, partial shadowing, and negatively impacts the yearly energy production of photovoltaic systems, regardless of the efficiency of the single components.

In order to improve the global behaviour of small to medium photovoltaic plants an innovative approach, based on distributed architecture is investigated, designed and developed, taking advantage on the strong experience of in semiconductor technology, system development and integration the involved partners.

The solar cells developed in WP1 will be used by WP2 to build such an innovative architecture. Specific electronic and electromechanical solution will be developed for each solar cell technology in order to maximize the energy extracted from the cells.

The distributed systems represent also a suitable field for smart grid integration, linking WP2 with WP4.

WP3: Efficient Power Conversion ***(Leader: TEL)***

The energy generated by solar cells has to be converted to appropriate voltage levels for energy storage and/or transportation with focus on minimum losses at every stage. Complete supply chains therefore will be build for optimum energy exploitation by MPPT tracking and power conversion on module / segment levels for PV and also CPV solar generators. Starting from specifications of requirements, the architecture of design solutions will be explored, as well for segmentation on module level, interfacing of function blocks, as for splitting of tasks between hardware and software control. The architecture study will elaborate different profiles of end-users, including

- direct grid connection
- energy storage option
- e-mobility support.

The results of this WP will be demonstrated on base of prototypes of novel conversion systems for PV and CPV inverters. Final evaluation of gained efficiency and comparison to previous states will complete this WP.

WP4: Smart Energy Distribution, Utilization and Management ***(Leader: POLITO)***

WP4 will develop the behavioural models for the individual components in the network and for the network as a whole. This allows the development of optimal energy dispatching and battery charging algorithms. These algorithms will obtain the inputs from sensor distributed over the network, with typically, but not exclusive, a wireless communication infrastructure. A demonstrator will be built based on a household application and an industrial application.

WPM1: Dissemination, Exploitation, Standardization ***(Leader: ST)***

WPM1 is concerned with activities that will secure the major impact of the project results onto the international industrial and scientific community such as standardization, dissemination of project results, and definition of exploitation plans and execution of work preparatory to results exploitation.

WPM2: Project Management ***(Leader: ST)***

WPM2 regards all the project management activities; technical management, resources management and communication with JU and IPR Management.

Co-operation

Results of WP1 for innovative solar cells will be taken into account and the cooperation with WP2 will be essential for the use of optimal strategy and methods. First results will used in the specification phase of WP3 and advanced methods can be implemented in the second design phase. The results of WP3 will be used in parallel by WP4 for the preparation of advanced energy distribution concepts.

WP2 and WP3 are working at different approaches for converters (DC/DC, DC/AC), trackers and communication modules for use in PV or CPV systems. The main differences are in power levels (WP3 considers both module-level and PV-array-level power conversion, whereas WP2 only considers module-level power conversion) and on details, such as the used power topology. A close cooperation of WP2 and WP3 is planned in order to keep track of the upcoming results and to avoid overlapping tasks as far as possible. Common meetings and exchange of specifications are foreseen and a comparison of results will be done in the final phase.

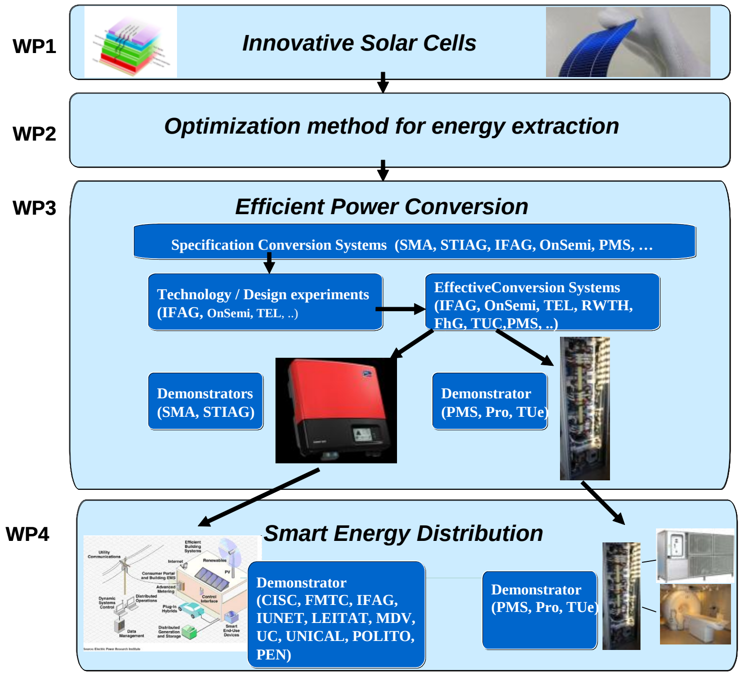


Figure 5 – Work Package flow chart.

6.2 Work package description

<table>
<tr><td>Work Package number</td><td colspan="2">WP1</td><td colspan="3">Start date or starting event:</td><td colspan="2">M1</td></tr>
<tr><td>Work Package title</td><td colspan="7">Innovative solar cells</td></tr>
<tr><td>Participant number</td><td>1</td><td>2</td><td>4</td><td>7</td><td>8</td><td>9</td><td>10</td></tr>
<tr><td>Participant short name</td><td>ST</td><td>AMAT</td><td>IUNET</td><td>UNICAL</td><td>UNICT</td><td>CNR</td><td>ELETTRA</td></tr>
<tr><td>Person-months per participant</td><td>72</td><td>114</td><td>90</td><td>25</td><td>17</td><td>55</td><td>58</td></tr>
<tr><td>Participant number</td><td>21</td><td>22</td><td>25</td><td>26</td><td>31</td><td>35</td><td></td></tr>
<tr><td>Participant short name</td><td>LEITAT</td><td>STUBA</td><td>SPR</td><td>Tyndall</td><td>BTE</td><td>USFD</td><td></td></tr>
<tr><td>Person-months per participant</td><td>24</td><td>98</td><td>72</td><td>24</td><td>50</td><td>32</td><td></td></tr>
</table>

Objectives

The aim of this work package is the development of innovative solar cells. The objectives are split between four Tasks:

Task 1.1: Hetero-junction Crystalline silicon cells

- Silicon based wide band-gap alloys deposited by PECVD on crystalline Si (CNR, ST, ELETTRA, STUBA)
- MOVPE growth of novel AlInGaN epitaxial films on Si (Tyndall, ELETTRA, STUBA)

Task 1.2: Ultra-thin Si cells

- Smart-cut process based on porous silicon (IUNET)
- Low-breakage handling (AMAT)

Task 1.3: Novel architectures for high performance silicon cells

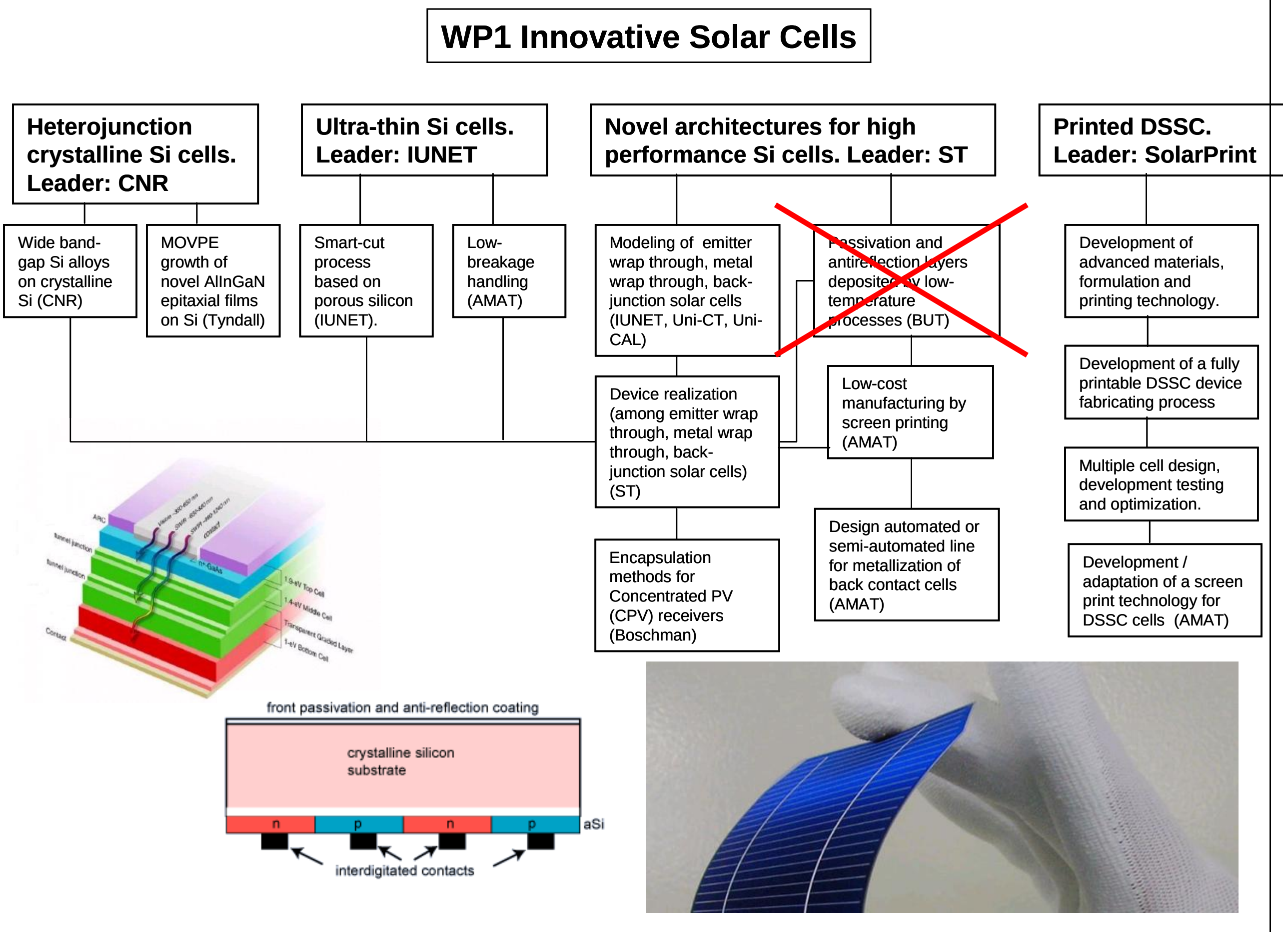
- Modeling of emitter wrap through, metal wrap through, back-junction solar cells and Optimal cell design by advanced evolutionary algorithms (IUNET, UNICT, Uni-CAL)
- Device realization (among emitter wrap through, metal wrap through, back-junction solar cells) (ST)
- Passivation and antireflection layers deposited by low-temperature processes (BUT)
- Low-cost manufacturing (screen printing of materials other than standard metal pastes (such as inks, dopant sources, or mask layers), screen printing in the presence of holes (AMAT)
- Design automated or semi-automated line for metallization and back-end processing of back contact cells, including emitter wrap through, metal wrap through, back-junction solar cells, etc (AMAT)

- Encapsulation methods for Concentrated PV (CPV) receivers, including receiver concept designs for CPV, development and testing of high heat resistant compounds (300C), and development of encapsulation method for Film assisted molding (BTE).

Task 1.4: Printed DSSC

- Development of advanced materials, formulation and printing technology for :
  - (a) printable electrolyte (to replace liquid electrolyte),
  - (b) advanced TiO2 photo-electrode
  - (c) counter electrode to meet high performance DSSC applications.
- Development of a printable DSSC process based on these materials and techniques
- Demonstration of multicell DSSC devices for industrial applications,
  - (a) a low-power, low light compatible monitoring DSSC module for wireless sensing in PV tracing application, and
  - (b) a large (approximately 30 x 30 cm2) DSSC module for commercial equipment charging applications.
- Develop / Adapt screen printing technology for DSSC cells.

In the following we describe in more details the activities carried out in this work package.



Description of work

Task 1.1: Hetero-junction Crystalline silicon cells. Leader CNR

Leader: CNR – Other participant(s): STUBA, Tyndall, ELETTRA
Start date: M1 – End date: M36

Silicon based wide band-gap alloys on crystalline Si (CNR, STUBA, ELETTRA)

Current state of the art PV technology based on wide band gap alloys are hetero-junctions of aSi:H layers on crystalline Si with structures like the HIT cells. This technology offers conversion efficiencies higher than 20%. Advantages of such a structure are related to the simple fabrication processing, to the low required thermal budgets, to the higher Voc, and to the excellent performance at high temperature. The key point of the hetero-structure approach is that wide band-gap layers need only to be of sufficient electronic quality to support the quasi-Fermi level separation in the high quality narrow-gap active layer. Due to its larger band gap, the hetero-contact material may be disordered and of poor quality and still be able to support the voltage generated in the active layer. The other main point is that the interface states at the hetero-contact must be passivated. This interface can be obtained by inserting a buffer passivation thin layer of intrinsic aSi:H with low defect density, between the emitter and the substrate.

The quality of the a-Si based materials is determined by deposition parameters such as: substrate temperature, pressure, flow rate of the source gases, plasma frequency, power and dilution of the feedstock gases with hydrogen. The symmetrical structure where the wide band gap layer is formed on both sides of a high quality c-Si wafer effectively passivates both a front hetero-junction emitter that collects minority carriers and a back contact that collects majority-carriers. Pioneering works on such a double-sided structure proposed the usage of Silicon Rich Oxide (SRO) as a wide band-gap material for a superior quality hetero-junction. Changes in the oxygen dilutions determine the nanograin size, thus providing a control on the density of potential contact points with the substrate, and consequently ensuring enough conductivity for majority – carrier electrons. Further importance relies on the usage of SiN layers, for the increase of the band gap and/or for the exciton quantum confinement within silicon nanostructures embedded in the layer formed after phase separation, with the major advantage of a lower energy barrier respect to the SiO_2.

CNR activity will be focused on the fabrication and testing of materials and devices based on Hetero-junctions with Silicon based Wide Band gap alloys. In particular CNR will focus on Oxygen rich silicon films (SIPOS), SRO, and Nitrogen rich silicon, using hydrogenated amorphous Si as baseline material for the hetero-junction on crystalline Si. The deposition technique will be PECVD. The first part of CNR activity will be on the materials formation, and optimisation of the process parameters, in terms of deposition temperature, plasma energy and gas fluxes. Evaluation of the structural, optical and electrical properties of the different materials deposited on a few reference diodes with transparent Top Contacts (TC) will be delivered at M12 (D1.1). After choice of selected materials, hetero-junction devices both in the TC configuration as reference PV diodes and in the BC configuration, will be realised in collaboration with ST at M18 (D1.2). Structural and electrical characterizations will be performed and delivered at M24 (D1.3). Particular attention will be devoted to the evaluation of important material characteristics such as sheet resistance, band gap and CB/VB offsets (in collaboration with ELETTRA). Based on the characterisation results, a second optimised version of the diodes in the TC, and of the devices in BC configuration, will be realised at M30 (D1.4). The final detailed characterisation on all the optimised devices will be available at M36 (D1.5).

STUBA offers the precise nanoscale structural analysis of the geometry, morphology and physical properties of materials and structures by FE SEM (SE, EDS, EBIC, CL), ION-TOF SIMS, AFM and microRaman spectroscopy combined with optical and electrical characterization performed in a wide temperature range to support the technological development and optimization of fabrication process.

ELETTRA will characterize the Hetero-junctions with Silicon based Wide Band gap alloys with synchrotron radiation. Particular attention will be devoted to the evaluation of important material characteristics such as band gap and CB/VB offsets, band bending, interface formation.

MOVPE growth of novel AlInGaN epitaxial films on Si (Tyndall, STUBA, ELETTRA)

The current state of the art in III-V multi-junction (MJ) solar cells is a 3 junction concentrator cell based on the Ge/GaInAs/GaInP system with champion device conversion efficiencies of over 40%. Concentrator PV (CPV) systems facilitate increased efficiency with "production" efficiencies of 25% for Si and 35% for III-V currently demonstrated. However there is a need for a cell with a lower cost than III-V but higher efficiency than 1J Si for CPV. Up to now, the only viable solution has been III-V 2J and 3J systems such as GaAs/GaInP or Ge/GaInAs/GaInP which in both cases are 10-100 times more expensive per cell area than Si due to substrate and epitaxy (i.e. MOCVD) processing costs in the case of III-V growth. There are additional issues to consider relating to the toxicity of conventional III-Vs and the abundance of Ge. III-N (AlGaInN) materials are direct band gap, thus efficient emitters and absorbers right the way to their band edge. The spectral range of InGaN varies from the UV (360 nm) to infrared (1.7 μm). Unlike current multi-absorption solar cell materials, e.g. the 3J system based on Ge/GaAs/GaInP, this potentially enables effectively full solar spectrum absorption through only one material system. Furthermore, the performance of III-N power and LED devices grown on Si does not appear to suffer from the large density of crystalline defects as with conventional III-Vs. An additional advantage is the robustness of nitride-based solar cells for high temperature operation, which is particularly relevant under high solar concentration in CPV. Several theoretical studies have shown that InGaN PV "top" cells can provide considerable (10-15%) efficiency enhancements to conventional structures. Significantly, 2 and 3 junction tandem InGaN/Si cells have theoretical efficiencies of up to 28% and 35%, respectively. This can be increased further to over 40% under optimum concentration, cell temperature control and resistive loss minimisation.

STUBA will contribute with a nanotechnology approach and various nanostructures prepared from III-V semiconductors, particularly heterostructures based on GaP/InGaP combined with ZnO. Their application will allow to shift the absorption edge more to the bluepart of solar spectra. Nanocrystalline ZnO layers will be prepared by sputtering or pulse laser deposition. Complex nanoscale structurel analysis of the physical geometry, morphology of materials and structures, their physical properties properties by FE SEM (SE, EDAX, EBIC,CL), ION-TOF SIMS, AFM and microRaman spectroscopy combined with optical and electrical characterisation performed in a wide temperature range (reverse engineering) will underpin the technological development and optimization of fabrication process.

ELETTRA will analyse using synchrotron radiation the novel AlInGaN epitaxial films on Si provided by Tyndall, in terms of electronic properties (band gap, band bending), chemistry and band matching at interfaces. Moreover the chemical analysis, also in a microscopic way, and the charge transfer characteristic of the heterostructures based on GaP/InGaP combined with nanocrystalline ZnO, will also be checked.

Task 1.2: Ultra-thin Si cells

Leader: IUNET – Other participant(s):AMAT, CNR, ELETTRA, ST,

Start date: M1 – End date: M36

Smart-cut process based on porous silicon (IUNET)

Current state of the art photovoltaic technology based on crystalline solar cells provides modules with typical conversion efficiency around 17% and cell thickness of 150 microns. This Task aims at further developing crystalline-silicon technology targeting at higher conversion efficiencies (approximately 20% at the module level) and lower costs. While the increase of efficiency will be obtained by developing advanced light-trapping strategies, cost reduction will be possible by thinning the cell, therefore reducing the amount of silicon required for fabrication.

IUNET-Roma will develop ultra-thin photovoltaic cells with wafer thickness in the range 20-50 micron. Thin wafers will be obtained by a smart-cut technique based on porous silicon; the porous silicon layer will help light trapping thanks to light scattering at the cell surface.

CNR Advanced passivation process, and TEM characterization.

ELETTRA will perform syncrotron light characterization of the cells, in particular regarding the electronic properties and the analysis of the chemical elements present in the cells.

ST doping and passivation processes; clean electrochemical process.

Advanced deposition processes for passivation and anti-reflection coating layers will be developed by **BUT**.

The technologies needed for the industrial manufacturing of very thin crystalline cells will be pursued by **AMAT** as described in the next sub-task (Low breakage handling).

IUNET-Bologna will complement fabrication activities by performing accurate numerical electro-optical simulations for the analysis of different technological options for the implementation of advanced light-trapping schemes in ultra-thin cells.

Experimental characterization techniques will be developed by **IUNET-Padova** with emphasis on in-line testing applications and on the analysis of the correlation between performance / reliability and the structure of the devices.

Activity description

- Simulation of light trapping schemes (reported in D1.1, M12).
- Preliminary results for the fabrication of ultra-thin c-Si PV cells (reported in D1.2, M18 and D1.3, M24);
- Process steps for the fabrication of final version of ultra-thin c-Si PV cells; advanced light-trapping strategies (reported in D1.4, M30).
- Final results for the fabrication of ultra-thin c-Si PV cells; advanced manufacturing and characterization techniques (reported in D1.5, M36).

Low-breakage handling (AMAT)

One of the key points to solve for mass production of large amount of silicon cells is the breakage-free handling. This is particularly an issue with wafers becoming thinner and thinner, not to mention with the ultrathin wafers delivered by the smartcut process (above) The main subjects to be investigated in order to reduce breakage are:

Cracks and microcraks detection: the detection of a microcrack, possibly able to propagate and to lead to wafer breakage, at the beginning of the processing allows to keep productivity high and to avoid the additional cost of processing not useful wafers. Main techniques available today to this purpose are based on infrared cameras, on photoluminescence, and on ultrasound detection. AMAT will test all or part of these systems to validate them and find the right combination of low processing time, low cost, and high accuracy.

Soft handling: the other direction to work on is the development of equipments with an intrinsically lower breakage rate. This can be done for example by using contactless or near-contactless handling (such as adoption and development of advanced grippers based on the Bernoulli principle instead than vacuum cups), but also by working on the equipment concept itself (for example, wafer loading and unloading technologies, wafer transport technologies, novel flipping devices, and so on).

Screen printing refinement: in order to avoid breakage during screen printing, we will need to carefully work on details such as the squeegee technology, the real time pressure control, the real time control of squeegee angle and velocity. All of these will be addressed.

Activity description

- Evaluation of different microcrack detection techniques (reported in D1.3, M24)
- Novel soft handling concepts, including new Bernoulli grippers, applied to handling of ultra thin wafer (reported in D1.3, M24)
- Successful breakage-free screen printing of ultrathin wafers (reported in D1.5, M36)

Task 1.3: Novel architectures for high performance silicon cells
Leader: ST – Other participant(s): IUNET, UNICT, UNICAL, AMAT, BTE,
Start date: M1 – End date: M36

Modelling of emitter wrap through, metal wrap through, back-junction solar cells (IUNET, UNICT, UNICAL)

Physics-based electro-optical simulation of solar cells can provide relevant information concerning the impact of available technological options on the conversion efficiency. As of today, the PV community adopts 1-D simulators specifically developed and optimized for the analysis of PC cells. On the other hand, advanced cell architectures adopting Selective-Emitter and Rear-Point-Contacts lead to inherently 3-dimensional devices that cannot be realistically simulated by means of the conventional approaches.

In this project we will adopt a commercial 3D electrical device simulator (S-Devices Synopsys) with physical models tuned through comparison with available experimental results for PV cells, coupled to an in-house developed optical simulator based on Rigorous Coupled Wave Analysis (RCWA) method.

For the Si PV cell parameter optimization algorithm, the optimal cell design problem will be tackled by using advanced evolutionary algorithms for the optimization of geometric and physical parameters in PV cells. In particular, we will use the Constrained Immunological Algorithm, a new population-based algorithm which has proven to be more performant than other state-of-art approaches like Controlled Random Search (CRS), Divide Rectangle (DiRECT) and the Real Coded Genetic Algorithm (RGA).

Device realization (among emitter wrap through, metal wrap through, back-junction solar cells) (ST)

The output of the modelling will drive the fabrication of the cells about the choice of the cell architecture among emitter wrap through, metal wrap through, back-junction solar cells, the process flow set-up and the cell design.

For the fabrication, we will use conventional semiconductor processing technology, including photolithography. This step will allow to optimize cell architecture and cell key parameter (as for example optimum contact size and spacing) comparing experimental results with simulations without concerning with cost and throughput. We will focus on cost once the cell is optimized.

Low-cost manufacturing: screen printing of materials other than standard metal pastes (such as inks, dopant sources, or mask layers) (AMAT)

Manufacturing advanced solar cells requires the capability to handle different materials with respect to the traditional metal-based pastes. Novel materials include, but are not limited to, dopant and etchant pastes. For all these, process conditions will be different from those of traditional metal pastes, with respect to screen materials, screen printing parameters, safety measures, and drying oven characteristics. Further, accurate alignment will be needed in order to carefully superimpose the metal contacts to the underlying structures realized with the novel materials just described. In order to study these aspects, AMAT will qualify for use on its equipments at least two materials, one dopant and one etchanr paste, and of each of them will consider all the aspects above (safety, drying, alignment, printing parameters, screen material).

Activity description

- Simulation and modelling of back-contact cells (reported in D1.1, M12)
- Qualification of dopant paste (reported in D1.3, M24)
- Qualification of etchant paste (reported in D1.5, M36)

Design automated or semi-automated line for metallization and back-end processing of back contact cells, including emitter wrap through, metal wrap through, back-junction solar cells, etc (AMAT)

In order to develop an automated line for back contact cells, all these aspects will need major revisions. In particular, the back contact process line developed by AMAT will likely incorporate many of the following advancements (which ones will actually be implemented depend on the advancement status of different technologies):

processing will be mainly (if not exclusively) on the backside, and handling on the front. If this makes things easier since no flipper is needed, it is also true that contamination should be kept at minimum and the front surface should be absolutely damage-free in order to get the maximum advantage from the new cell architecture.

It will also be necessary to reliably draw very thin (<100um) lines. This will require dedicated squeegee, screens, and squeegee pressure control.

A complex architecture will feature several layers of metals and/or insulators superimposed. In order to get this done reliably in mass production, superior alignment capabilities will be needed,

In particular, in order to correctly align a layer to the already existing one, one has to properly visualize the first pattern. This will/may require the use of dedicated illumination systems and optical filters.

Many back contact cells feature through-wafer holes (vias). While tools are available to perform these operations on lab scale, mass production will require the same high throughput and low breakage rate of screen printing lines.

Finally, metrology requirements will be different. The easiest example is the solar simulator, which need to have all contact on the backside.

Another example may be the use of advanced tools for defect characterization, including microcracks, lifetime, hot spots (tools like photo-luminescence, electro-luminescence, and so on). These will be needed since the higher performances of back contact cell will ask a better control of all defects.

Activity description

- Solution for contamination-free handling and for screen print of 60 um lines (reported in D1.1, M12)
- Laser-based solution for high productivity hole drilling and a solution for metrology for back contact cells (reported in D1.3, M24)
- Complete automated line for back contact cell processing (reported in D1.5, M36)

Encapsulation methods for Concentrated PV (CPV) receivers (BTE)

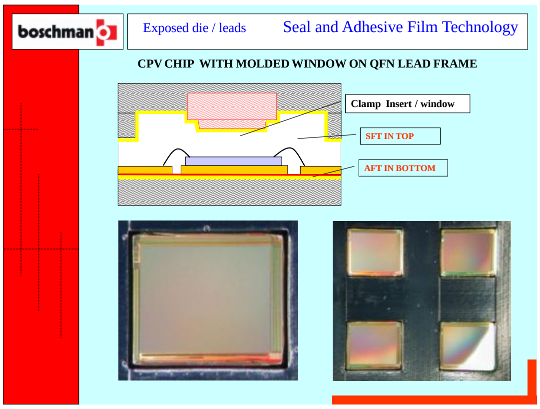
In general packaging technologies are lacking new innovations compared to front end (die) development (More Moore investments). On the other hand packaging is become much more important due to the need of specific packaging solutions for the More than Moore roadmap, use of advanced materials and the increase of packaging costs.

For nowadays advanced packages packaging represents often already more than 50% of the costs!!

CPV is a new technology domain with potential to compete with PV technologies in the future. One of the major drivers is costs. Our effort is focused to realize a breakthrough in costs for CPV packaging. Nowadays very expensive materials are used to package the CPV-cells, i.e. ceramic carriers, very expensive dam-fill materials, etc.

In BTE's solution we will develop a new innovative technology which will not use these materials and at the same time use as much as possible semiconductor assembly technologies to increase productivity. It is expected that, after successful completion, we can reduce the packaging costs with a factor 2 (at least). Reduce needed investment with a factor 10.

Schematic package solution:



Task 1.4: Printed DSSC

Leader: SolarPrint – Other participant(s): ELETTRA, LEITAT

Start date: M1 – End date: M36

Development of advanced materials, formulation and printing technology (SPR, ELETTRA, LEITAT)

Development of printable electrolyte, based on IP generated in SPR which combines the formulation of ionic liquid, solid conductors such as CNT, graphene, nanoclays, etc and polymer to synthesize printable electrolyte. This is to replace the current DSSC technology which uses liquid phase electrolyte. It is a slow and tedious process with a high risk of leaks; it is a major obstacle to long term reliability of DSSC devices.

Development of advanced TiO_2 photo-electrode, also known as the working electrode (WE). Additives (or impurities) such as CNT, graphene or other chemical compounds, will be doped in the TiO_2 materials to improve its photo-reactivity and/or electrical conductivity favourable for electron injection or transport in semiconductor band-gap point of view.

Development of an advanced counter electrode to improve the catalysis, which is currently a thin platinum layer used as a catalyst for iodide/iodine couple redox activity. Combination of a number of unique properties of advanced materials such as high conductivity, electron-and-hole transport mobility, and high surface area, allows the counter electrode with low resistance, hole transport (in addition to electron transport) and high surface catalytic area. Materials such as CNT, graphene, and Pt will be printed to form this architecture.

The afore-mentioned three materials developed in SPR and ELETTRA will then be transferred to LEITAT for further advance electro-spinning process development.

ELETTRA will also characterize these DSSC devices, from the very beginning, with synchrotron radiation, in order to optimize the organic/inorganic interface properties and the charge transfer characteristics.

SPR will develop the three groups of materials described above and assemble into DSSC electrodes for analysis and evaluation

LEITAT will reveive the DSSC materials and assembled devices from SPR for testing and characterization. They will also develop further the electro-spinning process.

ELETTRA will study the materials provided by SPR, investigating degradation mechanisms and charge transfer mechanisms and efficiencies at the crucial interfaces.

Development of a printable DSSC device fabricating process (SPR, LEITAT)

Combine the materials, formulation and printing techniques developed in the previous sub-task to further develop a printable DSSC device fabricating process. Development of printable advanced materials is the key to obtain high performance DSSC modules. Issues of electrolyte filling and leakage cause device processing complexity and affect reliability and life time. It is the purpose of this Task to solve these issues. Thermoplastic sealing may be required between components of the printed module.

- Development of printable DSSC with chemically materials compatibility in various stages of printing, testing, assembly and product demonstration.
- Single cell structure design, development, testing, and optimization
- Single cell fabrication to meet the application for PV tracking and sensing application
- Single cell device characterized and demonstrated for ray tracking and sensing

SPR will develop printable DSSC manufacturing processes to produce single cell DSSC.

LEITAT will characterise the cells provided by SPR, using and adapting appropriate standards for reliability and lifetime testing.

Multiple cell design, development testing and optimization (SPR, LEITAT)

- Low power module design, development
- Low power module, target active area efficiency 8% characterized by LEITAT
- Advanced evolutionary algorithms for the optimization of the PV design for DSSC (UNICAL)
- Commercial sized charging module design and development
- Commercial sized charging module, target active area efficiency 7%, characterized by LEITAT

SPR will design and produce firstly small, low power modules for low light use, and secondly larger commercial size charging modules, interconnecting multiple cells within a DSSC module.

LEITAT will characterise the modules provided by SPR, using and adapting appropriate standards for reliability and lifetime testing and developing these standards towards future certification.

Development / adaptation of a screen print technology for DSSC cells (AMAT)

To adapt conventional screen print technology for DSSC is challenging since the starting material is different (using relatively thick glass instead than thin silicon), the size is different from standard c-Si wafers, materials to be printed are different (requiring different ovens, different screens, different squeegee, and different print parameters).

AMAT will customize an automated screen-printing process for reliable processing of DSSC devices.

Participants' role

ELETTRA will work on the characterization with synchrotron radiation of the cells produced by other partners and on the study of novel materials and interface morphology for DSSC.

Tyndall will design and develop InGaN/Si PV structures for novel CPV materials. Trade-off of optimum base/emitter thicknesses for maximum absorption and carrier generation vs. critical thickness for minimum threading and point defect density InGaN/Si growth will be considered. PV device simulation will be optimised to identify optimum contact grid geometry and photon capture structures. Design structures will be realised by MOVPE growth of InGaN on Si substrates under optimised growth conditions and subjected to in-depth material (structural, electrical, optical) and opto-electronic testing, also using synchrotron radiation techniques. Prototype InGaN/Si cells will be fabricated for solar simulation test and qualification in terms of solar cell parameters (source current, open-circuit voltage and efficiency).

Tyndall will liaise with partners in WP2 in designing the layout geometry and defining the performance requirements of the InGaN/Si CPV cells under desired concentration levels. Tyndall will also work engage with partners in WP3 in order to optimise performance and reliability of the cells. Feedback monitoring of individual cell performance parameters (Isc, Voc, temperature, etc) is highly desirable for maximising power output and identifying drift in cell performance. The wireless sensor devices for cell monitoring proposed in WP3 by Tyndall (power by SolarPrint's DSSC technology) is therefore highly applicable.

Deliverables

D1.1. Simulations / Enabling Materials / Enabling Processes (M12).

Nature: Report. Dissemination level: Restricted and Public version.

Description: Simulations on emitter wrap through, metal wrap through, back-junction solar cells, light trapping schemes for ultra-thin crystalline Si cells. Materials for Si Hetero-junctions. Ultra-thin Si wafer process. ARC and novel passivation materials. Methodology for dynamic testing and shunt resistance evaluation of PV cells. Solution for contamination-free handling and for screen print of 60 um lines. Development and formulations of advanced printable electrolyte, photo-electrode, counter electrode and sealant materials (for DSCC). Design specification and performance simulation for InGaN/Si heterostructures.

D1.2. First Version of PV Cell Devices (M18).

Nature: Prototype. Dissemination level: Restricted.

Description: Back Contact Si PV cell (included concentrated PV versions), Top contact hetero-junction Si cells, Ultra-thin crystalline Si cells, and DSSC. Epitaxy of InGaN PV cell grown on inactive Si substrate.

D1.3. First Device Evaluation. Device Model Refinements. Guidelines for Refinements on Enabling Materials / Enabling Processes (M24).

Nature: Report. Dissemination level: Restricted and Public version.

Description: Time zero performance of Back Contact Si PV cell (included concentrated PV versions), Top contact hetero-junction Si cells, InGaN/Si solar cell demonstrator, Ultra-thin crystalline Si cells, and DSSC delivered at M18. Preliminary Reliability evaluations. Comparison with models / expected results. Individuation of eventual process / material / architecture errors and proposals for correction. Manufacturing techniques for ultra-thin Si wafer processing (microcrack detection techniques, novel soft handling concepts). Qualification of dopant paste for screen printing. Laser-based solution for high productivity hole drilling and a solution for metrology for back contact cells. ARC and novel passivation materials with surface recombination velocity less than 100 cm/s. Description of semi-automated line for processing of DSSC cells. Evaluation of InGaN PV cell structure on inactive Si substrate (material characterisation/inspection) and PV device electrical and optical characterisation.

D1.4. Refined Version of PV Cell Devices (M30).

Nature: Prototype. Dissemination level: Restricted.

Description: BC Si PV cell including hetero-junctions and novel dielectrics for passivation and ARC (included concentrated PV versions); Ultra-thin crystalline Si cells; DSSC module on Large Area.

D1.5. Refined Device Evaluation. Preliminary Evaluations of Cost / Performance Perspectives (M36).

Nature: Report. Dissemination level: Restricted and Public version.

Description: experimental evaluation of final version of device demonstrators, i.e. BC Si PV cell including hetero-junctions and novel dielectrics for passivation and ARC; Ultra-thin crystalline Si cells; DSSC module on Large Area. Comparison of the advanced Si and DSSC technologies in terms of performances including spectral response and under different illumination conditions, both at time zero and with preliminary reliability evaluations. Estimates of the actual technology costs and evaluation of cost reduction perspectives. Manufacturing techniques for ultra-thin Si wafer processing (screen printing). Qualification of etchant paste for screen printing. Complete automated line for back contact cell processing. ARC and novel passivation materials with surface recombination velocity less than 50 cm/s. Dynamic testing of thin PV cells in product line and local defects tester.

Milestones

M1.1. First Version of PV Cell Devices. (M18). Content: Back Contact Si PV cell (included concentrated PV versions), Top contact hetero-junction Si cells, Ultra-thin crystalline Si cells, and DSSC

M1.2. First Device Evaluation. Device Model Refinements. Guidelines for Refinements on Final Version of Devices (M24). Content: Time zero performance and Preliminary Reliability evaluations. Comparison with models / expected results. Individuation of eventual process / material / architecture errors and proposals for correction.

M1.3. Refined Version of PV Cell Devices. (M30). Content: BC Si PV cell including hetero-junctions and novel dielectrics for passivation and ARC (included concentrated PV versions); Ultra-thin crystalline Si cells; DSSC module on Large Area.

M1.4. Final Device Evaluation (M36). Comparison of the advanced Si and DSSC technologies in terms of performances including spectral response and under different illumination conditions, both at time zero and with preliminary reliability evaluations. Estimates of the actual technology costs and evaluation of cost reduction perspectives (reported in D5).

Deliverables

Del. No.	*Deliverable Title*	*Contributors*	*Due date*
D1.1	Simulations / Enabling Materials / Enabling Processes.	**Leader**, ST, SPR, IUNET, CNR, Tyndall	M12
D1.2	First Version of PV Cell Devices.	**Leader**, ST, SPR, IUNET, CNR	M18
D1.3	First Device Evaluation. Device Model Refinements. Guidelines for Refinements on Enabling Materials / Enabling Processes.	**Leader**, ST, SPR, IUNET, CNR	M24
D1.4	Refined Version of PV Cell Devices.	**Leader**, ST, SPR, IUNET, CNR	M30
D1.5	Refined Device Evaluation. Preliminary Evaluations of Cost / Performance Perspectives.	**Leader**, ST, SPR, IUNET, CNR	M36

Milestones

Mil. No.	*Milestone Title*	*Means of Verification*	*Related Deliv.*	*Due date*
M1.1	First Version of PV Cell Devices.	Devices available	D1.2	M18
M1.2	First Device Evaluation. Device Model Refinements. Guidelines for Refinements on Final Version of Devices.	Report released	D1.3	M24
M1.3	Refined Version of PV Cell Devices.	Devices available	D1.4	M30
M1.4	Final Device Evaluation. Comparison of the advanced Si and DSSC technologies.	Report released	D1.5	M36

Work Package number	WP2	Start date or starting event:						M1
Work Package title	Optimization method for energy extraction							
Participant number	**1**	3	4	6	11	21	23	34
Participant short name	**ST**	COMPEL	IUNET	UNIBO	ONSEMI -B	LEITAT	POWER TEC	ENEC SYS
Person-months per participant	**140**	116	14	56	122	10	98	117

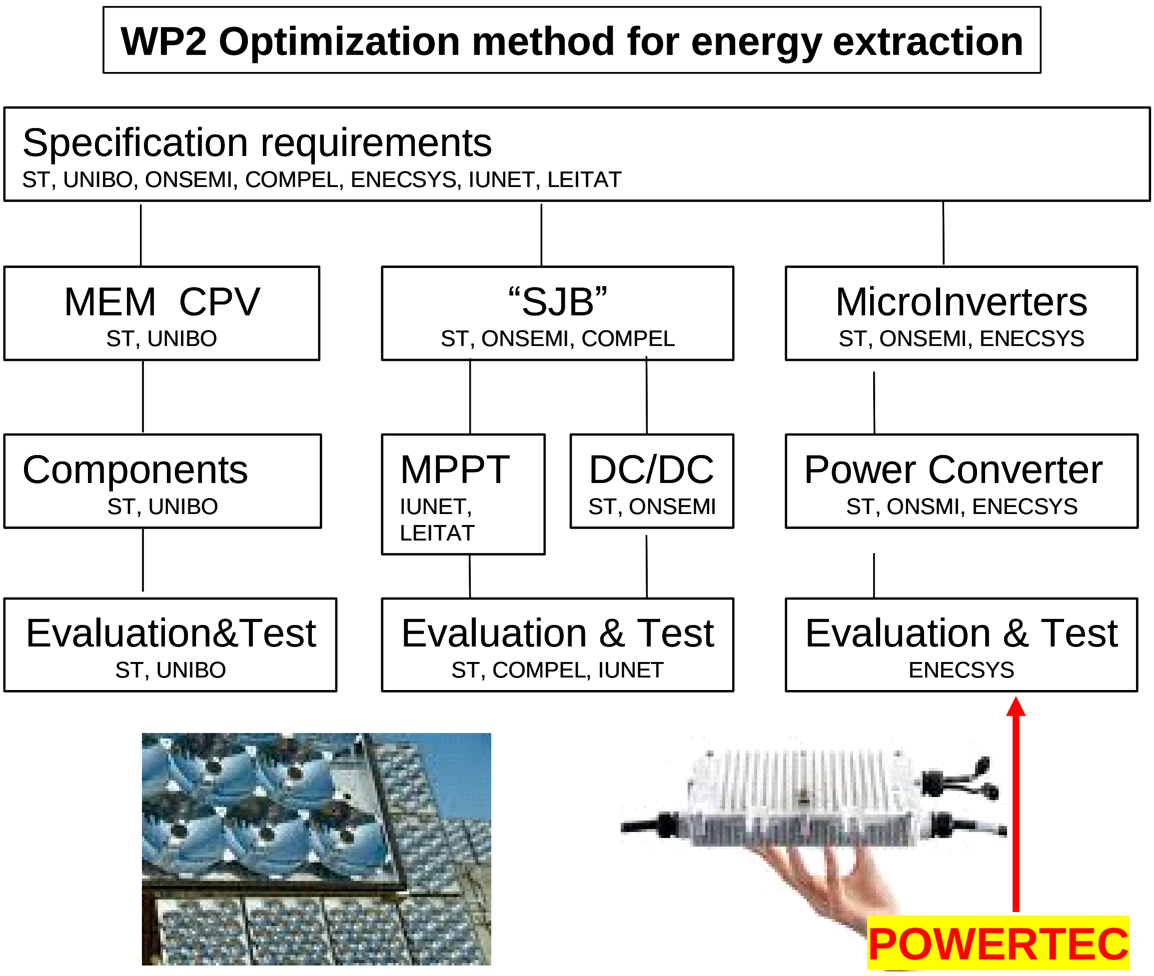
Objectives

The objective of this work package is the optimization of the energy generated by photovoltaic systems: standard silicon, DSSC and concentrated (CPV).

The activity will be focused on power management electronics for silicon cell panels and on micro electromechanical systems for CPV.

The power management electronics will be developed to introduce an innovative solution based on distributed approach by mean of “Smart Junction Box”, able to boost the energy generated by photovoltaic systems up to 30%, compared to standard plants.

As an alternative and suitable solution, microinverter technology will be investigated and developed in order to fully evaluate the performance and benefits of such solutions.



Description of work

The work which will be done in this work package is focused on energy extraction optimization at panel level. The main activities are related with power electronics and micro electromechanical systems for maximized power management.

The activity is divided into 3 main Tasks:

- Task 2.1 is dedicated to micro electromechanical systems with dedicated electronics for CPV.
- Task 2.2 is dedicated to efficient power conversion at panel level by means of DC/DC converters able to generate a suitable voltage for grid-connected systems.
- Task 2.3 is dedicated to microinverter solutions which still represents an innovative approach for distributed architecture allowing maximum power extraction from single photovoltaic panel thanks to dedicated MPPT function and high efficiency conversion for low power grid-connected systems in the range up to 400W.

Task 2.1: Microsystems for concentrated photovoltaic systems

Leader: UNIBO – Other participant(s): ST

Start date: M1 – End date: M36

Concentrated photovoltaic energy production requires the concentration of solar energy in a precise location at low cost. This Task will cover the issue of designing an optical subsystem based on extensive use of distributed electronic microsystems for sun tracking and power concentration. The work will be organized in three phases:

A design tool kit will be assembled to support different design choices related to the optical parts (e.g. mirrors, lenses) and related electronic drivers/controllers. The software tools will be based on parallel algorithms running on GPUs to perform accurate simulation in acceptable time.

A sample design of a microcontrol system supporting distributed sensing and control will be designed and its cost determined. Given the fact that a replication of these control engines is assumed, low cost is a key feature to be achieved through a careful design of simple interfaces.

A demonstrator consisting of a simple optical system controlled by the previous microsystem will demonstrate the capability of the approach to reduce the cost of the concentration optics in a photovoltaic system.

Task 2.2: Power electronics and related control algorithm for panel based DC/DC converters

Leader: ONSEMI-B – Other participant(s): ST, COMPEL, IUNET, LEITAT

Start date: M1 – End date: M31

The Task is dedicated to investigation, design and development of innovative systems for distributed photovoltaic systems. The core of the new architecture is a dedicated DC/DC converter IC with embedded MPPT control, developed by **ST** able to efficiently control a power converter based of high performance semiconductor switches developed by **ONSEMI-B**. The embedded MPPT algorithm will be developed and tested by **ST**, **IUNET** and **LEITAT**. The power electronics systems will be housed in a dedicated module developed by **ST** and **COMPEL**, in order to match the PV panel with conditioned output to the input of standard string or central inverter. The final product will be a “Smart Junction Box” with energy booster for distributed DC/DC systems. Inside the module also communication chips will be located by **ST** as an innovative cost effective approach. The output of this Task in terms of communication on the grid will be an input for WP4.

Task 2.3: Power electronics and related control algorithm for low power grid tied converters
Leader: IUNET – Other participant(s): ONSEMI-B, ST, ENECSYS, LEITAT, POWERTEC
Start date: M1 – End date: M36

This Task is focused on a distributed approach as described in Task 2.2 but based on “microinverter” approach, i.e. on panel converter with grid connection capability. This approach represents an alternative to the DC/DC module and is currently on fashion in USA. Inside this Task **ST**, **ONSEMI**, **ENECSYS** and **POWERTEC** will investigate innovative cost effective solution based on latest generation power switches together with high efficiency control algorithm and monitoring functions.

The final systems will be developed and tested under standard condition of input power and grid connection in order to fully validate the proposed solution in terms of efficiency, cost and life time.

Participants’ role

IUNET - Modena-Reggio Emilia will develop high efficiency front-end electronic circuits for distributed maximum power point tracking (MPPT) and conversion circuits, integrated directly with the photovoltaic module, and energy harvesting solution for low power applications (like Wireless Sensor Nodes).

Energy harvesting circuits are generally comprised of an energy management and a storage circuits. According to the available power budget, different analog circuit architectures with different MPPT options will be investigated to convert efficiently the energy harvested from the photovoltaic module in electrical energy usable.

Custom DC-DC power converters will be designed, considering also alternative technology if available (SiC, GaN) for higher efficient solutions.

At the same time novel circuit architecture for the energy storage circuits will be investigated, suitable to be fully integrated with the conversion circuits.

Another possible contribution is the design of energy multiple source harvesting systems. In this case, the focus will be on the investigation of high efficiency power combining techniques.

LEITAT will collaborate to this work package by designing and developing a control system for DSSC modules. This control system will incorporate energy generation monitoring, failure detection, maximum power point tracker (MPPT) and wireless communications based on Zigbee protocol. Cost, energy consumption and reliability will be the main requirements for designing this control system which will be demonstrated by its integration in a DSSC solar panel.

COMPEL will develop a “Smart Junction Box” for PV panels, able to increase the efficiency of the distribution of power outgoing from the Photovoltaic Panels (PVs). COMPEL will be involved in the design of an innovative Junction Box for advanced photovoltaic modules, increasing the efficiency of its internal connections due to the reduced contact resistance and consequently the reduced power loss.

The new Junction Box will host the electronics for MPPT tracking, improving the power efficiency of each PV panel or its subassemblies using smart functions of power management. The power dissipation of the electronic components will be optimized in compliance with the safety requirements of the photovoltaic environment with the aim to improve the power distribution.

The design of the new Junction Box will also pay great attention to achieve reduced dimensions as well as optimized solutions in order to contribute to save costs of the system. This will be obtained through innovative design concepts and state-of-the-art materials, which also will allow the new Junction Box to be processed in highly automated assembling operations on the panels manufacturing lines.

ST will develop a dedicated IC for PV application suitable to control high efficiency power converter for distributed architecture. The IC will feature advanced performance in terms of efficiency and cost, in order to further reduce the cost/kW of PV systems improving the annual energy generation. Based on such a converter, the complete module to be housed inside the dedicated box developed by COMPEL will be developed. ST will explore different DC/DC converter architectures, as they fit better with different application requirements (in terms of efficiency and reliability). ST will collaborate on realization of a versatile DC/DC converter to find the best solution in terms of cost-benefits analysis for its industrialization. Inside such a scenario, ST will propose a converter architecture using a monolithic controller that provides all necessary control signals, protection features and driving functions to successfully manage operations for different DC/DC converter topologies. Furthermore, focusing on optimization of the power conversion, ST will design the controller IC, exploring on different MPPT algorithms (to be embedded in the controller) and on different driving techniques. ST will further provide its in-house BCD technology for the IC realization.

ONSEMI-B will develop an advanced new generation power switch. The idea is, based on the core trench of a XtreMOS™, to split the gate in an upper part and a lower shield gate. For a successful development of this split-gate XtreMOS™-module, very specific process steps need to be developed:

- Inter-polyoxide, in the trench, with a high degree of uniformity in both horizontal and vertical axis
- Minimize and further reduce process variability
- Shape of the trench will be more critical than for the non-split-gate module
- Hard mask definition for trench module needs new etch processes in order to tune uniformity of the module

Besides two test-chips for module development and initial characterization, 5 different modules will be designed and processed, each module with different dimensions, in order to obtain specific electrical targets.

After processing the wafers need to be back grinded down to 100µm. Due to the presence of trench modules, this process is not straight forward: specific development is required to deal with wafer bowing. Both sides of the wafer will receive metallization and patterning. Specific front STM (solder top metal) will be required. In combination with thinned wafers, specific precautions for processing need to be developed. SO8FL packaging is preferred. Based on previous experience, a dedicated crack-free passivation layer in combination with PI processing will be developed. Finally TCAD simulation for different applications will be performed.

ENECSYS will investigate and develop novel circuit topologies for a range of solar PV technologies including CPV. Drivers for the design will be overall weighted efficiency (Euro), cost and lifetime. As part of the design process Enecsys will evaluate the latest development in power semiconductor devices including new Si and GaN devices and where feasible incorporate into the designs. Enecsys will also focus its efforts on the use of ASICs to try to simplify and reduce cost of the micro-inverters. Enecsys will attempt to work with partners in creation of such ASICs. The project will also entail exploring new algorithms for MPPT. In addition Enecsys will evaluate the latest advances in monitoring and where possible use the most appropriate methods for the newly developed micro-inverter.

POWERTEC will participate on design and testing of modern diagnostic and control systems of PV cells able directly analyze every cell with designed ultra-low power cell control unit, integrable within PV cell or realized as a stand-alone system. The system will contribute in optimization of variable power output at full irradiance and should be able selectively control the output of each single cell. System communication over power line will be investigated with the aim of increasing efficiency and reliability. We will contribute to improvement of the architecture suitable for managing of stable power output using energy storage circuits developed and improved together with other project partners.

UNIBO will develop parallel simulation algorithms for solar power concentrators. These algorithms will be used to optimize the performance and cost of a concentration system. UNIBO will also design and demonstrate a prototype of a concentrator system based on simple optical modules that can be replicated to obtain the desired performance.

Deliverables

Del. No.	***Deliverable Title***	***Contributors***	***Due date***
D2.1	Technical report on specification of power conversion systems	**Leader**, contrib. 2, contrib. 3, UNIBO, ...	M06
D2.2	Design report	**Leader**, contrib. 2, contrib. 3, UNIBO, ...	M18
D2.3	Report on process module characterization	**Leader**, contrib. 2, contrib. 3, UNIBO, ...	M24
D2.4	First prototype validation report	**Leader**, contrib. 2, contrib. 3, UNIBO, ...	M30
D2.5	Test reports for realized demonstrators	**Leader**, contrib. 2, contrib. 3, UNIBO, ...	M36

Milestones

Mil. No.	***Milestone Title***	***Means of Verification***	***Related Deliv.***	***Due date***
M2.1	Specifications of power conversion systems	Specifications available, report released		M6
M2.2	Systems design ready	Specifications available, report released		M18
M2.3	Prototype of demonstration systems	Prototype available		M30

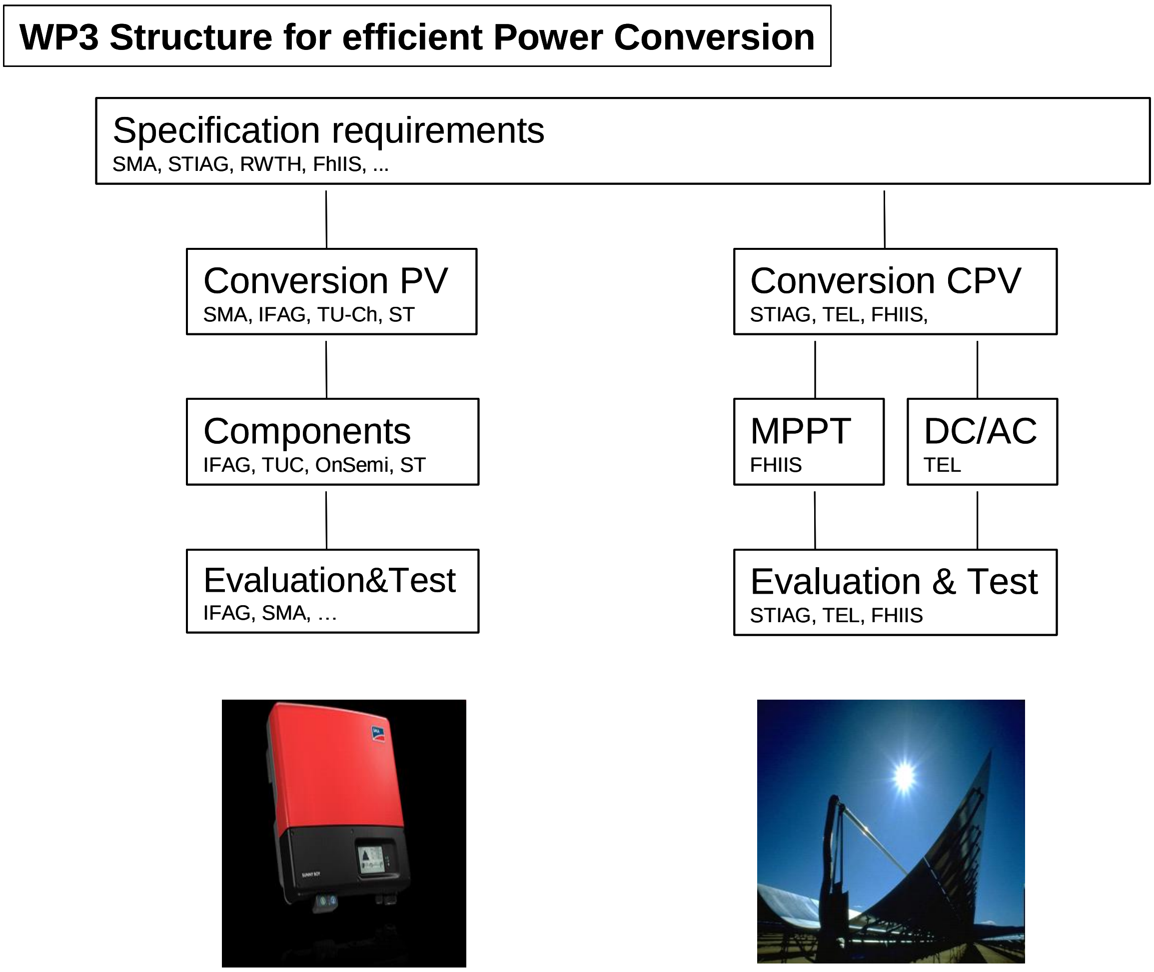
Work Package number	WP3	Start date or starting event:			M1	
Work Package title	Efficient power conversion					
Participant number	7	8	14	**15**	16	17
Participant short name	UNICAL	UNICT	STIAG	**TEL**	FRAUNHOFER	RWTH
Person-months per participant	11	17	130	**191**	44	47
Participant number	18	19	20	25	26	27
Participant short name	IFAG	SMA	TUC	SPR	Tyndall	NXP
Person-months per participant	223	106	34	1	20	69

Objectives

The focus of WP3 is on increasing the efficiency of conversion for the generated power of solar cells.

As general objective the reduction of energy losses by 20% in the complete supply chain is targeted. The results will be demonstrated in form of high efficient applications.

The overview about the conversion tasks is given in the following picture.



The workload for efficient power conversion will start with a **specification phase**, in which partner SMA – as worldwide leader of inverter production – will bring into the consortium PV-specific specifications for future markets needs. New ideas from academic and industrial partners for novel architectures will be evaluated and realistic options will be fixed for implementation in subsequent developments. One focus will be on the potential of high voltage levels for increasing efficiency.

The **architecture study** in the first phase will evaluate different profiles of end-users, including

- direct grid connection
- energy storage option
- E-mobility support

An additional cooperative study ("**Optional Implementations**") will cover supplemental functions as:

- Fire protection, safety of fire fighters
- Failure diagnosis and communication
- Efficiency logging
- Burglary prevention

These functions will be classified for their economic feasibility and implemented in demonstrators as far as reasonable.

The special case of Concentrated Photovoltaic Systems (CPV) with own specific needs will be covered by the system partner **STIAG** with its background in CPV solar generators.

Both PV- and CPV chains will be strongly supported by academic and research partners **RWTH** (PV, CPV), **FRAUNHOFER** (CPV, MPPT) and **TUC** (SiC MPS diode) and **Tyndall** (CPV monitoring).

Starting from given specifications University **UNICT** will develop a high frequency model of the converter in order to test by simulation different solutions based on active or passive filters, able to reduce the total level of EMI/EMC according to the limits imposed by international standard. The reduction of conducted emissions of power converters of the proposed topology will be analyzed in order to get the best solution on EMI problems. The experimental activity will be carried out using the anechoic chamber and EMC test equipment of CePTIT-DIEES EMC lab.

The energy storage option will be covered by partner **UNICAL**. In particular, in this work package the Microelectronic & Microsystems Laboratory of the University of Calabria will investigate suitable electronic system architectures for smart battery charging both for automotive and energy storage systems in close cooperation with the other WP3's partners. These architectures will be developed so to allow the efficient implementation of the enhanced efficiency algorithms developed in WP4. The evaluation of the effectiveness of the selected architecture will be carried out by means of an experimental set-up with the aim of demonstrating also the operation principles of the smart charger sub-system.

Tyndall will contribute a system architecture and hardware solution for sensing the performance of the CPV cells and reporting fault operations.

The semiconductor partners **IFAG** and **TEL** will evaluate given specifications from system partners **SMA** and **SolarTech** and discuss the technical and economical feasibility of novel architectures directly with production orientated partners. The jointly elaborated specifications will lead in direct line to demonstrator specific prototype designs on component (IGBTs / SiC diodes) and module level. Semiconductor runs will produce silicon hardware for further use in hardware demonstrators. Foreseen are at least 2 design phases for first studies and final designs.

Semiconductor partner **NXP** will bring into the consortium the design of innovative semiconductor solutions for panel-based power management topologies for solar systems, making optimum use of the specialized power IC technologies available in the company. NXP will cooperate in the specification task, with focus on module-level DC/DC converter concepts with optimum granularity and efficiency for PV systems. Optionally, a comparison will be made between module-level DC/DC converters and module-level DC/AC converters, or combinations thereof, also focussing only on PV systems. A proof of overall efficiency will be done with realized test ICs.

Cooperation

The cooperation with WP2 will be essential for the use of optimal strategy and methods. First results of WP1 and WP2 will be taken into account in the specification phase of WP3 and advanced methods can be implemented in the second design phase. The results of WP3 will be used in parallel by WP4 for the preparation of advanced energy distribution concepts and energy storage option.

“Specification of conversion system and technology platforms” carried out in WP3 (deliverable D11, M6) will be used in WP4 for the development of battery charging algorithms. In turn, the system architecture regarding the energy storage option will be developed in WP3 so to allow the efficient implementation of the enhanced efficiency algorithms developed in WP4 (D4.3, M24).

Final evaluation of gained efficiency will complete this WP. The efficiency will be demonstrated using prototype systems for PV and CPV converters.

Description of work

Task 3.1: Specification of Conversion Systems with focus on power efficiency

Leader: SMA – Other participant(s): STIAG, TEL, FRAUNHOFER, RWTH, IFAG, TUC, NXP, UNICT, Tyndall, UNICAL

Start date: M1 – End date: M15

An architecture study will start at M1 and give first input to system specifications tasks.

Specifications will be jointly elaborated for:

- PV, CPV converters (SMA, STIAG, RWTH, NXP) (PV converters only, module level)
- Maximum Power Point Trackers, Communication (FRAUNHOFER)
- SiC, IGBT technologies (IFAG)
- Charging management system for smart energy storage option (UNICAL)
- Performance Sensing (Tyndall)
- EMI filter integration and optimization (UNICT)

The continuation of this study will bring in its final results in the phase of system development (Task 3.3). This study of architectures will be done in 2 steps.

The first step will work out user profiles for different classes of end users with:

- Direct network connectivity
- Energy storage option
- E-Mobility support

The second step will be a amendment for additional functions like:

- Fire protection
- Error detection and communication

- Burglary and vandalism prevention

The functions will be investigated and evaluated concerning commercial feasibility and implemented as far as possible. Converter architectures will consider failure diagnosis and communications (**Tyndall**) and optional smart battery charging methods both for automotive and energy storage applications (**UNICAL)**.

As resulting objectives the application specific specifications will be elaborated for each planned technology and conversion system with focus on the planned demonstrators. In each phase, the energy efficiency gained will be taken as measure of success.

At related Milestone M3.1 the specifications will be ready for implementation in Task 3.2 and 3.3.

RWTH Aachen will elaborate different step-up converter architectures to find the optimal one for module integrated ASIC based converters. This is necessary to exploit the advantages of integration like better timing control, more complex control logics and integrated well matched drivers.

TEL will participate in the specification of conversion systems. The specifications will be checked for feasibility and a definition of needed technologies will be done.

FRAUNHOFER will contribute to the specification of the CPV conversion unit. The PPT part will specifically address the requirements of concentrated PV module equipment. Further on properties of the necessary communication for monitoring and control arising from additional functionality will be defined.

STIAG will contribute to the specification of conversion systems with focus on CPV applications. In cooperation with academic partners the optimum solution for highest efficiency will be elaborated.

NXP will participate in defining the optimum distributed power topology (i.e. power converters on PV module level) for grid-connected solar PV systems. In addition to specifying desired input and output voltages and current, an optimum selection of IC technology will be made based on these specifications. Drivers in the selection process are cost and efficiency, where an increase in efficiency will yield additional energy and associated financial income from the system, which should not be cancelled by the cost of additional electronics. Another important boundary condition is reliability, where the electronic solution should have a lifetime at least equalling that of the solar panels to which it is attached.

In addition to the power topology, also solutions to ensure safe operation of the solar system, e.g. in case of fire, and solutions to obtain as much operational data from the system as possible will be studied and specified.

IFAG will participate in the evaluation of device properties requirements (e.g. surge current capability, electric strength, …) from application specific conditions (switching frequency, DC-link voltage, stray inductance, currents ...) and in the identification of application specific module requirements (switching frequency, DC-link voltage, stray inductance, currents, mission profile, ...) based on simulation (FEM system simulation). In addition IFAG will convert the evaluated requirements into device/module specification and the electrical load profiles and environmental conditions into reliability requirements for the Power Modules.

SMA will define the converter class as platform for further investigation. Converter class is characterized by output power and number of phases. For this converter class SMA will investigate different converter topologies to find a maximum efficiency, optimal DC link voltage and switching frequency by using semiconductor modules from partner IFAG. The design of the components like filters will be elaborated. Power and temperature profiles will be defined.

TUC will participate in the specification of the Si and SiC power devices regarding current loads, necessary device area, losses resulting temperature swings, expected power cycling- and temperature cycling lifetime.

UNICAL will contribute to the definition of possible battery charging management system architectures supporting smart charging features. To this aim, the impact of different charging patterns for commercial battery cells on storage efficiency will be studied. This activity will be carried out developing a test methodology for evaluating the dynamic performance of a cell in the presence of time-varying charging current profiles, as actually it occurs due to typical power availability in a PV cell-based distribution grid. The results of this phase will lead also to the definition of the specifications of the conversion system sub-modules dedicated to the smart energy storage option.

Tyndallwill work with the other partners to understand the trades off in the numbers of sensors required Vs the granularity required to identify a failure or performance deficiency in a given cluster of CPV cells. The sensing platform devised will be based on the Tyndall Wireless Sensor Network (WSN) mote platform that has been used for multiple applications such as energy, environmental and healthcare monitoring.

The type of parameters that require investigation will include source current, open circuit voltage, temperature of the CPV cells and report fault operations. The motes will need to be configured to sense multiple CPVs. Types of sensors, criteria for fault reporting, sensing intervals etc will be determined. Architecture options for power sources for the wireless sensors will also be reviewed (e.g. using DSSC technology from SPR to create an independent supply Vs interconnect with main CPV array). Performance will be evaluated on packaged CPV receivers developed using AlInGaIN/Si and conventional (e.g. III-V multi-junction or crystalline Si) CPV cells.

UNICT will participate giving the specifications of the EMI filter. Considering the filter impact on the efficiency, additional specification will be specified on EMI filter efficiency target.

Task 3.2: Basic Design Experiments of technological and technical innovations

Leader: NXP – Other participant(s): SMA, STIAG, TEL, FRAUNHOFER, RWTH, IFAG, TUC, UNICT

Start date: M7 – End date: M24

The needed technologies will be explored and the feasibility of the specification from Task 1 will be verified.

Architecture options will be selected from the study (Task 1) for final implementation in the demonstrator designs. As results the technological approaches are ready for system development and demonstrator designs.

Objectives will be experimental results for improved effectiveness:

- DC/DC conversion systems (NXP, RWTH, FRAUNHOFER)
- DC/AC converter elements (FRAUNHOFER, TEL, NXP, RWTH)
- Fast switching IGBTs in low inductivity module; 1200V SiC Schottky-diode(IFAG, TUC)
- Innovative interconnect technologies for a short time heat storage in the case of

overload (IFAG)

- Investigations on low-inductance inverter design (SMA)
- Models for converters including high frequency behaviour (UNICT)
- Smart battery management module (UNICAL)

TEL will select the appropriate technology according to the requirements of Task 1. The intended technologies are Smart Power SOI or bulk technologies with high voltage option for breakdown voltages up to 700V. In the selected technology first converters for DC/AC or DC/DC/AC (with storage option) concepts will be designed in cooperation with partners FRAUNHOFER and RWTH. TEL will provide a mask set and will process first silicon samples in its production line.

Based on the architecture study the most promising step-up converter architecture will be implemented by **RWTH** in a test chip. For a maximum integration level the boost converter test chip will also include a simple MPPT block to enable a direct connection to solar cells without any additional circuitry. In addition the integration of inverters into a single chip will be reviewed. For all chips designed during this project the Telefunken SmartPower SOI technology will be used to decrease the standby losses.

FRAUNHOFER will design the PPT circuitry part for the CPV converters. The smart power technology from TEL will be used with as less additional components as possible. Power line communication as well as wireless communication modules will be investigated together with STIAG and will be optimized.

STIAG will evaluate first converters (DC/AC or DC/DC/AC with storage option) for increased efficiency for intended CPV applications. Investigations of optimum modularity and best connectivity will be done for the application with CPV modules.

NXP will focus first on breadboarding selected options in Task 3.1, where use is made primarily of existing components. Building a system like this will reveal whether the chosen approach will work in practice and will shed first light on the fulfilment of the important boundary conditions of high efficiency and low cost, at high reliability. The specifications of the power topology will be linked to a suitable IC process, where 100V SOI-based automotive-qualified NXP processes seem to be a logical candidate for panel-based conversion systems for PV. Higher voltages up to 700 or 800 V on SOI technology are also possible, which may become relevant when designing micro inverters (DC/AC converter on PV-module level). Focus will be on module-level DC/DC converters.

IFAG will research on optimization possibilities of doping profiles and of Schottky cell structure regarding Vf at nominal current and surge current as well as on optimization possibilities of epitaxy regarding Vf at nominal current and surge current.

Concerning system level simulation models for Power Module IFAG will research on the extraction of partial module inductances/coupling and integration into network simulator for all power modules, the development of device model under consideration of oscillation behaviour and on the coupling of device model with inductance models. Complementary IGAG will evaluate coupled models as unified module and together with inverter simulation (system level). The verification of models in comparison to measurements will round the IFAG task.

SMA will investigate the influence of stray inductances in the inverter design and elaborate arrangements to reduce stray inductances in the inverter design in close cooperation with partner IFAG. Semiconductor modules from partner IFAG will be tested under the conditions of a PV converter.

TUC will install numerical device simulation for SiC Merged-pin-Schottky diodes, will evaluate existing models, will select models and improve models, and solve convergence problems in electro-thermal numerical simulation of SiC structures. First simulation of surge current events will be executed. A metallization and bond wire arrangement with increased thermal capacity is to be found in close cooperation with partner Infineon. Measurement equipment for double pulse test to characterize the switching behaviour and ruggedness of SiC diodes and Si IGBTs will be installed. Thermal simulations of low-inductance module configurations will be done, including operation- and overload conditions. Coupled thermal-mechanical simulations of temperature cycles and power load cycles will be executed. An optimized layout is to be found in cooperation with partners IFAG and SMA.

After a combined analysis of expected performances and technical feasibility jointly with other WP3's partners, **UNICAL** will select the candidate preliminary architecture of the battery management system for further system development and demonstrator design.

UNICT - DIEES activities will regard the study and design, in collaboration with the other groups of suitable topologies for the addressed application in consideration of the EMI performance requested by the standards. In particular, the high frequency behaviour of the proposed topology will be analyzed in order to get the best solution on EMI problems. A high frequency model of the converter will be developed in order to test in simulation different solutions based on active or passive filters able to reduce the total level according to the limits imposed by international standard.

Task 3.3: Development of Energy Efficient Power Conversion Systems and Demonstrators

Leader: IFAG – Other participant(s): SMA, STIAG, TEL, FRAUNHOFER, RWTH, TUC, NXP

Start date: M12 – End date: M30

In this Task the designs of new power conversion systems will be done on the base of given specifications and feasibility explorations of previous Tasks. Finally selected architecture elements will be implemented in demonstrator designs. A redesign phase is foreseen for corrections and final adjustment.

As objectives will be elaborated here final building blocks, ready for implementation into power demonstrator systems:

- DC/DC and DC/AC converter controller IC, for different MPPT algorithms (NXP, FRAUNHOFER) and inverters for module integration and CPV collectors (TEL, FRAUNHOFER, RWTH)
- PV inverters using improved low-inductance -modules and -inverter design (SMA)
- Power module with integrated IGBTs and SiC components with new interconnect technology for extreme low inductivity, fast switching behaviour and heat storage features (IFAG, TUC)
- Battery manager concept module for smart storage option (UNICAL)

A test chip ready for implementation into power demonstrator system of the fully integrated inverter will be designed by **RWTH** on basis of the knowledge gained in Task 2. Using the Telefunken SmartPower SOI technology the high output power will enable module integration and increase the MTBF. In addition the reduced component count will also further boost the reliability of the inverter and decrease its cost.

TEL will combine proven function blocks from Task 3.2 and enhance them with optional functions. The design experience from Task 3.2 will be used to design complete converters. The resulting layouts will lead to a final mask set with additional blocks from the design partners RWTH and FRAUNHOFER. The designs will be processed as a Multi Project Wafer run (MPW) in the production line of TEL. As results are expected chips with full functionality for the common demonstration.

FRAUNHOFER will design the PPT system as well as the communication interface parts for the final demonstrator from STIAG. The components will be implemented in the smart power technology together with the components from partners TEL and RWTH. Additional parts will be realized with standard hardware components as far as necessary.

STIAG will provide additional functions according to the specifications of Task 3.1, as for example power measurement function of modules, data storage and evaluation. First experiences from initial designs will be implemented.

NXP will translate the lessons learned from Task 3.2 into a power control IC, possibly with additional functionality in the area of safety and communication. The IC will be designed by NXP and will be processed and packaged in internal factories. A full converter will be built with the realized power-control IC and several of these converters will be attached to solar panels in a state-of-the-art solar-system PV test set-up.

IFAG will in Task 3.3 research on 3 sub-topics:

- Low inductance module based on flexible configurable Easy Module Package with SiC Diodes
- Development of low inductance module concept
- Characterization of power module properties.

For the topic “Low inductance module” IFAG will research on inductance simulation with PEEC Method for extraction of parasitic elements of power module package, on layout optimization of DCB substrates, on optimization of distributed power connector elements, on optimizations of connection DC-link capacitor/power terminals of module as well as IFAG will investigate oscillation at switching, new package design and in innovative assembly of modules.

For the topic “Development of low inductance module concepts” IFAG will research on innovative package concepts for low inductance Power Module with SiC Diodes, layout optimizations of DCB substrates, the optimization of integrated power terminals and DC-link capacitors and will make investigation of oscillation at switching and in assembly of modules

For the topic “Characterization of Power module properties” IFAG will measure the static power module characteristics (on state characteristics, blocking capability, isolation, ...), the dynamic power module characteristics (switching losses / switching behaviour, short circuit behaviour at RT and Tjmax, …) as well as the thermal behaviour (static Rth, transient Zth) and the mechanical characteristics (bow at operation, bending, housing, ...).

SMA will adapt the design of the converter by using the improved power modules from partner IFAG and optimized converter design and optimized components like filters. A first demonstrator will be manufactured. First tests will be started in the laboratory to investigate losses and efficiency.

TUC will measure the switching behaviour and turn-off ruggedness of optimized SiC diodes and IGBTs according the specific conditions, in consultation with partner SMA. Surge current behaviour of optimized SiC MPS will be investigated. Effects of paralleling of SiC diodes and of parasitic inductances will be analyzed. The electromagnetic emissions of PV inverter demonstrator systems using improved low inductance modules will be measured.

After the selection of the more suitable architecture for the effective battery charging made in the previous phases, **UNICAL** will design a concept module to manage the smart battery charging in accord with possible innovative charging strategies developed in parallel in WP4.

Task 3.4: Demonstration of Efficient Applications and Evaluation

Leader: SMA – Other participant(s): STIAG, TEL, FRAUNHOFER, RWTH, IFAG, TUC, NXP, UNICT, UNICAL, Tyndall, SPR

Start date: M24 – End date: M36

For the prove of new concepts following demonstrators will be built:

- PV converter (SMA)
- CPV converter system (STIAG)
- Power Module (IFAG)
- Charger system for smart battery charging algorithms (UNICAL)
- Smart battery management unit (UNICAL)
- PV-module-level DC/DC converter with NXP control IC (NXP)

EMC behaviour and efficiency will be tested by IFAG (on module level) and UNCT using the CePTIT-DIEES EMC lab.

A comparison to previous state of the art, with focus on gained overall efficiency will finalize this task.

TEL will provide silicon chips for the demonstration at the system partners and support them with needed semiconductor know how. TEL will take over the results of the system evaluation of partners for future use in own product developments.

RWTH will perform measurements on the demonstrator IC and evaluate the performance of the new sub-module concept. Special attention will be paid to the systems efficiency in situations like partial shading and single cell failure.

FRAUNHOFER will support the setup of the demonstrator from STIAG. Therefore appropriate modules for the communication and monitoring equipment will be provided.

STIAG will demonstrate the application of new converters for a CPV system. The performance will be evaluated and compared to previous results. STIAG will give feedback to partners for the design of future converter solutions.

NXP will demonstrate the merits of the realized converters, based on custom-designed NXP ICs, in the test system. Focus will be on the efficiency of the PV system, where a system without additional converters will be compared to a system with the additional converters attached on panel level under the same conditions. The operation of additional functionality may also be demonstrated, dependent on what has been specified in Task 3.1.

IFAG will demonstrate the improvement of the research activities by evaluation of power modules regarding expected efficiency and system behaviour (mechanical characteristics, extraction and conversion loss data into dynamic temperature dependence simulation model, thermal-electric simulation under application conditions, extraction and evaluation of lifetime limits with system simulations).

In addition, IFAG demonstrate the improvement of the research activities based on validations of SiC Diodes concerning reliability and Power Modules concerning reliability and lifetime (high temperature reverse bias, high temperature gate stress test, high humidity, Power Cycling, Thermal Cycling, Thermal Shock).

SMA will optimize the demonstrator to improve the efficiency and EMC behaviour. Further measurements of losses, efficiency and EMC are an essential part of the work in this Task. Tests and calculations concerning reliability, life time and costs will be accomplished. In this way SMA will demonstrate the improvements of the research activities.

TUC will evaluate turn-off ruggedness and surge current capability of SiC Schottky diodes. The PV converter demonstrator developed by SMA will be investigated regarding its electromagnetic emissions.

UNICAL will carry out a hardware/software experimental set-up for the evaluation of the correctness of the principle of operation of the battery management system and its effectiveness in implementing energy-efficient battery charging strategies.

Tyndallshall provide and evaluate parts for integration into CPV cell areas for performance monitoring and failure detection as prepared in Task 3.1.

Participants' role

SMA will investigate, in close cooperation with IFAG and TUC, how to increase the performance and efficiency of PV inverters by using improved low-inductance modules and a low-inductance inverter design. Task of SMA will be the investigations on low-inductance inverter design as well as testing the different approaches and modules of the partners in the application context of PV inverter topologies and for the special requirements of PV inverters. A special focus will be on reliability and lifetime as well as on the validation of the expected advances from the point of view of an inverter manufacturer (especially efficiency, EMC characteristics and reduction of costs). Furthermore SMA will realize an experimental PV inverter to test and demonstrate the advances achieved.

STIAG will provide specific requirements of power conversion electronics for CPV applications. The specifications will be developed and negotiated with semiconductor partner Telefunken, in order to ensure the integration feasibility. The targeted MPPT tracking functionality will be focused on the special needs of CPV conversion systems, and can be re-used in other PV systems with high demands on shadow management. SolarTec will accompany the development of circuits for CPV power conversion and MPPT application, and will check intermediate results at regular milestones. First and second prototypes will be tested in real systems and results will be compared to the previous state of the art.

SolarTec has established exclusive development cooperation with the Ioffe-Institute in St. Petersburg (developer of concentrator technology) and participants in the Apollo program (EU

Seventh Frame Work Program).

TUC will contribute, in cooperation with IFAG and SMA, to improved devices and an improved low-inductance module. To improve the SiC MPS diode at surge- and overload conditions, a new top-side contact structure with increased heat capacity will be calculated using numerical thermal-electrical coupled device simulations. A metallization with increased thermal capacity (e.g. Cu) as well as an optimized arrangement of bond wires will be investigated. Measurements of the switching characteristics and of the overload behaviour will be performed.

In the module development, TUC will perform thermal simulations to ensure a homogeneous thermal load at indented application conditions and to achieve a high temperature cycling and power cycling capability. The arrangement with the best trade-off between homogeneous temperature and lowest electrical inductance is to be found.

RWTH. The Chair of Integrated Analog Circuits and RF Systems of RWTH Aachen University will contribute to WP3 efficient power conversion. By dividing the solar module into several sub-modules each having a separate converter the performance of the module no longer depends on the worst cell in the series connection but only on the worst cell in each sub-module. Shadowing, worst solar cell contacts or module breakdowns due to single cell failure are no longer a problem with this new sub-module concept. The combination of the sub-module concept with an energy storage circuits seems promising, because it enables highly flexible and scalable power supply for mobile applications. This research covers the whole power scale from ultra low energy devices to PV plants.

For increasing the output energy of the solar cells different MPPT circuit concepts will be investigated. Furthermore the Chair of Integrated Analog Circuits will conduct a survey on different architectures for inverters to find the optimal concept for integrated inverters exploiting all the advantages of integration. For a proof of concept this architecture and the MPPT circuit will be implemented together with integrated converters (DC/DC or DC/AC) using the Telefunken Smart Power SOI technology in cooperation with partners Telefunken, FRAUNHOFER.

FRAUNHOFER IIS will develop the analogue and digital circuit building blocks for the maximum power point tracker. The main functional block is a power converter with a digital regulation loop to achieve the maximum output power of the input source, namely the solar module. The loop senses the output power and controls the power converter to arrive at the maximum power point. In this way, the power degradation caused by illumination variances, shadowing, aging or destruction of the solar modules will be decreased. Different control algorithms will be investigated to achieve the maximum efficiency and best suppression of mismatches between solar modules. Energy efficiency, precision and transient time will be the design goals of the focussed MPPTs.

A combination with the power inverter afterwards and a reuse of certain building blocks will be investigated.

Furthermore, a communication link from the maximum power point tracker to other system components will be investigated and developed. This link should report power information from individual solar modules which are available at the maximum power point tracker. This information shall include the individual output voltages and currents of the modules or the output power and control signals of the power converters.

The implementation of the buildings blocks for this intelligent power point tracker has to enable a cost-effective commercial application, and the combination of power electronics, signal processing circuitry and communication interface within one SoC or SiP will lead to a small components count.

TEL will explore and provide an IC demonstrator design with focus on effective DC/AC energy supply systems and high voltage capability. As part of a supply chain of German partners we will work on the specification and integration of a novel CPV-MPPT tracking and power inverter design.

The architecture of the MPPT tracking and power conversion system will be optimized in cooperation with academic partner RWTH and FRAUNHOFER. The optimum split between hardware and software control of MPPT functions will be explored in cooperation with FRAUNHOFER.

The resulting efficiency will be evaluated in a measurement campaign and the results will be evaluated and compared to the state of the art. A benefit of 20% reduction of losses by leakage effects is expected.

Telefunken will further provide its SmartPower SOI technology for high efficiency systems, with very low standby losses for intelligent power control. For high voltage applications a 700V technology will be available. This technology is actually being developed in the ENIAC project SmartPM and will be re-used here. Possible enhancements will be introduced according to requests of applications. The technologies will be offered for use of partners with design tasks in this project. Telefunken will offer design kits with technical support and a MPW (Multi Project Wafer) -service for related partners.

IFAG will investigate several advanced technological design options for the replacement of existing boost diodes to enable the operation of high performance low cost solar inverters under difficult conditions (start up at low temperature, degradation of material, ...).

Infineon AG will develop high efficiency IGBT and SiC components as well as innovative interconnection technologies for enhanced functionalities and a significant performance improvement. Concerning chip / module interconnection significant improvements and completely new technologies have to be researched on. This has to be realized on three levels; on component side (metallization), on module side and the interconnect technology itself.

In close co-operation with SMA and TU Chemnitz. Infineon will investigate in the development of fast switching IGBT components and SiC diodes to increase the performance and efficiency of PV inverters. The system characteristics of the inverter, as well as more efficient utilization of devices, increased efficiency or improved EMC behaviour are to be achieved by fast switching elements in combination with drastically reduced inductivities on module level.

On chip level Infineon will research on a 1200V SiC Schottky-diode significantly improved concerning robustness and overload ability. Based on a Merged-pin-Schottky-structure the device will be able to compensate a short time overload by an integrated heat accumulator. Therefore a new chip/module construction with extremely low inductivities is necessary.

Infineon will make investigations on low-inductance chip / module design as well as testing the different approaches for the special requirements of PV inverters. A special focus will be on reliability and lifetime as well as on the validation of the expected advances (especially efficiency, EMC characteristics).

NXP's contribution to the ERG WP3 work package is the design of innovative semiconductor solutions for panel-based power-management topologies for solar systems, making optimum use of the specialized power IC technologies available in the company. NXP would like to perform the following tasks:

Play a role in defining the specifications of the optimum conversion system aimed at increasing the overall energy output of a solar system (Task 3.1). Such a conversion system involves power converters on panel level (DC/DC and/or DC/AC, i.e. micro inverters, in the 100-200W range). Playing a role in the specification phase as a semiconductor company makes a more integrated and therefore cheaper realization more likely.

Realize test ICs with which the intended power converters can be realized (Tasks 3.2 and 3.3).

After proof of concept in Tasks 3.2 and 3.3, realize final test IC implementation to build total application and proof increased overall efficiency.

UNICT - DIEES will collaborate in the tests of the efficiency of the converters and EMC issues. The DIEES-CePTIT power electronics lab has a specific test bench to carry out accurate static and dynamic efficiency test for PV applications. In particular, a PV field simulator is available, based on programmable DC power source. Moreover, in order to test the response of different MPPT algorithms in term of the maximization of the energy production in variable sunny conditions, a suitable test procedure has been set up. As regards the EMI-EMC issues, the CePTIT-DIEES EMC lab has an anechoic chamber and EMC equipments for pre-compliant tests, able to measure EMI emissions and device immunity.

Tyndall will devise architecture to sense the performance (source current, open circuit voltage, temperature) of the CPV cells and report fault operations. In many cases it is not practical to have one WSN mote per CPV cells so the motes will be configured to sense multiple CPVs. Types of sensors, criteria for fault reporting, sensing intervals etc will be determined. Architecture options for power sources will also be required for the wireless sensors (e.g. using DSSC technology from SPR to create an independent supply Vs interconnect with main CPV array). Tyndall TNI-UCC shall provide parts for CPV demonstrators and work with partners to optimize the architecture, sensor selection and definition of parameters to determine CPV performance and failure detection.

UNICAL research group will analyze the impact of different charging patterns for commercial battery cells on storage efficiency by developing a test methodology for evaluating the dynamic performance of a cell in the presence of time-varying charging current profiles. On these bases, optimal charging strategies in the presence of typical power availability in a PV cell-based distribution grid will be studied, in order to define possible battery charging management sub-module architectures.

The candidate preliminary architecture of the battery management system will be selected taking into account also expected performances and technical feasibility for actual system development and demonstrator design. After these phases, UNICAL will design a concept module to manage the smart battery charging in accord with possible innovative charging strategies developed in parallel in WP4. The evaluation of the effectiveness of the selected strategies will be done by means of an experimental set-up implementing the principle of operation of the selected smart battery management system architecture.

SPR will work closely with partner Tyndall in supporting Tyndall's development and integration of conditional (performance & fault) sensor solutions for the CPV cells. This will include the sensors & sensing parameters, optimizing the level of granularity required Vs number of sensors used and reliable self-powering of the sensors. A key consideration for this work will be integrating SPR's DSSC technology as part of the hybrid energy management system (provision of samples, helping Tyndall to maximise DSSC conversion efficiency under various environmental conditions whilst minimising leakage currents & MPPT circuit power dissipation).

Deliverables

Del. No.	***Deliverable Title***	***Contributors***	***Due date***
D3.1a	Specification of Conversion Systems and technology platforms, with segments: • Report on system specifications for sub-module and MPPT concepts: o PV converters (SMA)	**SMA**, STIAG, TEL, FRAUNHOFER, RWTH, IFAG, TUC, NXP, UNICT, Tyndall, UNICAL	M06

	○ CPV converters (STIAG, RWTH) ○ Maximum Power Point Trackers, Communication (FRAUNHOFER) ○ SiC, IGBT technologies (IFAG) ○ Charging management system for smart energy storage option (UNICAL) ○ Performance Sensing (TNI-UCC) ○ EMI filter integration and optimization (UNICT) ○ PV-module-level DC/DC converters (NXP) • Specifications of used semiconductor components in chosen topology (IFAG, TEL, NXP)		
D3.1b	Architecture Study for implementations in demonstrator designs, with segments: • Architecture for sensing CPV generator cells (STIAG, UNICT, Tyndall, FRAUNHOFER, TEL, NXP, RWTH) • Architecture study for smart battery charging both for automotive and energy storage systems (UNICAL) • PV-module-level DC/DC converter topologies (NXP)	SMA, STIAG, TEL, FRAUNHOFER, **RWTH**, IFAG, TUC, NXP, UNICT, Tyndall, UNICAL	M15
D3.2a	Report on test designs: • Sensing and communications infrastructure in place for CPV demonstrator (Tyndall) • IGBTs with low inductivity; 1200V SiC Schottky-diode (IFAG, TUC) Report on tape out of MPPT / power conversion ICs (TEL, FRAUNHOFER, RWTH, NXP)	TEL, FRAUNHOFER, RWTH, Tyndall, IFAG, TUC, **NXP**	M18
D3.2b	Report on experimental results for improved efficiency: • DC/DC and DC/AC converters(NXP, RWTH, FRAUNHOFER, TEL) • Interconnect technologies for heat storage modules (IFAG) • Models of converters including high frequency behaviour (UNICT) • Smart battery management architecture (UNICAL)	SMA, STIAG, TEL, FRAUNHOFER, RWTH, IFAG, TUC, **NXP**, UNICT, UNICAL	M24
D3.3	Report on realization of test silicon, with segments: • Realization of test silicon for solar converters, DC/DC and/or DC/AC (TEL, FRAUNHOFER, RWTH, NXP) • Proof of concept on converter level (SMA, STIAG) • Power module with integrated IGBTs and SiC (IFAG) • Proof of concept of the battery management system (UNICAL)	SMA, STIAG, TEL, FRAUNHOFER, RWTH, **IFAG**, TUC, NXP, UNICAL	M30
D3.4	Test reports for realized demonstrators, with segments: • Report on measurement results of the MPPT and sub-module concept (STIAG, TEL, FRAUNHOFER, RWTH, NXP) • Smart Battery management system (UNICAL) • Sensing infrastructure for CPV generator cells (Tyndall, SPR) • Power module (IFAG) • Report on EMI-EMC performance (UNICT)	**SMA**, STIAG, TEL, FRAUNHOFER, RWTH, IFAG, TUC, NXP, UNICT, UNICAL, Tyndall, SPR	M36

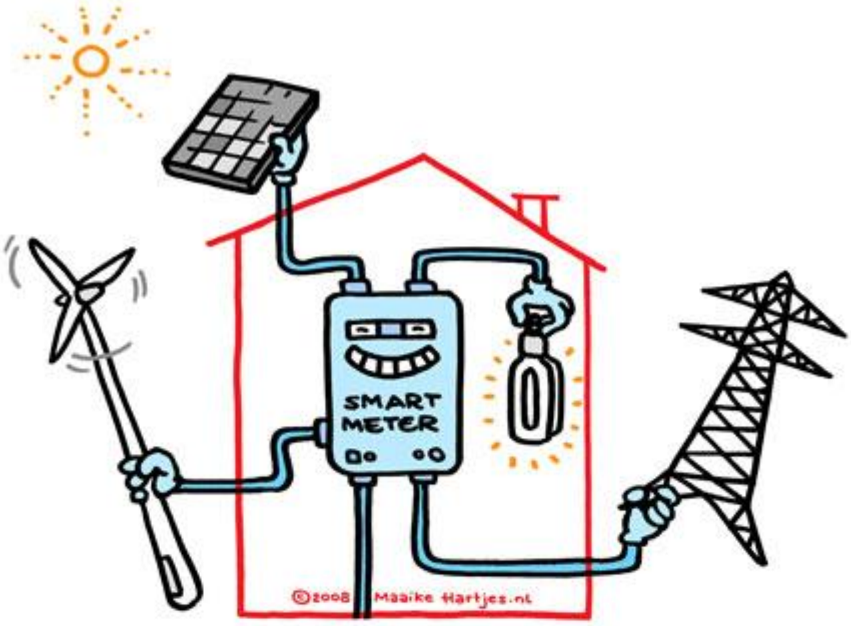
Milestones

Mil. No.	***Milestone Title***	***Means of Verification***	***Related Deliv.***	***Due date***
M3.1	Specifications of conversion systems available	Specifications available, report released	D3.1a	M06
M3.2	Test designs available	Tape Outs done, report released	D3.2a	M18
M3.3	Silicon for demonstration available	Silicon available, report released	D3.3	M30

Work Package number	WP4	Start date or starting event:			M1			
Work Package title	Smart energy distribution, utilization and management							
Participant number	**5**	1	4	7	21			
Participant short name	**POLITO**	ST	IUNET	UNICAL	LEITAT			
Person-months per participant	**117**	100	14	14	10			

Objectives

In state of the art grids electrical energy generation is based on the load demand. When switching to renewable energy sources this scheme becomes problematic, because sources are not always available on demand, unless a large costly storage capacity is introduced. A cheaper solution is to match the demand of the load with the instantaneously available power and amount of stored energy. This is only possible with a communication network between generator, storage and load. Advanced models are required to implement an efficient management strategy. ERG will develop the monitoring and communication equipment and demonstrate if for a large scale commercial smart grid and in an industrial micro grid.



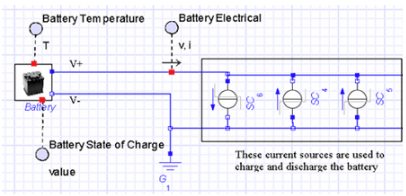
WP4: ***Smart Energy Distribution, utilization and Management***

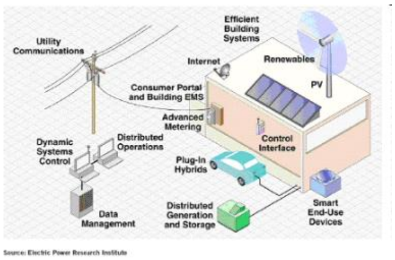
Specification requirements
IUNET, LEITAT, POLITO, TYNDALL, UNICAL, ST

Modeling
POLITO, ST, UNICAL

Network monitoring
IUNET, LEITAT, TYNDALL

Smart grid demonstrator
IUNET, POLITO, ST, UNICAL





Description of work

Task 4.1: Development of models for the performance of individual devices and the network as total

Leader: IUNET – Other participant(s): UNICAL, POLITO, ST

Start date: M1 – End date: M36

The objective of this Task is to obtain a realistic behavioural model, based on power sources and load profiles, for the development and evaluation of suitable energy dispatching policies that allow the optimal utilization of the electric energy coming from the energy distribution system and photovoltaic systems.

The activity is aimed to the development of advanced battery charging algorithms that allow implementing the optimal energy dispatching policies developed in the early stage of the WP. For this phase the objective is to improve the Mean Satisfaction Degree of final users from the value of 67%, at the moment achievable by the use of standard algorithms proposed in literature, to a value of 80-85%.

Smart charging algorithms will be proposed in order to maximize the efficiency of the battery charging process when the previously discussed energy dispatching policies are applied, aimed to increase overall efficiency of the charging process of 10% with respect traditional systems. Other figures of merit used for the ranking of policies might include (depending on user or use case constraints) battery lifetime, or demand fulfilment of load current.

Task 4.2: Development of monitoring and communication equipment

Leader: IUNET – Other participant(s): LEITAT

Start date: M4 – End date: M36

The objective of this Task is to develop sensors and communication chips for smart grids, including the application software.

Task 4.3: Demonstrators

Leader: ?? – Other participant(s): IUNET, POLITO, UNICAL, ST
Start date: M12 – End date: M36

The main demonstrator will be a smart grid related to a household application. This grid will be powered via PV and connected to smart consumer-type loads, like solid state lighting and appliances. A key feature will be a wireless sensor network and connection to Internet. A second smaller demonstrator will focus on a micro smart grid in an industrial/healthcare application.

Participants' role

IUNET-Pisa proposes to focus on the design, development and deployment of Wireless Sensor and Actuator Networks (WSAN) based on the Zigbee Pro standard for smart energy management in residential and commercial buildings. Sensors include AC power meters (smart meters), temperature, light and presence sensors. The system includes also actuators, a network coordinator implementing active energy management policies, a gateway to the Internet to allow for remote control and configuration of the system. IUNET-Pisa has developed prototypes of Zigbee sensor nodes, a gateway, and a software infrastructure for data collection, storage and presentation. Such prototypes will be further developed and tested towards a full demonstration of a smart energy management system.

LEITAT's contribution to WP4 will consist in the implementation of a Wireless Sensor Network, based on Zigbee protocol, including energy monitoring, sensors for energy efficiency improvement and actuators. Other aspects such as energy harvesting solutions for powering WSN will be considered. LEITAT will collaborate with other partners in the demonstration of WSN to improve energy efficiency.

POLITO will contribute with smart energy management solutions for multi-supply systems. Since a PV supply system is available intermittently, a sort of accumulation is needed, usually through a rechargeable battery. Under some particular conditions (full sunlight), however, it might be convenient to distribute the available energy to the load and to the battery in a non obvious way. The conventional paradigm is to consider the PV cells as the 'charger' element of the storage device: when light is available the battery is charged, and the battery is viewed as the true "supply device".

The proposed approach corresponds to have a "peer" view of the two energy sources (PV and battery) as supply devices: in practice, to map the As a matter of fact, there might be periods of low irradiation in which the battery experiences low state-of-charge (SOC) periods and in which the electrical load is attempted to be matched. A smart management system would monitor the SOC and gradually reduce the energy taken from the battery (i.e., reduce the load) to help prevent continuous operation at a low SOC, which deteriorate the lifetime of the battery. Similarly, under condition of excess charge (low load periods in condition of high irradiation), the management system could use the excess charge generated to directly supply the load.

In order to evaluate such scheduling policies, a model of the power sources characteristics (e.g., available charge, voltage, and SOC vs. load current) as well as the typical load conditions (e.g., current profiles). Given those models, POLITO will develop a software simulator that is able to evaluate various "load-driven" energy distribution policies and calculate the optimal one for the target load.

UNICAL. The activity will first of all focus on the analysis of real specification of the problem, in particular with regard to expected load trends during a specific time, load specification, maximum and minimum current allowable for a specific load topology.

The development of a realistic behavioural model for the evaluation of suitable energy dispatching policies will follow, which allow the optimal utilization of the electric energy coming from the energy distribution system or by photovoltaic supplies, resulting in a maximum charging efficiency and quality of service.

The third step consists in finding ad-hoc algorithms for the smart management of grids for sustaining the energy demand from large numbers of battery-based systems (both for automotive and energy storage applications), most of all in the presence of solar-photovoltaic-based energy sources.

After this phase, the activity will focuses on the development of specific charging algorithm aiming to enhance the overall charger/battery system efficiency.

Deliverables

Del. No.	*Deliverable Title*	*Contributors*	*Due date*
D4.1	Specifications for sensor, communication chips and demonstrators.	**Leader**, contrib. 2, contrib. 3, ...	M12
D4.2	Behavioural models of network components	**Leader**, contrib. 2, contrib. 3, ...	M18
D4.3	Battery charging algorithm	**Leader**, contrib. 2, contrib. 3, ...	M24
D4.4	Wireless sensors (voltage, current, light, presence), network topology and management software	**Leader**, contrib. 2, contrib. 3, ...	M24
D4.5	Integrated demonstrator	**Leader**, contrib. 2, contrib. 3, ...	M36

Milestones

Mil. No.	*Milestone Title*	*Means of Verification*	*Related Deliv.*	*Due date*
M4.1	Specifications available	Report released	???	M12
M4.2	Network components and algorithms available	Prototype components and software available	???	M24
M4.3	Smart grids demonstrated	Demonstrator available	???	M36

Work Package number	WPM1	Start date or starting event:		M1			
Work Package title	Standardisation, Dissemination, Exploitation						
Participant number	**1**	2	3	4	5	6	7
Participant short name	**ST**	AMAT ITALIA	COM PEL	IUNET	POLITO	UNIBO	UNICAL
Person-months per participant	**27**	6	2	3	2	1	1
Participant number	8	9	10	11	14	15	16
Participant short name	UNICT	CNR	ELET TRA	ONSEMI -B	STIAG	TEL	FRAUNHOFER
Person-months per participant	1	1	2	4	2	2	1
Participant number	17	18	19	20	21	22	23
Participant short name	RWTH	IFAG	SMA	TUC	LEITAT	STUBA	POWERTEC
Person-months per participant	1	2	1	1	2	1	1
Participant number	25	26	27	31	34	35	
Participant short name	SPR	Tyndall	NXP	BTE	ENECSY S	UoS	
Person-months per participant	1	1	2	5	2	2	

Objectives

The present work package shall be the ladder to ensure the greatest possible impact of the project outcomes onto the international industrial and scientific design community in the broadest possible sense. It is one of the major objectives of the ENIAC AWP, not only to secure the European companies short term industrial applications by leveraging all intellectual excellences available in the Community area to commit to a strong **dissemination and exploitation** plan and consequent execution, but also to be the lighthouse that concretely drives market trends by the definition of commonly accepted **standards**.

TM1.1 shall develop and execute the plan that will define and coordinate the standardisation activities.

The dissemination work will be split into two Tasks, TM1.2, the set-up and maintenance of a lively, user-friendly and easily-accessible web-site which will be one of the instruments of the TM1.3 that will deal with all the issues related to the dissemination of the project progress and achieved results to a wide audience, including designers, engineers and scientists from industry and SMEs, as well as researchers, instructors and students from educational institutions and research centres. The web site will also be the effective instrument of the project management by providing a flexible and powerful tool for internal communications and collaboration in its private part as described in the TM1.1

The last piece of work in this WP regards the fundamental task of project result exploitation. Task TM1.4 covers the exploitation activities, which include also market analysis and short term roadmaps definition. Exploitation comprehends the advertisement and promotional activities for awareness creation about the outcomes of the project, as well as the preparation of the exploitation plans by the individual partners and by the Consortium as a whole. Market analysis and road-mapping covering the aspects solar energy exploitation, management and distributions (including standard definition) important building bricks towards the maximization of the impact of the project and they will pave the way to best commercial exploitation of the achieved results.

Description of work

Task M1.1: Standards

Leader: ST – Other participant(s): All

Start date: M1 – End date: M36

The standardization activities will start at the very beginning of the project as they are simultaneously driver and outcome of the project activities. The Standards panels to be targeted are described in section 4.3. The Task foresees and initial plan to be delivered at month six and updated at month 20. At month 18 and 36 the first report and final report of the achievements of the projects with respects to the standards definition and contributions.

Task M1.2: Set-up and maintenance of the project web-site

Leader: ST – Other participant(s): All

Start date: M1 – End date: M36

The objective of this Task is the set-up and maintenance of a public web-site that will constitute the main point of collection of the project information, including public deliverables, summary of major scientific achievements, advertisement of dissemination and training activities. Maintenance and incremental updates will take place monthly, major revisions and restructuring will occur every six months. The web-site will be mastered by partner ST. A link to a private, password-protected section of the web-site will be reserved for communication internal to the ERG Consortium, and it will also be used for communication to the EC and to the project Reviewers.

Task M1.3: Dissemination

Leader: IUNET – Other participant(s): All

Start date: M1 – End date: M36

The partners of the ERG Consortium will disseminate the project results through various means, including scientific presentations at international conferences and workshops, publication of papers in international journals, magazines and conferences, participation to activities such as tutorials, panels, round tables and seminars in international events, as well as to summer courses and targeted dissemination actions regularly organized by the scientific community.. It is expected that the project will generate a large amount of innovative, scientifically sound research results, which could lead to several publications. A measure of success of the scientific impact that the project will have is certainly the number and quality of the papers published jointly by the partners. Given the size of the Consortium, the scientific excellence of the partnership and the broad range of innovative topics covered by the project, we predict that no less than 40 conference and 10 journal papers will be published within the project lifetime (or immediately after project conclusion). A dissemination plan will be prepared and issued at the beginning of the project, and updated at month M18. It will serve as reference for the execution of the dissemination activities.

It is understood the project will improve the technological transfer potential of the academies to SMEs at the local regional and national levels.

Task M1.4: Exploitation

Leader: ?? – Other participant(s): ST, ELETTRA, ONSEMI-B, STIAG, TEL, IFAG, SMA, SPR, NXP, BTE, ENECSYS , IUNET, POLITO

Start date: M3 – End date: M36

The exploitation of the project results is the final step which is required to make the ERG project a success from the point of view of both industrial and societal impact. In order to implement a successful exploitation strategy, the partners of the ERG project, as well as the Consortium as a whole, must take the appropriate actions and measures already during the project lifetime to prepare for this target. The planned activities in this Task include the advertisement and promotion of the ERG design activities and prototypes following well established strategies based on participation to fairs and exhibits in the key areas of the energy supply chain and its applications, offering of on-site presentations and demos to potential customers, set-up joint marketing and distribution agreements to enhance the visibility of the new technologies, especially outside Europe. All the ERG partners will prepare result exploitation plans, indicating in detail what market and business opportunities will be favoured by the development of the new technologies made in ERG. A preliminary plan, jointly compiled by the Consortium as a whole and by each individual partner will be delivered at M18. The exploitation plan will then be finalized at the end of the project. Instrumental to the implementation of effective preparatory actions to result exploitation is the market surveying and road-mapping activity, which is part of this Task. Market surveying will be a continuous effort, spanning the entire duration of the project. Three updates of a market survey document will be delivered by the partners at months M6, M18 and M30.

More details on the Impact, Dissemination and Exploitation activities are to be found in sections 4.1, 4.2.

Participants' role

Deliverables

Del. No.	***Deliverable Title***	***Contributors***	***Due date***
DM1.1.1	Standards :first plan	**ST**, All	M06
DM1.1.2	Standards first report	**ST**, All	M18
DM1.1.3	Standard plan update	**ST**, All	M20
DM1.1.4	Standards final report	**ST**, All	M36
DM1.2.1	Set-up of the public ERG web-site	**ST**	M01
DM1.2.2	Registration of all project partners to the private part of the web site	**ST**, All	M03
DM1.3.1	Press release: Launching the ERG Project	**ST**	M01
DM1.3.2	Initial dissemination plan	**IUNET**, All	M03

DM1.3.3	First report on dissemination activities	**<u>IUNET</u>**, All	M18
DM1.3.4	Updated dissemination plan	**<u>IUNET</u>**, All	M20
DM1.3.5	Final report on dissemination activities	**<u>IUNET</u>**, All	M36
DM1.4.1	First release of market survey document	**<u>ST</u>**, ELETTRA, ONSEMI-B, STIAG, TEL, IFAG, SMA, SPR, NXP, BTE, ENECSYS, IUNET, POLITO	M06
DM1.4.2	Preliminary Exploitation Plan	**<u>ST</u>**, ELETTRA, ONSEMI-B, STIAG, TEL, IFAG, SMA, SPR, NXP, BTE, ENECSYS, IUNET, POLITO	M12
DM1.4.3	Second release of market survey document	**<u>ST</u>**, ELETTRA, ONSEMI-B, STIAG, TEL, IFAG, SMA, SPR, NXP, BTE, ENECSYS, IUNET, POLITO	M18
DM1.4.4	Report on preparatory activities for results exploitation	**<u>ST</u>**, ELETTRA, ONSEMI-B, STIAG, TEL, IFAG, SMA, SPR, NXP, BTE, ENECSYS, IUNET, POLITO	M24
DM1.4.5	Final release of market survey document	**<u>ST</u>**, ELETTRA, ONSEMI-B, STIAG, TEL, IFAG, SMA, SPR, NXP, BTE, ENECSYS, IUNET, POLITO	M30
DM1.4.6	Final Exploitation Plan	**<u>ST</u>**, ELETTRA, ONSEMI-B, STIAG, TEL, IFAG, SMA, SPR, NXP, BTE, ENECSYS, IUNET, POLITO	M36

Milestones

Mil. No.	***Milestone Title***	***Means of Verification***	***Related Deliv.***	***Due date***
MM1.1	Review of first half standardisation, exploitation, dissemination activities	Review passed, Reports released and approved	DM1.3.3 DM1.4.2 DM1.4.3	M18
MM1.2	Final Review of all standardisation, exploitation, dissemination activities	Review passed, Reports released and approved	DM1.3.5 DM1.4.5 DM1.4.6	M36

Work Package number	WPM2	Start date or starting event:	M1				
Work Package title	Project Management						
Participant number	**1**	2	3	4	5	6	7
Participant short name	**ST**	AMAT ITALIA	COMPEL	IUNET	POLITO	UNIBO	UNICAL
Person-months per participant	**9**	4	2	1	1	1	1
Participant number	8	9	10	11	14	15	16
Participant short name	UNICT	CNR	ELETTRA	ONSEMI-B	STIAG	TEL	FRAUNHOFER
Person-months per participant	1	1	1	2	1	1	1
Participant number	17	18	19	20	21	22	23
Participant short name	RWTH	IFAG	SMA	TUC	LEITAT	STUBA	POWERTEC
Person-months per participant	1	1	1	1	2	1	1
Participant number	25	26	27	31	36	37	
Participant short name	SPR	Tyndall	NXP	BTE	ENECSYS	USFD	
Person-months per participant	1	1	1	2	1	2	

Objectives

The work to be performed in this WP includes, primarily:

- Set-up and implementation of all the project management structures
- Organization of the project kick-off meeting and of the periodic management and technical meetings
- Execution of day-by-day project administration and monitoring of work progress
- Technical steering of the project
- Identification of potential risks and definition of appropriate recovery plans
- Monitoring of the performance of the Consortium partners
- Implementation of corrective actions to cope with possible misbehaviours of some partners
- Definition of standards and conventions regarding matters such as documentation and review procedures
- Preparation and delivery to the JU of the required documents and reports

- Organisation and preparation of the project review meetings
- IPR Management

Description of work

Task M2.1: Project management

Leader: ST – Other participant(s): All

Start date: M1 – End date: M36

In this Task, the project coordinator and all the partners will perform the due project management activities, including technical, strategic, administrative and financial actions, all devoted to an efficient, on-time execution of the project work and the delivery of the corresponding results. Key tool for project management will be the Internal Project Web Site. It will be used to manage the contact and distribution lists, as well as a repository for communication and documentation exchange among the partners. It will be implemented as part of the project public web-site.

Two are the key activity of this Task:

1) the project coordinator will set-up and implement the necessary project management structures, in accordance with the schemes described in Section 5 In addition, the project coordinator will convene the END project kick-off meeting no later than two weeks since the official start date of the project.
2) the preparation and delivery of the Periodic Project Reports on Progress, and Use of Resources. The project coordinator will ensure that such reports will be organised so that the individual contributions of each partner within the different Tasks and their individual contribution to a specific (part of a) deliverable is clearly visible in order to allow the different Member States involved to judge the level of contribution of each participants in view of the resources used and results achieved.

Task M2.2: Communication with the JU

Leader: ST – Other participant(s): -

Start date: M1 – End date: M36

The project coordinator will be the primary contact point to the JU and the reviewers for all the matters, technical and administrative, concerning the execution, progress and management of all project activities. Any action concerning communication to the JU and the reviewers, as well as the exchange of material, technical, administrative and legal documents occurs in the context of this Task. A specific section of the Internal Project Web Site will be dedicated to the interaction with the JU and the reviewers, through secure connections and password protected folders and directories.

Task M2.3: IPR management

Leader: ST – Other participant(s): All

Start date: M1 – End date: M36

This Task concerns the establishment of appropriate policies and rules for the management of background and foreground Intellectual Property for the technologies developed within ERG. The documents that will finalise the agreed rules shall be the EPCA to be delivered at month 6. IPR management will be a continuous activity covering the entire project life. We foresee a first release of the IPR Management database containing the list new know-how generated by the R&D activities during the first 18 months of the project. The second version of the IPR management database, consisting of the IP overview table organized as a list of exploitable results on how the knowledge could be used in further research, will be delivered by month M36.

Section 4.4 has been dedicated to the impact of the ERG IPR Management.
Participants' role

Deliverables

Del. No.	*Deliverable Title*	*Contributors*	*Due date*
DM2.1.1	Project Management Handbook	**ST**	M03
DM2.1.2	First Periodic Project Report on Progress, Use of Resources and Financial Statement	**ST**, All	M12
DM2.1.3	Second Periodic Project Report on Progress, Use of Resources and Financial Statement	**ST**, All	M24
DM2.1.4	Third Periodic Project Report on Progress, Use of Resources and Financial Statement	**ST**, All	M36
DM2.1.5	Final Publishable Summary Report	**ST**, All	M36
DM2.3.1	IPR Management Database: First Release	**ST**, All	M18
DM2.3.2	IPR Management Database: Final Release	**ST**, All	M36

Milestones

Mil. No.	*Milestone Title*	*Means of Verification*	*Related Deliv.*	*Due date*
MM2.1	Review of first half of project activities	Review passed, Reports released and approved	DM2.1.2 DM2.1.3	M18
MM2.2	Final Project review	Review passed, Reports released and approved	DM2.1.4 DM2.3.2	M36

6.3 Description of milestones

Milestone number	Milestone name	Work package(s) involved	Expected date [9]	Means of verification[10]
M1.1	First Version of PV Cell Devices	WP1	M18	Devices available
M1.2	First Device Evaluation. Device Model Refinements. Guidelines for Refinements on Final Version of Devices	WP1	M24	Report released
M1.3	Refined Version of PV Cell Devices	WP1	M30	Devices available
M1.4	Final Device Evaluation. Comparison of the advanced Si and DSSC technologies.	WP1	M36	Report released
M2.1	Specifications of power conversion systems	WP2	M06	Specifications available, Report released
M2.2	Systems design ready	WP2	M18	Specifications available, Report released
M2.3	Prototype of demonstration systems	WP2	M30	Prototype available
M3.1	Specifications of Conversion Systems available	WP3	M06	Specifications available, Report released
M3.2	Test Designs available	WP3	M18	Tape Outs done, Report released
M3.3	Silicon for Demonstration available	WP3	M30	Silicon available, Report released
M4.1	Specifications available	WP4	M12	Report released
M4.2	Network components and algorithms available	WP4	M24	Prototype components and software available
M4.3	Smart grids demonstrated	WP4	M36	Demonstrator available

[9] Measured in months from the project start date (month 1).

[10] Show how you will confirm that the milestone has been attained. Refer to indicators if appropriate. For example: a laboratory prototype completed and running flawlessly; software released and validated by a user group; field survey complete and data quality validated.

7 MARKET INNOVATION AND IMPACT

7.1 Impact

The impact of the nanoelectronic technologies for the “energy & CO2 budget” is foreseen in the area of the forthcoming solar energy market especially in the photovoltaic segment. Nanoelectronics is the main and most critical key enabler. It is envisaged that addressing the hearth of the production methods and the supply chain of networked solar energy appliances will improve the competitiveness of the electronic industry in Europe and speed up the full deployment of a set of smart photovoltaic applications and innovations.

The proposed project has a clear focus on urgently needed sustainable and renewable energy generation for a broad range of applications, to be in daily use by European and also worldwide citizens. The results will help to generate energy more efficiently by avoiding losses during conversion and transportation. Local energy generation and usage will avoid unnecessary transportation and will reduce the loads of future energy grids. Furthermore the usage of modern technologies like SOI will avoid losses in energy conversion by increasing conversion efficiency and significantly reducing standby losses.

This project has a significant strategic impact for whole Europe.

On the one hand this project strengthens the technology competence of the European solar industry. From the photovoltaic industry, to suppliers of converters/inverters, down to semiconductor and solar cell manufacturers, technology leadership is absolutely important in this extremely competitive and cost sensitive market segment that is extremely subsidized by the US or Asian governments

On the other hand the project results enable an efficient usage of "green" energy. An efficient usage of renewable energy sources like solar is one of the big challenges for Europe in the future (concerning market acceptance and worldwide competition) and therefore of strategic relevance

Based on the high and strongly increasing market volume of the solar technology and the challenging innovation targets of the project, the project will have an extremely significant impact on the European industry and economy as well as will support the political goal of reducing the greenhouse gas emissions to about 20% of the 1990 baseline by the year 2050 (Germany).

Photovoltaic-Market

Renewable energies, especially the photovoltaic technology are extremely fast growing market segments.

In particular by the end of 2008, total world energy consumption was approximately 15TW while the PV installed capacity was 16GW. To make a significant contribution to worldwide energy demand, the industry needs to move from gigawatts of production to terawatts. The historic rate of growth for PV since 1975 has been 30% per year, and in the last decade the growth has been close to 40%.

At the beginning the demand consisted in utility and government grid-connected demonstration projects, and in the off-grid market. The strong growth rate observed in recent years is due to subsidies, initially in Japan, Germany and California, later reinforced in Germany thanks to the feed-in tariff (FiT) law, soon followed by similar laws in many other European countries.

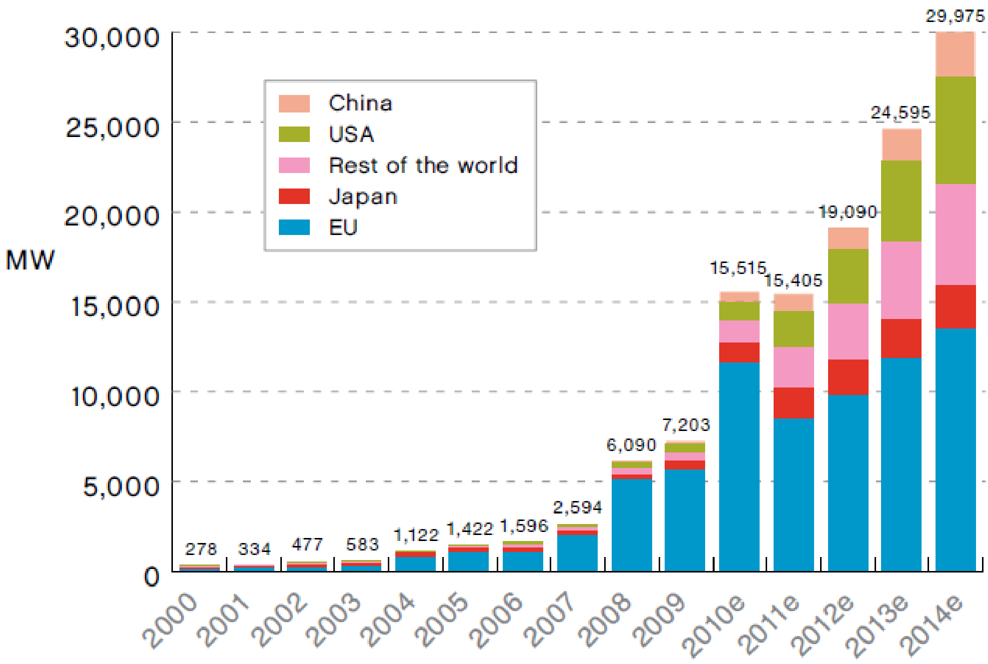


Figure 4.1 – PV Installation evolution with regional divisions, including short term forecast (Source: iSupply April 2010)

PV technology is dominated by silicon, in the form of crystalline and multi-crystalline modules. Recently the thin film technology has acquired more and more momentum, thanks, from one side, to the huge advancements mainly in the CdTe, with contributions of amorphous-Si and CIGS technologies, and on the other side, to a silicon feedstock supply shortage which affected the module cost of crystalline and multi-crystalline Si in the period 2004-2008. The shortage period has ended, producing a strong decline in the price of silicon modules.

However this market is extremely cost sensitive. Solar cells, power components, converters and photovoltaic systems at competitive cost and a more than competitive performance (energy efficiency) are the market success factor.

As a German study of the ministry of environment states, is efficiency in generation and usage of photovoltaic (solar cells and power electronics) extremely important to fulfil the challenging EC targets of CO_2 emission reduction.

“The foundation underpinning all efforts, however, must be a substantially more efficient energy management in all fields of conversion and use. With such a strategy Europe can drastically reduce its dependence upon fossil energy imports and can thus greatly improve the security of its energy supply. This would also prevent potential conflicts arising over increasingly scarce energy resources” (source: Lead Scenario 2008; study of the German ministry of environment).

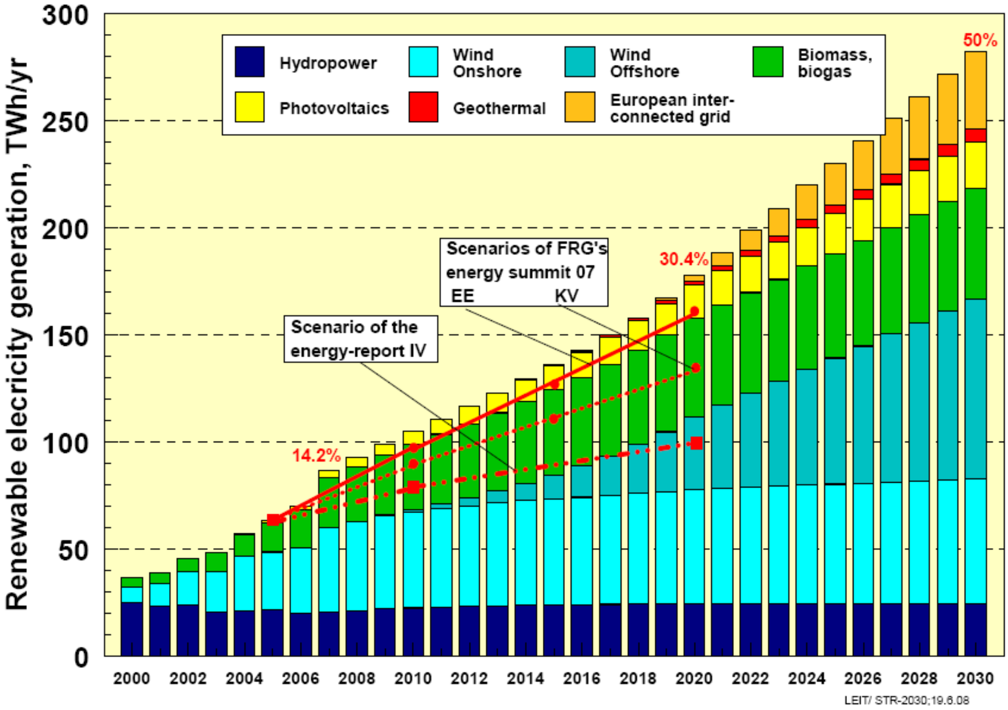


Figure 4.2: Electricity generation in Germany from renewable sources according to the Lead Scenario 2008

According to the Lead Scenario 2008, the contribution of renewables to electricity supply can rise from 87.5 TWh/yr in 2007 to 178 TWh/yr in 2020. The share of renewables in the calculated gross electricity consumption of 2020 is 30.4%. Insufficient efficiency improvements in electricity use can, however, seriously jeopardise relative targets or would require an additional increase in renewables-based electricity generation if the targets are to be attained" (source: Lead Scenario 2008; study of the German ministry of environment).

Table 4.1: Electricity generation from renewable sources in Germany according to the Lead Scenario 2008

PV energy TWh/y	2000	2007	2010	2015	2020	2025	2030	2040	2050
	0.1	3.5	6.2	11.0	15.5	18.7	21.9	25.3	27.7

The project thereby will create a market growth for the European system and equipment companies as well as for the semiconductor manufacturer and in the long run will create many jobs all over Europe. In addition this project strengthens the industry in its global competition by reducing energy and maintenance costs significantly and last but not least is a starting point for a lot of future innovations.

An additional impact of this project is the strengthening of the Smart Grid Trend. Solar panels are a key component of the upcoming Smart Grids (micro grid) and the efficiency is a market issue. Micro-grid approach in Japan is to permit a smart and clean consumption of electricity between the house, the grid, the eventual renewable energy sources and the battery parks

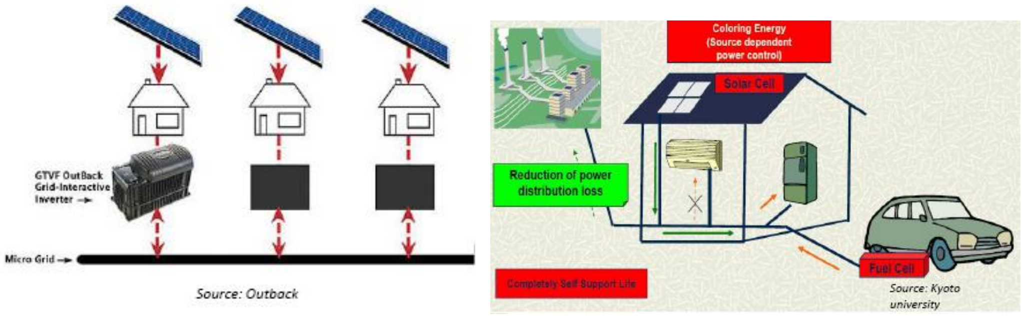


Figure 4.3: Renewable energy and Smart Grid interaction.

As a matter of fact, end-consumers are more inclined to reduce their power consumption when they know exactly how much it will cost them by the end of the month. High efficient solar cells, power electronics, converters and in the end solar panels help significantly for cost reduction and end-consumer acceptance.

Distributed generation of energy (small solar panels – market focus of this project) will be a key innovation in the future (source Yole Development)

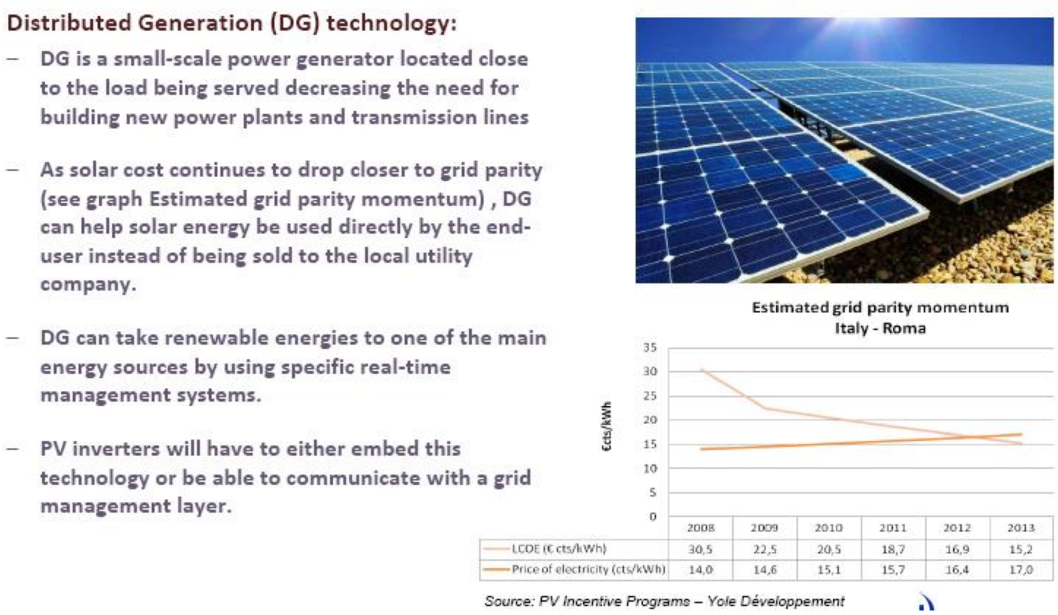


Figure 4.4: Distributed generation technology.

China will be in the future worldwide leading in the area of renewable energy. Renewable energies law is effective since 2006 to encourage renewable energy resources. Renewable energy is expected to reach 10-12% of total installed power capacity by 2020 in China. China is to become the first market in Renewable Energy from 2010. To address this market is a fact of survival for the European solar industry. This project will help to ensure our economical future.

Additional impact is foreseen for industrial partners in their specific market niches.

For ST the impact of the development of innovative solar cells, dedicated IC for Photovoltaic power conversion as well for any other renewable energy source, in conjunction with innovative system architectures integrated in the Smart Grid arena will be directly on the market share in such a fast growing worldwide application sector as well as in Company outlook in terms of social commitment. Thanks to the design and development activities which have been proposed in ERG, ST will contribute in the spreading of the European know-how all over the world, keeping this know-how as European knowledge.

For ON Semiconductor the impact of the development of the splitgate XtreMOS^{TM} is twofold: it will strengthen and improve ON Semi's market position for power MOSFETs, and on the other hand it will improve on energy losses in power converters. It is the goal to improve in switching converter efficiency from 70% up to >85% → 90% by increasing the switching frequency in the 100-300 kHz range. These new power MOSFETs can be used in a wide range of applications: DC-DC converters, AC-DC adapters, power supplies, consumer electronics (i.e. LCD LED TV), UPS, automotive applications, etc. Market projections predict a doubling in units shipped over 5 years: from 400E6 units in 2009 to 800E6 units in 2014.

The combination of an improved switching efficiency with a doubling of the units shipped, will result in a significant power saving, what will lead to a severe reduction in CO_2 emission.

Infineon will transfer the improved system properties, costs and lifetime in serial products. Based on the project results it is possible to develop new significantly improved photovoltaic power modules for different applications within the frame of subsequent product development. The markets to be addressed with devices containing such power modules have a considerable volume estimating an increase in photovoltaic-usage from **1%** in Germany to perhaps **30%**. Same applies to the largely undeveloped global markets.

Regarding IGBT-Modules Infineon is no. 2 after Mitsubishi. Infineon is world market leader regarding semiconductor power elements with a market share of 11% and achieves a worldwide turnover of 930 M€. With the current IGBT-Power Modules Infineon generates a turnover of 330 M€ per year. In the segment of IGBT-Power Modules we are expecting a market share of approximately 34.5%. (Source: IMS research Power Semiconductor Discretes&Modules 2010 Preliminary Market Share).

In the long run, the market grows by double-digit percentage. Due to project results in energy efficiency and energy savings, the essential market driver, the industry will strengthen its market position.

Applied Materials is the world market leader for c-Si solar cell equipments, in particular for screen printer, test and sort lines, and laser platforms.

Applied Materials will transfer the outcome of the project into its product lines. In particular, the lessons learned by working at the ultra thin wafers handling will translate not only into the possibility to serve a new niche market (where no mass production tool is available today), but will also be used to improve the current breakage rate. In fact, since silicon is still one of the major factors determining final module cost, reducing even more the breakage rate is critical even if the current performances of Applied Materials' equipments are the market reference. On the other side, the activity on the design of an automated line for high volume manufacturing of back contact cells will directly translate into a new product, ready to serve one of the most promising and interesting markets for c-Si in the next years. Finally, the activity on DSSC cells will be important as preliminary studies for the possible introduction of products serving a new market niche, where (once again) no mass production tool is currently available.

The target of the leading ERG Partner in DSSC, SPR, is to launch applications in the market which has a relatively small, but nevertheless a substantial growth share in the future. Equally attractive will be its low cost of manufacturing and its environmental friendly processing and materials to be used. Moreover, its potentially viable technology for flexible, light weight and conformal surface contour for applications such as portable devices, on-board charge for automobiles, wireless sensors, garments etc.

An important upcoming application will be Electrification of Road Transport which European Commission has been promoting for next 10-20 years. DSSC can be used to charge automobile directly on board. Light-weight, flexible, conformal DSSC can be installed in the car interior where is directly exposed to sunlight such as dash board. It also can be integrated as part of the automobile exterior which is exposed to direct sunlight. Potentially viable process for DSSC on polymer substrate is the most promising technology to make light-weight, flexible and surface conformal solar cell without compromising for weight increase or appearance athletics. Medium-to-low, diffused light contributes most of the charging for automobile in everyday life.

Indirect charging can be also accomplished by using DSSC to power through the grid.

Independent measurements performed by Aisin Seiki (Toyota Group) of Japanese show consistent observations as what have been found in SPR.

7.2 Dissemination and exploitation

Dissemination and exploitation of the project results are naturally the ultimate goal of the ERG Consortium as a whole, as well as of the Partners individually. The technical solutions addressed by the project cover several markets that exhibit a constant growth, and whose cumulated share is quite relevant. In such a scenario, it is evident how the supply chain put in place by the ERG consortium will constitute a breakthrough innovation for all involved industries, thus providing clear competitive advantages. In this sense, the ERG project will contribute to the consolidation and extension of the market shares of the industrial Partners in the business sectors of concern.

7.2.1 Dissemination

Dissemination plays an important, albeit less directly revenue-related role for the Consortium: First and foremost, it generates visibility and underlines the Partners' expertise in the area, thus promoting their standing. Furthermore, this also fuels interest in the topic as such. Last, but not least, dissemination helps to drive the convergence of the technical state-of-the-art. This, in turn, is a mandatory pre-requisite for a commercially exploitable market. All Partners will work towards dissemination by publications in international, refereed journals and at targeted conferences, Partners will use their links to industrial and academic institutions to get an up-to-date and complete picture about overall market needs and potential of each of the achieved results. Key strategic contributions will be evaluated for patenting.

On a scientific level, the dissemination activities will be carried out through publications in specialized journal of energy related journals, like:

- **Presentations of papers at national and international Conferences**, like
  - World Conference on Photovoltaic Energy Conversion (WCPEC)
  - European Photovoltaic Solar Energy Conference
  - IEEE Photovoltaic Specialists Conference (PVSC)
  - Darnells Power Forum
  - IDTechEX Energy Harvesting and Storage
  - PowerMEMS
  - International Conference on Integrated Power Electronic Systems (CIPS)
  - Renewable Energy
  - Solar Energy Materials
  - Solar Cells
- **Exhibition :** EU PVSEC**,** ELECTRONICA or the Hannover Fair.
- **Submission to Journals of high rank**, like
  - IEEE Transaction on Electron Devices
  - IEEE Electron Device Letters, Solar Energy Materials and Solar Cells (Elsevier)
  - Renewable Energy (Elsevier)

- Progress in Photovoltaics (WILEY)
- Journal of Optical Society of America (OSA)
- Journal of Applied Physics
- IEEE Power electronics Letters and IEEE Transactions on Power Electronics
- Power Conversion Intelligent Motion (PCIM)
- European Power Electronics (EPE)
- European Symposium on Reliability of Electron Devices
- Failure Physics
- Analysis (ESREF).

All **industrial partners** of the project, will publish in its commercial communications (customer presentations, catalogues and brochures, interactive demos) the results of the projects

Within all Academies involved in the ERG project the staff and students (PhD, master, diploma and bachelor) will contribute to the dissemination in form of PhD, diploma, master or bachelor thesis.

Where available within the Organisations participating in the ERG consortium, the internet and the web-pages will be used to distribute the project results. Newsletters from the Fraunhofer Energy Alliance will report about the project.

Furthermore, **LEITAT** and **ELETTRA** also work with radio and television media and create many tutorials for a general public to disseminate the results that may be of interest to the public.

7.2.2 Exploitation

Commercial Prospects

In the case of positive results - especially considering the intended improved system properties, costs and lifetime- the industrial partners intend to transfer and bring to market those results in serial products. Based on the project results Infineon Technologies will develop new improved photovoltaic power modules for different applications within the frame of subsequent product development. The markets to be addressed with devices containing such power modules have a considerable volume estimating an increase in photovoltaic-usage from 1% in Germany to perhaps 30% (even if the increase of the monetary volume will be lower due to the simultaneous and necessary cost degression). Same applies to the largely undeveloped global markets.

Regarding IGBT-Modules Infineon is no. 2 after Mitsubishi. Power semiconductors from Infineon have been established as industrial standard worldwide and are being offered equivalently by competitors. Infineon is world market leader regarding semiconductor power elements with a market share of 11% and achieves a worldwide turnover of 930 Mio. Eur. With the current IGBT-Power Modules Infineon generates a turnover of 330 Mio. Eur per year. In the segment of IGBT-Power Modules we are expecting a market share of approximately 34,5%. (Source: IMS research Power Semiconductor Discretes&Modules 2010 Preliminary Market Share).

In the long run, the market grows by double-digit percentage. Due to project results in energy efficiency and energy savings, the essential market driver, Infineon is expecting a strengthening of its market position to reach No. 1 also in the Power Modules market. Supplied by application engineers, commercialization takes place worldwide through the established sales channels.

The intended results will be the starting point for advanced industrial applications with chances in worldwide applications. A special chance by usage of CPV solar systems will arise for countries with high solar radiation. These countries will have additional benefits of independency and increased comfort for the citizens.

The foreseen increasing importance of the Photovoltaic require a consequently technology improvement. The forecasted cost cut cannot be compensated only by a cost reduction of the used components. This challenge can only be mastered by an overall system optimisation.

New reliable and highly efficient components (IGBT and SiC-diodes) based on improved converter topologies will be developed. By strengthening the European market position in the photovoltaic segment the market position of all companies in the value chain will be improved in the long run and will create a high number of new jobs in Europe (e.g. **SMA** produces a great amount in Germany, **Infineon** produces its Power semiconductors and SiC components in Austria and Germany and has its only power module manufacturing site in Warstein, Germany; **Telefunken** has it's headquarter and semiconductor fab in Heilbronn, Germany and a design centre in Hannover)

In view of the recent strategic change of **NXP** into High Performance Mixed Signal, the topic of renewable energy has been given strategic priority. As a semiconductor company we recognise the massive impact appropriately designed semiconductor solutions can have. Through participation in this project, NXP hopes to accelerate its innovation towards power management and control solutions for panel based optimisations. More specific, NXP aims firstly to enter the market with local MPPT control products.

Infineon (IFAG) is established at the market not only as semiconductor manufacturer of power electronic components but also as manufacturer of power modules.

Likewise Infineon is world market leader with system and semiconductor solutions for applications of automobiles.

Infineon is worldwide number 1 in Power electronics, number1 in components for automotive electronics and number 2 as manufacturer of power modules.

The research project strengthens with it directly (depending upon project result) the packaging competence centre in Regensburg and the Infineon manufacturing location for power modules in Warstein.

Infineon expects by the project results a strengthening and a further improvement of its world-wide top positions in the segments automobile and power electronics. The project results of highly efficient components and modules for solar converters will be strengthening this highly innovative and strongly increasing business segment significantly.

Thus arises, world-wide, a "totally available market" (TAM) from far over 1 billion € starting from 2020, with a semiconductor portion of more than 500 millions € per year. The project results will crucially contribute to it to open for Infineon a significant portion of this market.

For **ON Semiconductor** (ONSEMI-B) it is of strategic importance to establish ON Semi as a significant solution provider for Smart Power applications. In this program, ON Semi aims to strengthen its commercial position by the development of a more competitive and more robust high voltage power MOSFET. This will increase the use of ON Semi MOSFETs in applications where ON Semi ASICs or ASSPs are used. The new developed module will increase the share at existing customers and gain traction at new customers. The new module based on split gate, will allow enlarging the portfolio in the future to lower and higher voltage power MOSFETs segments. In 2008, ON Semi has 2.1% market share of the Medium Voltage TAM (40→400V). It's the aim to double this figure in a market segment that is doubling within 5 years.

As a large company operating in the cSi solar field, **AMAT ITALIA,** leader in the equipments for screen printing, test and sort, handling equipments, and laser for the photovoltaics industry, will exploit the results from the ERG project (in particular, the handling capability for ultra thin wafers, the automated back contact cell processing line, and the DSSC cell line) as will be stated in the ERG exploitation plan. As a consequence, AMAT

ITALIA will be able to better serve the constantly evolving market of c-Si PV cells, with particular emphasis on more advance and performing technologies.

By the close cooperation of **industrial partners** along the value chain the market entrance will be faster and the market share will increase. A faster market entrance (time to market) results in this fast moving power component/module market in additional market shares up to 40%. The project addresses a system market of roughly 1 billion € and a component market of more than 60 million € /year

Scientific and technical prospects of success

For the **research partners**, the most important exploitable project outcome is knowledge. Such knowledge will be exploited internally by training personnel and students, and externally to promote the Partners' reputation and standing. In an increasingly competitive international environment both of these aspects are highly important to secure the institutes' existence as drivers of Europe's high-tech industry. Both imply a dissemination of the generated knowledge. In the form of intellectual property, this knowledge will have a commercial implication: The research Partners will consider exploiting it indirectly by making agreements for its usage through third parties – preferably by Partners of this Consortium.

The exploitation will not start before the end of the project. However, the ERG Consortium will already act during the project lifetime to plan and prepare for this phase. An important and proven means for the preparation of the exploitation are demonstrations at customers' sites and at industry relevant trade shows, such as the design automation conference. Such demonstrations help to validate the market, detail the requirements and stimulate the interest.

Dissemination plays an important, albeit less directly revenue-related role for the Consortium: First and foremost, it generates visibility and underlines the Partners' expertise in the area, thus promoting their standing. Furthermore, this also fuels interest in the topic as such. Last, but not least, dissemination helps to drive the convergence of the technical state-of-the-art. This, in turn, is a mandatory pre-requisite for a commercially exploitable market. All Partners will work towards dissemination by publications in international, refereed journals and at targeted conferences, Partners will use their links to industrial and academic institutions to get an up-to-date and complete picture about overall market needs and potential of each of the achieved results. Key strategic contributions will be evaluated for patenting.

Referring to the subproject "Efficient photo voltaic inverters" and the development approach especially traced by **Infineon Technologies** together with **TU-Chemnitz** and **SMA**, scientific and technical prospects of success are being rated very high regarding the technical functionality of the prototypes and methods striven for as well as the intended increase in knowledge due to the consortium covering all necessary branches and competences and the long competence of the partners.

The expected improved efficiency due to quick switching photovoltaic power modules with SiC diodes is going to allow higher utilization and offers potential for cost degression of power modules. Any risks are seen in the range of cost targets followed by this approach. It is a clear goal of the project to find answers to the cost questions and to evaluate the gained new module characteristics. Besides there is expected a significant increase in knowledge and understanding (referring to the special development approach and related issues) which will be spread through technical publications or will be entering research activities of TU Chemnitz.

As a private-non profit Technological Centre, **LEITAT** has already been working in innovative solar cells development and in energy management systems. The implementation of ERG project will widely increase the knowledge of LEITAT in these fields, in particularly in the Smart Systems Unit and the Renewable Energies Unit. ERG project will help LEITAT to position itself as a reference in testing and integration photovoltaic modules. Furthermore, exploitation routes related with technological transfer activities in different sectors directly to industry partners is envisaged. LEITAT has a team dedicated to provide services related with technologies valorisation that will explore all the possibilities for the Centre to take advantage of the developments performed in the project.

Exploitations for **IUNET** imply the inclusion of the main concepts, objectives and results of the project in the content of a tutorial session at the end of the activity. The tutorial will focus on:

- novel solar cell architectures: introduction to photovoltaic energy conversion theory, loss mechanisms, light trapping strategies, state of art of solar cells, advanced architectures for high-efficiency energy conversion (back contact type, EWT, MWT, PERL), wide band-gap devices, hetero-junctions and dye sensitized solar cells.
- fabrication techniques: introduction to laser assisted doping and metalization, screen printing, low-breakage handling techniques
- device characterization, metrology, testing, reliability: description of experimental characterization methodologies aimed to evaluate the performance and the long-term reliability of the fabricated solar cells
- introduction to energy harvesting systems and circuits
- power conversion systems: DC-DC circuits, maximum power point tracker (MPPT) systems, energy management in the context of distributed generation

The main exploitations for **ELETTRA** at the end of the activity are the scientific knowledge and the possible tutorials for student and researchers on novel solar cells, from materials to energy conversion, the improved understanding of DSSCs and of their working parameters and fabrication methods. Moreover, Ph. D students will be trained in this activity and will be ready for a possible new job in related European industries or for a scientific career starting from the state of art knowledge on solar cells.

Fraunhofer wants to enlarge and strengthen its knowhow and IP-portfolio by means of this project in the field power management and –regulation and communications. It has experience in designing integrated circuits and systems for decades. Additionally there is the intention to develop the field of maximum power point trackers for high power applications. Research activities in the field of communication systems shall be extended for the application in power modules and electric power supplies. Because of the comprehensive preliminary work of the Fraunhofer IIS on these fields, the scientific prospects of success are outstanding.

The utilization of the results as support for industrial partners in further projects can be foreseen. Of course, additional work is still necessary for a commercial exploitation. For the arranged research topics a knowledge transfer from research to industry is secured. Mainly due to the combination of know-how on the fields of communication, power management, abstracting power efficient circuits and high voltage-circuit design, a multitude of future activities can be expected. Part of the required competence development therefore is supposed to occur within the submitted project.

Finally, all academies and research centres consider having an increased scientific reputation in this field at the end of the ERG project and part of the project results will be used to enhance its teaching performance in the university. In fact, the obtained outcomes are supposed to aid the European economy in continuative research and development projects and common projects with the industry. It is supposed to put the industry in the position to keep its international competitiveness and to even strengthen it. Accordingly, the Academies and Research Centres will try to transfer the emerging technologies in the industry as far as possible

The large partnership promoted by the Project, will allow some academies located in less favoured regions to reinforce links with industrial partners, of paramount importance for the bidirectional exchange of knowledge, skills and competences.

UNICAL will be able to use ERG experience for training engineers and researchers through education programs in the specific fields.

Scientific and economical connectivity

The essential result of this project is the realization of the feasibility of special, new technical approaches for the development of improved photovoltaic power modules. As described, on basis of this new gained knowledge new products shall be developed and being brought to market.

As the involved manufacturers are anchored on the relevant markets very well, prospects are very positive regarding both the necessary product developments following the project and the marketing of new products.

7.3 Contribution to standards and regulations

The fact the ERG consortium has build the full Energy supply chain puts the same in the position to significantly define the standards that shall drive the growing markets and industrial developments. Thus, in this section we believe it is worth to mention at least a couple of important standardization panels that are matching with the broad scope of the project. Such standardization initiatives are clearly setting the stage for a main industrial stream in their respective markets, as they are embraced by some major international standardization bodies.

A first initiative regards the development of a new standard about interconnection of distributed generation with Power Grids in order to enable the reactive power injection from PV generators. Although not permitted by actual standards, PV inverters may provide the necessary reactive power injection or consumption to maintain voltage regulation under difficult transient conditions. As side benefit, the control of reactive power injection at each PV inverter will provide the optimization of the performance for distribution utilities, e.g. by minimizing thermal losses. Moreover, by properly setting the active and reactive power values, the maximum active power that can be injected in each point of the Power Grid, considering the voltage limits, can be significantly increased.

Another initiative will regards the communication standards for equipment used in renewable energy systems. As a matter of facts, to accelerate the renewable energy diffusion it is important to create a common language that all renewable energy component manufacturers should adopt in order to enable interoperability amongst all compliant technologies. The main goal consists in removing the barriers that currently prevent the industry from being able to integrate distributed photovoltaic power generation systems cost-effectively and on a large-scale basis. Such issue will regard the definition of an open communication standard for interconnecting all apparatus in a network in order to supervise and manage all system functions.

As a final example of the competence of the consortium in the standardization field, is worth to say that ST is member of several national and international committees and working group, such as IEEE P1901.2 which is the working group on Smart Grid.

7.4 Management of Intellectual Property

IPR Management will rely on the detailed definitions of the Consortium Agreement (EPCA), which will be legally signed among all the parties by the start time of the contract grant. The purpose of this Consortium Agreement is to specify with respect to the project the relationship among the Parties, in particular concerning the organization of the work between the Parties, the management of the Project and the rights and obligations of the Parties concerning inter alia liability, access rights and dispute resolution.

Within the project, some confidential commercial information will be handled between partners, the conditions of how such exchange will take place will be defined in the CA. ERG will aim at a strategy for the management of knowledge and IPR, such a strategy is intended to be open between the partners, yet it will ensure that commercially relevant information will remain within the project and the respective owner(s). This implies that each dissemination or project output will have to be authorized on behalf of the partners. Any public output will be classified as official deliverable of the project and, as such, will be subject to evaluation of its exploitation potential.

In addition, the parties in the EPCA may decide to identify the background of subject matters to which they are willing to grant access rights to a specific partner, subject to the provisions of the Consortium Agreement and the Grant Agreement. The detailed terms, responsibilities and rights of the partners in terms of IPR management will be defined in the Consortium Agreement as well.

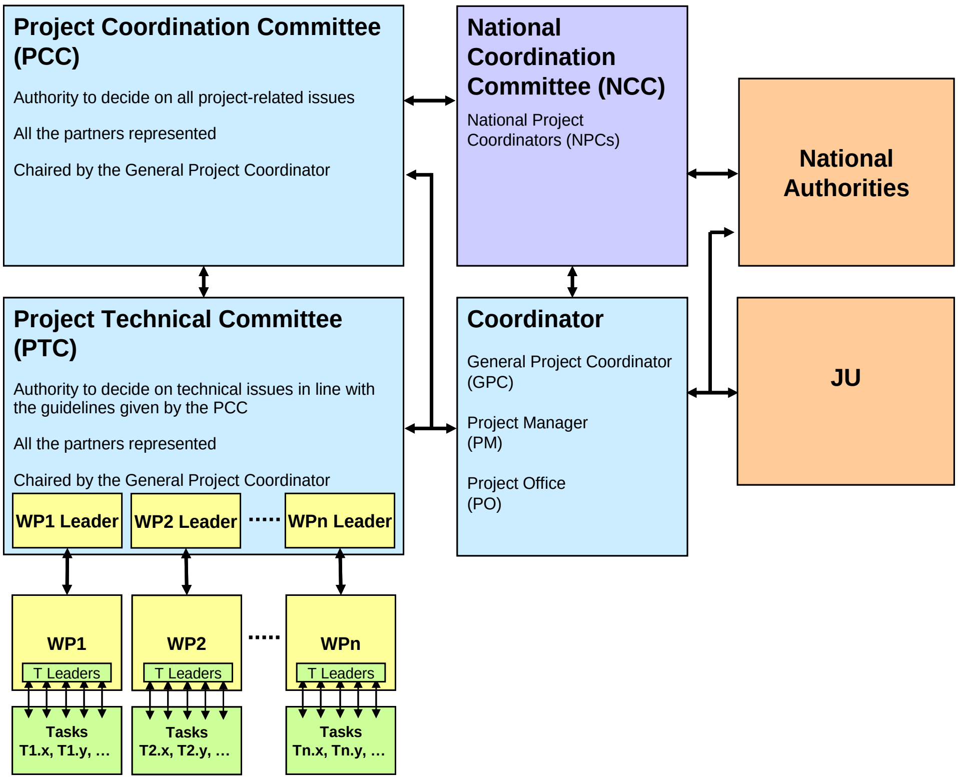
Appropriate means and tools for knowledge management and IP protection will be formulated and adopted by the partners and the Consortium, specifically around issues of protecting and/or sharing IP in ways that create incentives for all partners in the collaboration. In the framework of the ERG project, the IPR-related activities will span all kinds of “knowledge and invention protection” and intellectual property rights management, the objective being to enhance the exploitation of the existing and newly generated intellectual property. This will be achieved through two avenues. First, by undertaking actions that will enable the creation of a project-level IPR management strategy, which will leverage the experience and competence which is available from the individual partners, to develop a truly European dimension. Second, by implementing specific actions aimed at developing new models for IPR management and use.

8 QUALITY OF CONSORTIUM AND MANAGEMENT

8.1 *Management structure and procedures*

The management approach for the ERG project builds upon the structures and procedures of former FP6/FP7 IP projects (e.g., “CLEAN”, “THERMINATOR”, “NANOCMOS”, “PullNANO”, “COMSON”) and ENIAC projects (e.g. Call 1 “MODERN” and Call 2 “END”, “CSI”, “LASTPOWER”) that are of a similar size and complexity. The management structures of such projects have proven to be adequate, efficient and able to quickly respond to any changes and threats to the project. As such, they will be applied to the ERG project as well.

The project management will consist of the following structures and functions, whose interaction is shown in the figure below.



ERG project management structure.

- General Project Coordinator (GPC)
- Project Coordination Committee (PCC)
- Project Technical Committee (PTC)
- Project Manager (PM)
- Exploitation Manager (EM)
- Work-Package Leaders (WPLs)
- Task Leaders (TLs)
- Project Office (PO)
- National Coordination Committee (NCC)

- National Project Coordinators (NPCs)

The project is coordinated by the General Project Coordinator (GPC). The Project Coordination Committee (PCC) includes the GPC, the Project Manager (PM) and the Project Office (PO). The PCC nominates the Exploitation Manager (EM) and decides on all organizational project-related issues, whereas the Project Technical Committee (PTC) decides on all technical project-related issues. Both will be assisted by the PO, which is located at the GPC site. Each project work-package will be coordinated by the corresponding Work-Package Leader (WPL). Each project Task will be coordinated by the corresponding Task Leader (TL). The GPC is the main interface to the JU. The liaison of the GPC to the National Authorities is provided by the National Coordination Committee (NCC), which is composed of the National Project Coordinators (NPCs).

8.1.1 General Project Coordinator (GPC)

The project will be coordinated by the General Project Coordinator, who will be properly assisted by the Project Office. The GPC is responsible for the following tasks:

- Interfacing to the JU and the NCC
- Distribution of the funding
- Preparation of Reviews and Project meetings (PCC, PTC)
- Chairing of PCC and PTC
- Negotiation on contract, budget, Consortium Agreement, LOI
- Management of the Consortium in the wide sense on a continuous basis

8.1.2 Project Coordination Committee (PCC)

The PCC is composed of one representative for each partner in the Consortium, plus the GPC, the PM, the WPM2 leader and the EM. The representatives will have the authority to make decisions on behalf of his or her organization in terms of overall strategy and resources allocated to the project. The GPC will chair the PCC. The PCC is responsible for the overall direction of the project and has a final decision authority. The PCC will meet at least 3 times per year and more often as required for administrative and scientific management. The decisions will be taken by consensus or by simple majority in the case where consensus is not possible. Changes to the work-plan will require consensus or a double majority. Each member of the PCC, except PM, WPM2 leaders and EM, will have one vote. The General Project Coordinator will resolve any tie in the vote. The voting procedure as well as the responsibilities of the PCC will be laid down in the Consortium Agreement (EPCA). The main responsibilities are summarized as:
The daily management of the project.

- Deciding on adaptations of the work-plan
- Agreeing on the (re) allocation of the project's budget
- Making proposals for reviewing/amending the contract, if the case
- Taking measures to cope with defaulting partners
- Maintaining the Consortium Agreement
- Appointing the Exploitation Manager

8.1.3 Project Technical Committee (PTC)

The PTC is composed of the WP Leaders and, since all partners in the Consortium shall be represented in the PTC, (co-opted) partner representatives, plus the GPC, the PM and the EM. Members of the PTC differ from the PCC for their scientific and technical focus. The representative in the PTC shall be able to make decisions as to the particular technical interests and how to use the resources allocated to achieve the project's goals. The members of the PTC will be appointed by each of the prime partners. The GPC will chair the PTC. The PTC is responsible for the monitoring of the project progress and the preparation, review and updating of the detailed work-plan. The decisions will be taken by consensus or by a double majority in the case where consensus is not possible. Each member of the PTC will have one vote, except the PM and EM, unless they are delegated by any other member. Changes to the work-plan will require consensus or a double majority. The PTC will meet every 3 months. Meetings will be generally held by telephone conference. The voting procedure as well as the responsibilities of the PTC will be laid down in the Consortium Agreement (EPCA). The main responsibilities are summarized as:

- Coordinating the overall technical work on a continuous basis
- Coordinate the interaction and collaboration across Activities
- Proposing to the PCC budget (re)allocation and work-plan adaptation, when and if needed.

8.1.4 Project Manager (PM)

The Project Manager (PM) is appointed by the Coordinator. He/she is the head of the Project Office and he/she is in charge of the daily management of the project. The technical management of the project remains in the WPM2 leader.

8.1.5 Exploitation Manager (EM)

The Exploitation Manager (EM) will be responsible for the day-by-day management of the project exploitation activities. He will be in charge of the coordination of the exploitation actions for the THERMINATOR Consortium as a whole. The Exploitation Manager is a voting member of PCC and PTC, and is appointed by the PCC.

8.1.6 WP Leader (WPL) and Task Leader (TL)

The main responsibilities of the **Work Package Leaders** are summarized as:

- Co-ordinate the work in the WP
- Ensure a close communication among the participants
- Convene WP internal meetings
- Ensure the on-time availability of WP deliverables
- Participate to the meetings of the PTC
- Report progress and deviations from the work-plan to the GPC and the PTC

WP Leaders are assisted by **Task Leaders**, whose mission is to:

- Organize the technical exchanges between the partners contributing to the Task
- Check the progress and on-time delivery of the Deliverables of the Task
- Report to the Work Package leader, who will be coordinating all Tasks of his WP.

8.1.7 Project Office (PO)

Administrative management is the prime responsibility of the Project Office, assisted by an administrator and secretary from the coordinators staff. The Project Office is located at the Coordinator’s site. The main responsibilities of the Project Office are:

- Organizing meetings of members of the Consortium
- Taking care of payment’s delivery to the partners
- Collecting documentation, for the monitoring of the activities within the WPs
- Controlling the financial reports from the individual groups
- Collecting deliverables for submission to the JU

- Preparing a detailed list of deliverables, partner contact information, preparing and updating of the project calendar, establishing mailing lists

8.1.8 National Project Coordinators (NPCs)

The partners of each country represented in the project nominate among, them one, representative as their National Project Coordinator (NPC). The NPCs are appointed for the whole duration of the project and are responsible for coordinating the administrative actions internally to the national partnership of concern and to act as the interface towards the corresponding Public Authorities.

8.1.9 National Coordination Committee (NCC)

The NCC consists of all the National Project Coordinators; it is in charge of interfacing with the National Authorities for tasks such as budget negotiations and contract issues, as well as with the JU. In particular, the NCC coordinates activities related to EU and/or country policies and rules. The formal delegate acts as information, communication and coordination channel for all partners in his/her country. He/she ensures that all partners follow both the EU and country specific rules and requests about the project.

8.1.10 Management of pre-existing know-how, knowledge and IP protection

The project does provide means and tools for knowledge management and IP protection. Section 4.4 focuses specifically on the issue of protecting and/or sharing background and foreground intellectual property in an appropriate manner. In this respect, a key role will be played by the Exploitation Manager, whose function is that of coordinating and supervising the set-up of the measures and procedures for effectively handling IPR.

8.1.11 Decision process and conflict resolution

Mandatory decision rules and agreements are necessary for the success of the project. The decision making process will follow the policy to reach agreement as close as possible to the level of execution. Only if agreement will not be reached on a given level, the decision will be escalated to the next appropriate level.

Decision scope at the **Task level**: All partners being involved in a given Task are eligible to contribute to a decision regarding that Task. In case a capable decision cannot be taken at this level, the issue has to be forwarded to the WP Leader.

Decision scope at the **WP level**: All partners being involved in a WP are eligible to contribute to a decision with regards to this WP. In case a capable decision cannot be taken at this level, the issue has to be forwarded to the GPC.

Decision scope of the **PTC level**: The Project Coordination Committee is responsible for technical assessment of each deliverable and for taking decisions regarding the action plans.

The supreme decision committee is the PCC.

8.2 Individual partners

1. STMicroelectronics (ST)S

Organisation profile

STMicroelectronics is a global independent semiconductor company, world leader in developing and delivering semiconductor solutions across the spectrum of microelectronics applications.

ST is the world's fifth largest semiconductor company with net revenues of US$8.51 billion in 2009. According to the latest industry data from iSupply, ST holds market leadership in many fields. The Company is the leading producer of application-specific analog chips and power conversion devices. It is the #1 supplier of semiconductors for the Industrial market, set-top box applications, and MEMS (micro-electromechanical systems) chips for portable and consumer devices, including game controllers and smart phones. ST also occupies leading positions in fields as varied as automotive integrated circuits (#3), chips for computer peripherals (#3), and the rapidly expanding market for MEMS overall (#5).

Product Portfolio

ST aims to be the leader in multimedia convergence and power applications, offering one of the world's broadest product portfolios, including application-specific products containing large proprietary IP (Intellectual Property) content and multi-segment products that range from discrete devices to high-performance microcontrollers, secure smart card chips and MEMS devices. The Company provides solutions for a wide array of Digital Consumer applications, with a particular focus on set-top boxes, digital TVs and digital audio, including radio. In the Computer Peripherals arena, ST provides leading solutions in data storage, printing, visual display units, power management for PC motherboards, and power supplies. A wide range of ST's ASSPs (Application Specific Standard Products) power sophisticated Automotive systems such as engine control, vehicle safety equipment, door modules, and in-car infotainment The Company also supplies industrial integrated circuits (IC) for factory automation systems, chips for lighting, battery chargers and power supplies, as well as chips for advanced Secure Access applications. ST pioneered and continues to refine the use of platform-based design methodologies for complex ICs in demanding applications such as mobile multimedia, set-top boxes and computer peripherals.

Research & Development and Manufacturing

Since its creation, ST has maintained an unwavering commitment to R&D and is one of the industry's most innovative companies. ST is a partner in the IBM consortium for the development of next-generation CMOS process technologies, including 32nm and 22nm, adapted to the manufacturing of 300mm silicon wafers in Crolles (F). In 2009 ST spent US$2.37B in R&D, which is approximately 28% of the Company's total revenue. ST has established a worldwide network of strategic alliances, including product development with key customers, technology development with customers and other semiconductor manufacturers, and equipment- and CAD-development alliances with major suppliers. These industrial partnerships are complemented by a wide range of research programs carried out with leading universities and research institutes around the world, in addition to playing a key role in Europe's advanced technology research programs such as EUREKA (cluster CATRENE), FP7, JTI's such as ENIAC (European Nanoelectronics Initiative Advisory Council) and ARTEMIS (Advanced Research & Technology for Embedded Intelligence and Systems), and some of the major European Technology Platforms (ETP), like EPOSS (on micro-nano systems) and NEM (Network Electronics Multimedia).

At the regional level, STMicroelectronics is participating, or has been in the past, to the following European projects relevant to ERG: FP7 THERMINATOR: FP5 EASY;PERLA, FP6:CLEAN;MORPHEUS; SYMTECO (Marie Curie); COMSON (Marie Curie), ENIAC MODERN; END; LASTPOWER.

Main role in the project

Within the scientific scope of ERG, ST is participating with 3 teams: R&D group for solar cell activity in WP1 and Project Management in WPM1 and WPM2, and Systems Lab and Photovoltaics BU for distributed photovoltaic architectures in WP2. Each group has strong experience in the related sector of activity, spanning from semiconductor technologies to innovative materials and from analog and digital ICs to complex power electronics systems.

Key Staff Members Profile

Francesco Gennaro graduated cum Laude in 1996 at the University of Catania in Electrical Engineering and pursued the Ph.D. in Electrical Engineering in 2000 at the same University. Currently he is Team Manager of “Power Converters” inside Systems Lab, the Application Laboratory for Industrial and Multisegment, Sector developing system solutions in several application fields of power electronics and energy management.

Marina Foti obtained the Degree in Physics (1997) at the University of Catania (Italy) and she joined ST Microelectronics in 1998. She worked in Central R&D Group as Process Engineer on process development for Flash Memory technology node from 0.35 μm to 90 nm in Catania, Agrate and Singapore ST Sites; she coordinated defectivity reduction and yield enhancement activity for 90 and 65 nm technology in Crolles2 Alliance 12” Fab. Since 2008, she has been working on Photovoltaic as Technology Development Project Leader inside IMS (Industrial & Multisegment Sector) R&D organization in Catania.

Giuliana Gangemi graduated cum Laude in 1992 at Catania’s University in Applied Mathematics and, during the same year, joined STMicroelectronics as EDA engineer in a digital design team, whose projects were large 32bits SoCs and where she ended up having the responsibility of CAD Support and Development Manager. Since June 2007 Giuliana has joined the IMS CAD and Design Services Department in order to manage The Transfer of Knowledge and Research.

Salvatore Rinaudo, Director of CAD & Design Services Department of Industrial and Multisegment Sector of STMicroelectronics. He received the Laurea degree in nuclear engineering from the University of Palermo, Palermo, Italy, in 1989. He was involved in numerical simulation of semiconductor devices with emphasis on optimization and parameter extraction techniques for process and device design. Since 1991, he has been with STMicroelectronics, Catania, Italy. Since 2000, he has been responsible of Design Methods Developments covering also Process, Device and Physical Modelling across technologies, designs and Data management, Design Services and Knowledge Management.

Tiziana Signorelli graduated cum Laude in 1998 at the University of Catania in Informatics Engineering, joined STMicroelectronics during the same year. Currently she is Design Architecture Project Manager inside the Photovoltaic Business Unit of Industrial and Power Conversion Division of STMicroelectronics, providing architecture definition of new ICs for Photovoltaic application field.

Roberto Zafalon, EU Projects Director - Italy, is in charge to foster and leverage the link between ST technology groups and the R&D cooperative EU programs. Until June 2007 he has been the head of the Competence Center for Low Power System Design at the Advanced System Technology R&D group in STMicroelectronics, Agrate Brianza (Milano), Italy. In his current capacity since July 2007, he elaborates the vision and roadmap, seeks for project financing and drives industrial R&D teams to pursue innovative solutions in the field of embedded systems and nanolectronics, for corporate product divisions and labs. He is an active member of ARTEMIS’s and ENIAC’s WG’s and he currently is, and has been in the past, General Project Manager and Coordinator of major Integrated Projects under FP6, FP6 and JTI 2nd call. He contributed to over 66 international scientific publications so far, including conferences, Journals/Transactions, invited papers and books. He holds 8 international patents, four European, three USA and one Japanese, in the field of low power design, processors and computing architectures. He has been elected Senior Member IEEE in 2006.

2. Applied Materials Italia (AMAT ITALIA)

Organisation Profile

Applied Materials Italia was founded in 1967 as Baccini SpA, and in 1972 developed its first screen printing machine for microelectronics, most likely the very first in Europe at the time. In 2008 Baccini SpA has been acquired by Applied Materials and is now Applied Materials Italia Srl. It is the world leader in equipments for screen printing, handling equipments, and laser for the photovoltaics industry. The know-how of Applied Materials Italia is protected by many registered, filed or under filing patents, thanks to a great R&D effort carried out both internally (by using AMAT R&D workforce and network) and externally, in collaboration with R&D institutions around the world and with its customers.

Applied Materials Italia expertise in the crystalline silicon solar cell field ranges from to screen printing (where it is by far the worldwide market leader) to laser processes and systems, to test and sort equipment.

Key competences are: design and manufacturing of advanced automation systems, laser platforms, screen printers, advanced metallization processes, test and sort equipments, for the cSi solar industry.

Facilities provided are: state-of-the art laboratory focussed on advanced metallization of solar cells; production plants; design and test facilities.

In order to proactively comply with increasing requests for high precision, versatility, and reliability, in the last years AMAT Italia has reinforced its existing automation and advanced equipment design team, and created a new process development team. The close collaboration between these teams and the constant attention to customers' request is not only the foundation for future growth, but also the technical resources that AMAT Italia will provide to the project.

Particularly, the ***Automation and advanced equipment design team****,* constituted of more than 20 resources, deals with automation systems design, High Level and Low Level SW design, assisted mechanics and electronics; while the ***Process development team***, with 6 resources (and growing), deals with the enhancement, optimisation and re-design of processes through optimisation of the machines functional parameters.

Main Role in the Project

The Consortium will focus its activity on the development of novel strategies to increase efficiency and cost / efficiency figures of PV cells, with particular emphasis to the case of cells for concentration systems and of back contact crystalline cells. In accordance to this, AMAT will investigate the development of new equipments and/or the adaptation of existing equipments for the fabrication of this type of devices.

In particular, the aspects to be investigated will be the study on automated or semi-automated production lines suitable for back-contact cell production. Although the world record efficiency for crystalline silicon (c-Si) solar cell has been obtained with a front contact cell (Passivated Emitter Rear Local diffused, or PERL, cell), the back contact approach is widely seen as the way to achieve very high efficiency without incurring in too high cost. Hence, several alternatives are available at the lab scale to design and realize back contact cells, including several flavours of Interdigitated Back Contact, Metal Wrap Through, Emitter Wrap Through processes. While of these the first is the only one in mass production (by Sunpower), many manufacturers are looking at one or more of these approaches for their high efficiency roadmap. However the road to manufacture back contact cells with standard equipments and low cost is very difficult, and includes challenges such as the low-breakage handling (especially in case of cells, such as emitter wrap through and metal wrap through, featuring several or many laser-drilled holes), screen printing of materials other than standard metal pastes (such as inks, dopant sources, or mask layers), screen printing in the presence of holes, dedicated inline metrology systems and techniques (including for example microcracks, lifetime, print quality, efficiency measurement, and so on). All these aspects will be taken into account to design an automated or semi-automated line for metallization and back-end processing of back contact cells.

Partly in parallel and partly by transferring the experience accumulated, AMAT will study the feasibility of automated lines for mass production of concentration PV cells. In this case the challenges are different and are linked to the reduced dimension of the cells, but with several points of contacts, including the improved resolution of laser scribing tools, novel non conventional Si doping techniques, and dedicated cell metrology tools.

Key Staff Members' Profiles

Giorgio Cellere is Responsible for Research and Innovation in AMAT. He received PhD in Electronic and Telecommunication Engineering from the University of Padua and carried out a post-doc position working on reliability issues of microelectronic devices, in particular for space and biological applications. Prior to joining Applied Materials, he was founder in 2004 of the Biosilab company, and he developed and managed a number of scientific collaborations, both national and international. He is official reviewer for international scientific journals, and member of the scientific committee for international conferences (IEEE-ICICDT, IEEE-NSREC, RADECS). He is author of more than 100 scientific publications and patens, and received several scientific awards.

Tommaso Vercesi is Advanced automation manager in AMAT. Expert of Industrial informatics, he has a thorough experience in motion control and automation and is managing the automation team in the R&I dept. in AMAT.

Marco Gagliazzo is process manager in the R&D group at AMAT. He received a master in Applied Optics from the University of Padua. His scientific-technical experience focuses on the fields of advanced optics, laser and photovoltaics, with particular attention to the application of nanotechnologies and organic chemistry.

3. Compel Electronics s.p.a. (COMPEL)

Organisation profile

The foundations of Compel were laid in 1972 when a private group of investors established Compel Electronics in Cornate D'Adda, Italy. The company began its activity in developing and manufacturing multipin and coaxial connectors for the Telecommunication industry.

Compel Electronics is a private company with broad competencies in interconnection systems, from a simple connector to the most complex assembled rack for mobile radio base station.

In the course of the years, Compel enriched its competencies in different applications mainly related to telecom infrastructure: FTTx, switching, routing, media converters, antennas, cabinets; both copper and fiber optic.

At the same time Compel diversified its activities in different market segments: communication, networking, data equipment, broadcast, defense, transportation and last but not least photovoltaic. This one represents nowadays a strong challenge in the promising sector of renewable energies, where Compel is continuously present developing and manufacturing complete families of connectors / adapters as well as a wide range of Junction Boxes for the Photovoltaic Panels.

Compel has the privilege to serve the major companies in the communication and energy sectors.

Main role in the project

One of the main tasks of the ERG project will consist in increasing the efficiency of the distribution of power outgoing from the Photovoltaic Panels (PVs). Compel Electronics S.p.A. will be involved in the design of an innovative Junction Box for advanced photovoltaic modules, increasing the efficiency of its internal connections due to the reduced contact resistance and consequently the reduced power loss.

The new Junction Box will host the electronics for MPPT tracking, improving the power efficiency of each PV panel or its subassemblies using smart functions of power management. The power dissipation of the electronic components will be optimized in compliance with the safety requirements of the photovoltaic environment with the aim to improve the power distribution.

The design of the new Junction Box will also pay great attention to achieve reduced dimensions as well as optimized solutions in order to contribute to save costs of the system. This will be obtained through innovative design concepts and state-of-the-art materials, which also will allow the new Junction Box to be processed in highly automated assembling operations on the panels manufacturing lines.

Key Staff Members Profile

Maria Santina Marangon. She received the Laurea degree (summa cum laude) in Physics from the University of Milan and joined the R&D of STMicroelectronics, Italy. Over 20 years, she gained a wide experience in materials and technology development for Non Volatile Memories. She led several task forces to support the industrialization phase of new processes. She started and managed the Advanced Metallization R&D section. As company representative she was member in scientific committees (MAM). Besides, as Program Manager, she was involved in many development projects with national and international research institutions and industrial partnerships. She started and led development activities for innovative materials & technologies for new NVM devices (Phase Change Memories, based on chalcogenides). She joined Compel Electronics in 2008 as R&D & Process Engineering Director. She is author or co-author of several papers, conference contributions and international patents.

Mirko Despini. Graduate in Electronics in 1995, he worked for seven years in the R&D department of Alcatel to design and develop analog and digital electronic functions, both for signal and power circuitry. He joined Compel Electronics in 2003 and carried out his activity in the field of R&D interconnection systems. He is involved in many research projects for innovative Interconnection solutions, at first for telecommunications and nowadays in the field of renewable energies components. M.Despini is author of few patents.

4. Consorzio Nazionale Interuniversitario per la Nanoelettronica (IUNET)

Organisation profile

The “Consorzio Nazionale Interuniversitario per la Nanoelettronica” (IUNET, Italian Universities Nano- Electronics Team), is a non-profit, private Organization, aimed to lead and coordinate the effort of the major Italian University Teams in the field of Silicon Based Nanoelectronic Device Modeling and Characterization.

Current Members of IUNET are the Universities of Bologna, Calabria, Ferrara, Modena e Reggio Emilia, Padova, Pisa, Roma “Sapienza”, Udine, and the Politecnico of Milano. They offer reknown and complementary expertise in the field of modeling, simulation, design, characterization of CMOS-based nanometer-size electronic devices and solar cells.

IUNET will contribute with the fabrication, characterization and modeling of advanced ultra-thin solar cells, and with the development of strategies for efficient distributed power generation and management.

Main role in the project (divided to the task involved)

IUNET will contribute to WP1, WP2 and WP4.

Within WP1, IUNET will develop, fabricate and characterize ultra-thin crystalline-silicon solar cells.

IUNET will contribute to WP2 by developing advanced algorithms and circuits for Maximum-Power-Tracking in photovoltaic conversion systems.

The issue of efficient power management in a distributed environment will be addressed in the frame of WP4 by exploiting advanced wireless sensor networks.

Key Staff Members Profile

Claudio Fiegna received the Laurea and PhD Degrees in Electronics Engineering, both from the University of Bologna, Italy. From July 1992 to July 1993 he worked at the "ULSI Research Laboratories", Toshiba Corporation, Kawasaki, Japan.

From 1994 to 1999 he was Research Associate and from 1999 to 2004 he was Associate Professor with the University of Ferrara, Italy. He is now Full Professor of Electronics at the second Faculty of Engineering of the University of Bologna, Italy , where he coordinates the PhD course in “Information Technologies”. His main scientific interests are about numerical device simulation and its application to the analysis of advanced logic, memory and analog MOS device structures, and of silicon-based solar cells. Claudio Fiegna served the Modeling and Simulation Technical Committee of the IEDM Conference and is currently member of the Technical Committee of the ULIS (Ultimate Integration of Silicon) Conference. He is member of the Committee for the IEEE Electron Device Society Education Award.

Fabrizio Palma is Full Professor at the Rome University "La Sapienza" from November the 1th 2000; he is in charge of the course of “Electronics I” and “Radio frequency microelectronics system design” and "Laboratory of Electronics and Telecommunications". He is President of the Didactic Area of Electronic Engineering of the Rome University La Sapienza. Fabrizio Palma research activity concerned thin film electronic devices, in particular amorphous silicon devices. The activity involved photovoltaic conversion systems and light detectors: infrared sensors, ultraviolet sensors, and voltage tenable three color sensor in the visible range. His activity also involved characterization of crystalline and amorphous semiconductor, characterization of thin oxide layer for non-volatile semiconductor memory, integrated optics and surface acoustic wave devices. Past research activity also regarded the theory of phase noise in oscillator circuits and synthesized generators, the architectures of radio receivers, with emphasis to the problematic of CMOS integration, low voltage applications and mobile telephony. He is author of more than 120 international articles among magazines and congress reports. He also holds five international patents, three on thin film detectors, and two on low noise oscillators.

Gaudenzio Meneghesso graduated in Electronics Engineering at the University of Padova in 1992 working on the failure mechanism induced by hot-electrons in MESFETs and HEMTs and received the Italian Telecom award for his thesis work. In 1995 he was at the University of Twente, The Netherland working on the dynamic behavior of protection structures against ESD. In 1997 he received the Ph.D. degree in Electrical and Telecommunication Engineering from the University of Padova working on hot-electron characterization, effects and reliability of GaAs-based and InP-based HEMT's and pseudomorphic HEMT's. Since 2002 is with University of Padova as Associate Professor. His research interests are: i) Electrical characterization, modeling and reliability of microwave and optoelectronic devices on compound semiconductors; ii) Electrical characterization, modeling and reliability of RF-MEMS switches for reconfigurable antenna switches; iii) Study of the sensitivity of Electronics devices to Electrostatic discharge and development of suitable protection structures; and iv) Characterization and reliability of organic semiconductors devices. Within these activities he published about 400 technical papers (of which more than 50 Invited Papers and 6 best paper awards). He has been the General Chair of three conferences: HETECH 2001, HETECH 2008 and WOCSDICE 2007; He has been the Technical program Chair of WOCSDICE 2001, of the International Electrostatic Discharge Workshop (IEW) 2010 and he is the TPC co-chair of ESREF 2010. He is in the steering committee of several European conferences. He also served several years for the IEEE-International Electron Device Meeting (IEDM). He is Associate Editor of the IEEE Electron Device Letter for the compound semiconductor devices area since 2007.

5. Politecnico di Torino (POLITO)

Organisation profile

Politecnico di Torino (POLITO), with over 27,000 students, is the second largest technical university in Italy. The workforce dedicated to research and teaching includes around 900 Professors, 700 PhD Students and 300 Research Assistants, covering all major areas of the engineering and architecture disciplines.

POLITO participates to the ERG project through the EDA (Electronic Design Automation) group, which belongs to the Dipartimento di Automatica e Informatica. The group consists of 2 Full Professors, 1 Associate Professor, 2 Assistant Professors, 2 Post-Doc Researchers, 3 PhD Students and 10 Research Assistants. The research activities of the group are focused on the development of methodologies, algorithms and tools for the computer-aided design of power-efficient integrated circuits and systems. More specifically, research topics which are currently under investigation include: Leakage-aware design techniques, power and timing optimization under thermal and process variation constraints, power-driven clock-tree synthesis, RTL power estimation and management, low-power memory and bus interface synthesis, battery management, energy management systems and architectures.

POLITO has successfully participated to several EU-funded projects in the domain of microelectronics design, such as PEOPLE (FP4), POET, EASY, MARLOW and INTRALED (FP5), CLEAN and MAP2 (FP6). Currently, POLITO is involved in the ENIAC Call 1 MODERN project, the ENIAC Call 2 END project and the ENIAC Call 2 CSI project. It is also participating to the FP7 ICT THERMINATOR, COMPLEX and SEEMPUBS projects.

Main role in the project (divided to the task involved)

POLITO will contribute with smart energy management solutions for multi-supply systems. Since a PV supply system is available intermittently, a sort of accumulation is needed, usually through a rechargeable battery. Under some particular conditions (full sunlight), however, it might be convenient to distribute the available energy to the load and to the battery in a non obvious way. The conventional paradigm is to consider the PV cells as the 'charger' element of the storage device: when light is available the battery is charged, and the battery is viewed as the true "supply device".

The proposed approach corresponds to have a "peer" view of the two energy sources (PV and battery) as supply devices: in practice, to map the As a matter of fact, there might be periods of low irradiation in which the battery experiences low state-of-charge (SOC) periods and in which the electrical load is attempted to be matched. A smart management system would monitor the SOC and gradually reduce the energy taken from the battery (i.e., reduce the load) to help prevent continuous operation at a low SOC, which deteriorate the lifetime of the battery. Similarly, under condition of excess charge (low load periods in condition of high irradiation), the management system could use the excess charge generated to directly supply the load.

In order to evaluate such scheduling policies, a model of the power sources characteristics (e.g., available charge, voltage, and SOC vs. load current) as well as the typical load conditions (e.g., current profiles). Given those models, POLITO will develop a software simulator that is able to evaluate various "load-driven" energy distribution policies and

calculate the optimal one for the target load.

Key Staff Members Profile

Enrico Macii is a Full Professor of Computer Engineering at POLITO. His research interests are in the design automation of digital circuits and systems, with particular emphasis on low-power design aspects. In the field above, he has authored over 300 scientific publications. He is the Editor-in-Chief of the IEEE Transactions on CAD/ICAS for the term 2006-2009. He has been the Technical Program Chair and the General Chair of several IEEE and ACM conferences (e.g., the ACM/IEEE International Symposium on Low Power Electronics and Design, the IEEE PATMOS Workshop, the ACM/IEEE Great Lakes Symposium on VLSI). He was the technical manager at POLI for several EU-funded projects in the domain of microelectronics design, such as PEOPLE (FP4), POET, EASY and MARLOW (FP5), CLEAN and MAP2 (FP7). He was also the General Project Coordinator for project INTRALED (FP5). Enrico Macii was an Evaluator of proposals and a Reviewer of projects in the context of the European Commission’s FP4 and FP5, and he was a member of the Micro and Nanoelectronics Design consultation committee of the Nanoelectronics Unit for European Commission’s FP6 and FP7. Enrico Macii is a Fellow of the IEEE.

Massimo Poncino*,* Full Professor, received his PhD degree from Politecnico di Torino in 1993. His research interests are in the design automation of digital circuits and systems, with particular emphasis on low-power systems and embedded systems. In the fields above, he has co-authored over 200 scientific publications on peer-reviewed international journals and conference proceedings. He is an Associate Editor of the IEEE Transactions on CAD/ICAS since 2006. He has served on the Technical Program Committee of several CAD-related conferences, including DATE, ISLPED, GLSVLSI and PATMOS. He was an Evaluator of proposals in the context of European Commission’s FP5. Massimo Poncino is a Member of the IEEE.

Alberto Macii, Associate professor received his PhD degree from Politecnico di Torino in 2000. His research interests include several aspects of the computer-aided design of nanoelectronic circuits and systems, with particular emphasis on low-power design aspects. He has authored or coauthored over 130 scientific publications in the areas above, including a scientific book on memory design techniques. He is Senior Member of the IEEE.

6. Università di Bologna (UNIBO)

Organisation profile

UNIBO, founded in 1088, is the oldest university in the western world, and one of the largest in Italy (with more than 100,000 enrolled students). It is one of most active Italian universities in research and technology transfer, and it is the top Italian University for 7th FP funding and project participation.

UNIBO participates to the ERG project through ARCES (Advanced Research Center on Electronic Systems for Information and Communication Technologies) group, which was founded on 2001. The group consists of 10 Full Professors, 8 Associate Professors and 16 Research Assistant. Additionally there are 12 senior research fellows and 44 Ph.D. students and junior research fellows.

ARCES main goals are:

1) to develop innovative electronic systems, ranging from integrated sensors to micromechanical devices, from analog and digital signal processing architectures to multimedia communication equipments;

2) to conduct research activities in the field of wireless communications;

3) to devise new solutions for their applications in the field of image processing, machine vision, pattern recognition and pervasive computing;

4) to carry out the technology transfer of the more relevant research results to the National and European Industry.

Main role in the project (divided to the task involved)

UNIBO will collaborate to tasks of

- WP2, mainly tasks T2.1: the activity will focus on the design and preliminary demonstration of a distributed sensor and control system for sun light concentration.
- TM1.3: dissemination by developing a training course in the field of optical concentration.

Key Staff Members Profile

Roberto Guerrieri, Full Professor, received Electrical Engineering degree and Ph.D. from the University of Bologna where he is now Full Professor in Electrical Engineering. From 1986 he has been visiting the Dept. of EECS at the University of California at Berkeley and the Dept. of Electrical Engineering at the MIT in Boston. During his scientific activity he has published more than 90 papers in various fields including numerical simulation of semiconductor devices, numerical solution of Maxwell's equations, parallel computation on massively parallel machines and reconfigurable architectures. In 1998 he became Director of the Laboratory for Electronic Systems, a joint venture of the University of Bologna and ST Microelectronics for the development of innovative designs of systems on chip. In 1992 he has been awarded a Best Paper Award of the IEEE transactions on Semiconductor manufacturing for his work in the area of process modeling, and in 2004 an “ISSCC Best Paper Award” for his work on sensor system design.

7. Università della Calabria (UNICAL)

Organisation profile

UNICAL is a public institution established in the academic year 1972/73. It is located in Arcavacata in Rende (Cosenza - Italy). It is a medium size university with about 40.000 students. It has six Faculties and four Centres of Excellence and many advanced research laboratories. The research groups of UNICAL involved in this project are the Evolutionary Systems Group (ESG), within the Department of Mathematics, and the Microelectronics and Microsystems Laboratory (MML), within the Department of Systems Engineering and Electronics.

ESG (http://galileo.cincom.unical.it) is composed of approximately 25 people, among scientists, associate researchers, fellows and Ph.D. students. ESG aims at promoting scientific interchange and high formation in various fields related to Evolutionary Systems, such as Dynamical Systems and Chaos, Evolutionary Robotics, and Industrial Mathematics, using the modern technologies and the mathematical modeling approach. The research activity on Industrial Mathematics is mainly devoted on the modeling of microelectronic and nanoelectronic semiconductor devices, by means of macroscopic and kinetic models of transport. ESG has promoted a Ph.D. curriculum in Science and Technologies of Complex Systems, part of the Ph.D. School "Archimedes" in Science, Communication and Technologies. ESG has coordinated and coordinates many national and international Projects: MODERN **(**<u>*MO*</u>*deling and* <u>*DE*</u>*sign of* <u>*R*</u>*eliable, process variation-aware* <u>*N*</u>*anoelectronic devices, circuits and systems*), ENIAC JU project; COMSON **(**<u>*Co*</u>*upled* <u>*M*</u>*ultiscale* <u>*S*</u>*imulation and* <u>*O*</u>*ptimization in* <u>*N*</u>*anoelectronics*), FP6 Marie Curie RTN project; InterLink project on **"***Mathematical Models and Applications to Microelectronics", MIUR* program to foster the internationalization of the universitary system, by promoting international collaboration among universities; PRIN on "*Mathematical Modelling of Natural and Artificial Behaviour*", MIUR 2005-2006.

The Microelectronics and Microsystems Laboratory (MML) of the University of Calabria (UNICAL) is involved in research on the main areas of Electronics: design of analog and digital integrated circuits and systems, electrical and optical characterization of semiconductor devices, design of electronic instrumentation, data acquisition and elaboration. Its staff is composed of 7 Faculty members, 1 lab technician and 5 research assistants. The R&D area spans over 2 floors and occupies a surface of 300m2, fully equipped for the design of integrated circuits and electronic systems, electronic devices characterization and electronic system testing. Besides academic research activity, the laboratory provide scientific support for several private companies and numbers important cooperation activities with international research centers as the University of Rochester, New York, USA; University of Massachusetts, Lowell, USA; Idaho State University, Pocatello, USA; IMEC, Leuven, Belgium; CNR- IMM; Università "Mediterranea" di Reggio Calabria, Università di Bologna, Università di Siena, Politecnico di Milano. The laboratory is equipped with a broad series of advanced devices and tools for: design of analog and digital integrated circuits and systems (5 Sun workstations; Cadence, Synopsys, Mentor Graphics, HSPICE tools; access to fabrication facilities for several technology process from AustriaMicroSystems, STMicroelectronics, UMC), electrical characterization (probe station: SUMMIT 11861B, Cascade with Temptronic thermal controller (-65 °C to 200 °C); parameter analyzer: 4200-SCS, Keithley; LCR meter), data acquisition and elaboration (high-bandwidth oscilloscope: Wavemaster 8300A, LeCroy; Vector Signal Generator 2.7 GHz: NI PXI-5670; Vector Signal Analyzer 2.7 GHz: NI PXI-5660; Digital Waveform Generator/Analyzer 100 MHz: NI PXI-6552; 40 NI Multifunction Data Acquisition Boards; 12 NI FieldPoint Systems; 10 NI PXI-Chassis with P4 Controller; Power meters, form factor meters), and optical characterization (optical spectrum analyzer Ando AQ-6315B; monocromator/spectrograph Digikröm DK480).

Main role in the project

WP1 Innovative solar cells

Objectives:

The aim is the numerical simulation of a single PV cell in amorphous silicon, and the optimization of the coupling of several cells.

Task: mathematical modeling and simulation of photovoltaic conversion and silicon-based nanostructures.

Task: mathematical modeling and simulation of the coupling of several cells.

Total person-months in WP1: 25

WP3 Efficient power conversion

Objectives:

To define suitable electronic system architecture for the efficient implementation of automated charging algorithm for batteries suitable for automotive and energy storage systems; an hardware demonstrator of an enhanced efficiency smart battery charger.

Tasks:

The work is aimed to the study of architectural solution for smart charger capable of implementing the enhanced efficiency algorithms developed in WP4.

Firstly, the efficiency of the system charger/battery related to different charging techniques will be analyzed, referring to commercial battery technologies.

The development of a hardware demonstrator suitable for the implementation of various dispatching/charging strategies to enhance charging efficiency and battery life cycle

Total person-months in WP3: 11

WP4 Smart energy distribution, utilization and management

Objectives:

The first objective is to obtain a realistic behavioral model for the development and evaluation of suitable energy dispatching policies that allow the optimal utilization of the electric energy coming from the energy distribution system and photovoltaic systems.

The activity is aimed to the development of advanced battery charging algorithms that allow implementing the optimal energy dispatching policies developed in the early stage of the WP. For this phase the objective is to improve the Mean Satisfaction Degree of final users from the value of 67%, at the moment achievable by the use of standard algorithms proposed in literature, to a value of 80-85%.

Smart charging algorithms will be proposed in order to maximize the efficiency of the battery charging process when the previously discussed energy dispatching policies are applied, aimed to increase overall efficiency of the charging process of 10% with respect traditional systems.

Tasks:

The activity will first of all focus on the analysis of real specification of the problem, in particular with regard to expected load trends during a specific time, load specification, maximum and minimum current allowable for a specific load topology.

The development of a realistic behavioural model for the evaluation of suitable energy dispatching policies will follow, which allow the optimal utilization of the electric energy coming from the energy distribution system or by photovoltaic supplies, resulting in a maximum charging efficiency and quality of service.

The third step consists in finding ad-hoc algorithms for the smart management of grids for sustaining the energy demand from large numbers of battery-based systems (both for automotive and energy storage applications), most of all in the presence of solar-photovoltaic-based energy sources.

After this phase, the activity will focuses on the development of specific charging algorithm aiming to enhance the overall charger/battery system efficiency.

Total person-months in WP4: 14

Key Staff Members Profile

Pietro Salvatore Pantano is full professor of Physics-Mathematics at the Engineering Faculty of University of Calabria. He is co-Director of ESG (Evolutionary Systems Group). He coordinates the EU projects “Virtual museum net of Magna Graecia” and “NetConnect” from the technological point of view. Moreover, he is the coordinator of the local research unit in the Marie Curie RTN project COMSON (Coupled Multiscale Simulation and Optimisation in Nanoelectronics), and of the project “Mathematical Models and Applications to Microelectronics” financed by MIUR in the field of "Programs for improving the internationalization process of the Italian University system". His main fields of research are: nonlinear phenomena and theory of complexity; Human-Computer Interaction; communication and new technologies.

Giuseppe Alì earned a Master degree in Mathematics in 1990, at the University of Catania, and a Ph.D. in Mathematics in 1995, at the same University. The following year he was visiting researcher at UCDavis, California. From 1997 to 2003 he was Researcher in Mathematical Physics at the “Istituto per le Applicazione del Calcolo M. Picone” (IAC), CNR, and from 2003 to 2007 was First Researcher at the same Institute. In October 2007 he moved to the UNICAL, as Researcher at the Faculty of Engineering, where he teaches courses on modeling of semiconductor devices and applied mathematics. His research interests include asymptotic methods in applied mathematics, semi-classical and quantum models for semiconductors, coupled modeling of semiconductor devices, electrical networks and thermal effects. He has published over 20 papers in peer reviewed mathematical journals, as well as many conference proceedings, and one book, as coeditor.

Gregorio Cappuccino is associate professor of Electronics at the Department of Computer Science, Electronics and Systems, University of Calabria, Italy. His current research interests include digital and analog electronics, high speed interconnects and embedded systems for smart grid/electric vehicles. He holds several patents in these fields and has authored or co-authored over 60 publications. He has been selected as the recipient of the University of Calabria Young Researchers Award for 1999 and University of Calabria Learning Enhancement Project Award in 1999. Dr. Cappuccino is Associate Editor of the Journal of Circuits, Systems and Computers. Prof. Cappuccino is a IEEE member since 2000 and IEEE senior member since 2008. Since 2010 he is member of the IEEE Analog Signal Processing Technical Committee.

8. Università di Catania (UNICT)

Organisation profile

The University of Catania is one of the oldest academic institution in Italy with 12 Faculties and a School of Excellence. The research institution of UNICT working within the project are the Department of Mathematics and Computer Science (DMI) and the Department of Electrical Engineering, Electronics and Systems (DIEES).

The scientific group of the DMI involved in the project is that of applied mathematics with 3 full professors, 2 associate professor and 2 assistant professor along with 3 PhD students and 2 Post Doc fellows. This group has a long experience in the hydrodynamical modellingof charge transport in semiconductors, in the development of numerical schemes suitable for nano device simulation both at macroscopic and kinetic level, sensitivity analysis, multi-objective optimisation and parameter extraction. DMI will be involved in modelling and optimization. CAT offers direct experience with the state-of-art of sophisticated hydrodynamical modelling and effective robust optimization algorithms that are not common in the standard engineering problems. The group of applied mathematics at DMI has participated to several european and Italian research project. e.g. the RTN project COMSON within the 6FP, the Vigoni project between Italy and Germany, Italian PRIN and PRA, CNR grants. Moreover there is a PhD program on Applied Mathematics and several summer school have been organized on mathematical problems in micro and nano electronics.

The scientific groups working at the Department of Electrical Engineering, Electronics and Systems (DIEES), of the University of Catania have been active since 1971 in the sectors of Electrical and Electronic Engineering, and Systems and Automation. The Department carries out its institutional activities within the territory of eastern Sicily, but with strong scientific links with other Italian and foreign universities and cooperative relationships with industries and public institutions (Fiat, Ansaldo, CNR, ENEA). Among the collaborations, particularly important is that with various groups within ST Microelectronics. The Department operates in an international context, from the relationships that each researchers have woven over the years, which allows to carry out research activities aligned with those developed in the best engineering schools and train young researchers with significant experience abroad. They are conducted using the experimental facilities of the Department and are developed on the basis of modern and competitive strategies, with results of high scientific value, witnessed by national and international awards. The Department includes several laboratories, including that of Electrical Machines and Drives, Power Electronics, that of Microelectronics, the Electrical Measures and Electronic Equipment, the Automation and Systems, all equipped with machines, equipment and measuring instruments and advanced calculation, allowing the realization of experimental research.

With MURST co-financing on Reinforcement of Science and Technology Network, the Centre for the Promotion of Innovation and Technology Transfer (CEPTIT) has been created . The aim of the Centre is to launch projects aimed at encouraging the emergence of new and developing initiatives for existing industries operating in depressed areas, by promoting the use of new technologies for product and process. The heart of CEPTIT consists of an integrated Laboratory, which is used for the development of some electric, electronic and automatic prototypes, as required by SMEs for the development of their innovative products, or selected from proposals received by young graduates to stimulate the development of innovative business ideas.

Main role in the project

UNICT will collaborate to tasks of:

- WP1, task 3: the activity will focus on optimal cell design by advanced evolutionary algorithms.
- WP3, tasks 1,2 and 4: Converter architecture study and design, developing of models for converters including high frequency behaviour, EMC tests on converter prototype.

Key Staff Members Profile

Vittorio Romano is Associate Professor of Mathematical Physics at the Department of Mathematics and Computer Science, University of Catania, Engineering Faculty. His current main research fields are mathematical modeling and simulation of charge transport in semiconductors along with optimization of electron devices using evolutionary algorithms. He has been the scientist in charge in international projects like the RTN project COMSON (*Coupled Multiscale Simulation and Optimization in Nanoelectronics*) within the 6FP of EU and the Vigoni project between Italy and Germany. He has been the director of two international schools, MOMINE08 and MOMINE 09 on Modelling and Optimization in Micro and Nano Electronics, and is member of the PC committee of SCEE (Scientific Computing in Electrical Engineering) 2008 and 2010. He has published over 40 papers in peer reviewed mathematical journals, as well as many conference proceedings, and several chapters of books.

Orazio Muscato is Associate Professor of Mathematical Physics in the Department of Mathematics and Computer Science, University of Catania. His research fields are transport models for semiconductor, Monte Carlo simulation, statistical design for yield optimization. He has been responsible of national and international research project, among which Italian C.N.R. grant (1997), I.B.M. Corporation “J.T. Watson Research Center”, Yorktown Heights, New York (USA) (1993,1994,1995,1997), Progetti di Ricerca d’Ateneo (2005,2006,2007,2008).

Prof. Alfio Consoli was born in Catania, Italy, in 1949. In 1972, he graduated in Electrical Engineering from the Politecnico di Torino, Italy. After a short period at Fiat in Torino, Italy, working at the R&D unit, he has been with the University of Catania since 1975. He is Professor of Electrical Machines since 1986, teaching in the areas of electrical machines, electrical drives and power electronics. He has authored or co-authored over 250 technical papers, as a result of more than thirty years of research activity in the areas of energy conversion, electrical drives, robotics, and power electronics with applications in information, industry, consumer products, renewable energies, transportation, control and optimization of such technologies, including electromagnetic compatibility. In such areas, he has directed several international and national research projects performed within the frame of industry cooperation, such as Ansaldo, Genova, Ansaldo Breda, Napoli, ST Microelectronics, Catania, Fiat, Torino, and Reliance, Cleveland, USA, or supported by MURST, MIUR, CNR, ENEA, and the European Community. Among his international achievements, it is worth to mention two IEEE awards, respectively obtained in the year 2000 for the best paper published in the IEEE Transactions on Power Electronics, and in 1998 as the third prize paper presented at the IEEE-IAS Annual Meeting. Both papers were on sensorless control of ac motor drives. Prof. Consoli holds three international patents, two of them on sensorless control of drives, and is coauthor and coeditor of the book "Modern Electric Drives" published by Kluwer, Amsterdam, The Netherlands, 2000. He is also the author of "Electrical Motors" within the Italian national Encyclopedy "Treccani", Appendix V, Vol.III, pp.564-575.Dr. Consoli is a Fellow of the IEEE of which he was one of the Distinguished Lecturers for the period 2002-2004. From 1997 to 2001 he was a member of the Executive Board of the IEEE-Industry Application Society. Actually he is a member of the Executive Committee of the IEEE Power Electronics Society, where he serves as Chairman of the Technical Committee on "Motor Drives", and is an Associate Editor of the IEEE Transactions on Power Electronics. In 2005-2008 Prof. Consoli was the President of CMAE (Converters, Machines, and Electrical Drives) the Association of the Italian Professors on Power Electronics. Presently he is the Rector Delegate at the National Consortium on Transports and Logistics (NITEL)" and Head of CePTIT, the "Center for Promotion and Transfer of Technological Innovation", that he created in 1999.

Mario Cacciato was born in Catania, Italy in 1969. In 2000 he obtained a position as an Assistant Professor from the University of Rome - "La Sapienza", where he worked in the Department of Electrical Engineering from November2000 to October 2004. In November

2004 he moved to the University of Catania, where he is currently teaching in the Department of Electrical, Electronics and System Engineering. The main scientific interests of Dr. Cacciato include power electronics, control of electric drives, electromagnetic compatibility, renewable energies and hydrogen applications, power electronic devices. Dr. Cacciato is the author of about 60 technical papers, published on journals and proceedings of international conferences, obtained as a result of several research activities that have been developed in collaboration with researchers of Italian and foreigner universities, as well as industry research groups such as ST-Microelectronics, Centro Ricerche Fiat, Ansaldo-Breda, and Ansaldo Ricerche. He is the coordinator of a research unit of the 'PRIN 2006' project of the Italian Minister of University and Research entitled "Integration of Photo-Voltaic Systems in Conventional and Hybrid Vehicles". He has also participated to several research projects founded by Italian and foreigner agencies such as CNR, ENEA, and the European Community. Since 1998, Dr. Cacciato is a member of the IEEE, and since 2004 of AEIT, the Italian Association of Electrical and Electronic Engineers. Within AEIT, he is presently a member of the scientific board of the Automation Group.

9. Consiglio Nazionale delle Ricerche (CNR)

Organisation profile

IMM is one of the institutes of Consiglio Nazionale delle Ricerche (CNR), the largest public research institution in Italy. The IMM permanent staff includes about 120 scientists and 70 collaborators (technical and administrative personnel). The headquarters of CNR-IMM is in Catania, with sections located in Bologna, Rome, Lecce, Agrate and Naples. The section involved in the present project is the one located in Catania.

The activity of CNR-IMM in Catania is mainly devoted to research and development of silicon based technologies, in particular relatively to new materials and devices for microelectronic and photonic applications, development of novel techniques for solid state device characterisation, multi-scale multi-approach process simulation. CNR-IMM Catania is well equipped with computer facilities, among them a cluster of parallel CPU's for computationally intensive calculations, analytical laboratories (TEM, SEM, AFM, SRP, Electrical Measurements, Electro- and Photoluminescence) and processing facilities (ICP-CVD, IR Laser).

CNR-IMM Catania has a significant experience of participation and coordination of national and European projects. In particular, the Institute has been the coordinator of the IST project SCOOP, dedicated to Si-based optoelectronics, FLASH, dedicated to the laser annealing process applied to transistor fabrication, FINFLASH, on memory device by FIN-FET architectures, and NUOTO, on high K dielectrics; it also was principal contractor of the IST projects EQUIS, IMPULSE, FRENDTECH, and ADAMANT. CNR-IMM has been also involved in two TMR projects (ENDEASD and HERCULAS), and, either as contractor or as coordinator, in several national projects on materials science, device design and MEMS subjects.

Main role in the project

In ERG, IMM will be the coordinator of WP1 dedicated to innovative solar cells. IMM will mainly contribute in two ways: realization of hetero-junctions with a-Si:H and O rich a-Si:H or SIPOS on Si by ICP-CVD for Si hetero-junction cells; characterization by state of the art analytical techniques, hence contributing to the physical characterization of materials and devices.

Key Staff Members Profile

Salvatore A. LOMBARDO received a B.S. (cum laude) and a Ph.D. in Physics from the University of Catania, Italy, in 1989 and in 1994, respectively. He joined the Italian National Research Council (CNR) in 1994 and in the period2001-2010 he was Senior Scientist of CNR at the IMM Institute. From 2010 he is Research Manager of CNR at the IMM Institute. He has spent various periods as visiting scientist at Cornell University, IBM-Research, and STMicroelectronics. His research interests are in the field of semiconductor devices and electronic materials. Dr. Lombardo is committee member and served as chair of numerous international workshops and conferences. He was involved in the coordination of several R&D national and European projects and of scientific collaborations with USA, Singapore, and Israel institutions. He is author of 7 patents, 5 review articles, and of about 200 scientific and technical papers published on international journals.

Antonino LA MAGNA was born in Catania (Italy) on April 10th, 1968. He got his Master in Physics (cum laude) and his Ph.D in Physics at the University of Catania in 1992 and 1996 respectively. He was post-doc research fellow at CNR from 1996 to 1999. From 1999 he is a member of the research staff at CNR-IMM, responsible for modeling and simulation activities. From 2009 is a member of the CNR-IMM Scientific Council. He contributed, often as the scientist in charge of CNR-IMM, to several European Project (SCOOP, FRENDTECH, IMPULSE, FLASH, IMPROVE, GRAPHIC-RF, ATEMOX), in the field of semiconductor device processing and modelling. He is author of about 150 publications, delivered several invited talks at international conferences, won 3 awards at national and international conferences.

Vittorio PRIVITERA is Senior Researcher at the Institute of Microelectronics and Microsystems (IMM) of the Consiglio Nazionale delle Ricerche (CNR) and Head of the Group “Advanced methodologies for micro and nanoelectronics”. After joining the IMM staff, he has been a member of the project management committee of several European Projects (ENDEASD, FRENDTECH, IMPULSE) in the field of semiconductor device processing and modelling. He has been the Coordinator of the IST European project “Fundamentals and applications of laser processing for highly innovative MOS technology” (FLASH). He is author of more than 140 publications in international scientific journals, delivered several invited talks at international conferences, won 4 awards at national and international conferences and holds one patent.

Other key staff are Dr. **Rosaria Puglisi** (characterization) and Dr. **Giovanni Mannino** (ICP-CVD).

10. Elettra-Sincrotrone (ELETTRA)

Organisation profile

ELETTRA is an international multidisciplinary laboratory exploiting a third generation synchrotron light source operated by Sincrotrone Trieste as a user facility and developing a fourth generation source (FERMI@Elettra) that will allow the investigation of ultrafast phenomena, like charge/energy transfers, reactive steps in chemical reactions, etc.

ELETTRA produces ultrabright light in the spectral range from Ultra-Violet to X-rays. There are 22 beamlines open to international users. Some beamlines provide micro- and nano-spectroscopies with a lateral resolution inaccessible to campus-based spectroscopies. Other techniques available are XRD and SAXS for the study of the produced material crystal structures. There are beamlines collecting photoemission, x-ray absorption and x-ray emission spectra in few seconds (i.e. ~ 1 s for a photoemission core level spectrum) with all the light polarization possible. Finally, clean rooms are connected to the two deep- and nano-lithography beamlines with instrumentations, like the scanning electron microscope, the electron and focused ion beam, the nanoimprinting lithography, that allow to sculpt matter in the micro- and nano-range.

The accumulated experience has created and consolidated a wide body of skills and technical expertise, whose benefits ELETTRA wishes to offer in support of industry R&D activities. The Industrial Liaison Office (ILO) has been set up by Sincrotrone Trieste to manage technology transfer and to promote the use of Laboratory facilities in applied research and for industrial applications. The ILO technology transfer activities include the industrial usage of the Synchrotron Light, the Product and Software development, R&D projects, Spin-off setup, advance training for external industrial users.

ELETTRA has a proven experience in collaborating with other research institution and industry and in coordinating EC programs, as for example the I3 project IA-SFS under the FP6 and FP7 “Structuring the European Reserch Area” programs.

Main role in the project

Substrates, coatings, solar cells and contacts identified and developed by the project partners will be studied by all the experimental techniques available at ELETTRA. The possibility to study the morphology and chemical state will give an advanced understanding of solar cell interfaces as well as of the used system materials, before and after all the processing conditions. The use of synchrotron light will allow photon energy change in order to be more sensitive to different chemical elements or to have a relatively large penetration depth of the probe, using an electronic and chemical sensitive technique like photoemission, simply working in the hard X-ray or very low UV region of the spectrum, giving an important contribution to the analysis of the buried interfaces. More in general, the analysis performed at ELETTRA will give information on the optimal choice of stoichiometry, on the possibility to adapt the band gap of the systems as well as the band positions relative to a contacting layer, which is a path for a good band matching between layers and will influence the device efficiency.

ELETTRA is also active in studying and developing new full organic and DSSC solar cells. The field of activity spans from the synthesis/growth of advanced photoactive materials (polymers, molecules, carbon-based nanomaterials) and their characterization to the study of organic/inorganic interfaces. Charge generation, charge transfer and transport in organic molecular materials and interfaces will be actively investigated as well as the possibility of using novel materials, like nanotubes and/or graphene, for realizing new electrodes. Studies over the degradation patterns of the cells, in order to get insights into the actual performance degradation mechanisms, will also be performed.

Key Staff Members Profile

Andrea Goldoni, Head of the "Surface Science Division" and coordinator of the "Beamline Group". Experience: growth and analysis of materials and ultra-thin films - including fullerenes, nanotubes, transition metal oxides, simple metals, semiconductors and interfaces – using surface science techniques and electron spectroscopies, study of surface chemical reactions and skills in ultra-high vacuum systems. Coordinator of national projects funded by the Italian Ministry for University & Research (MIUR) and regional projects.

Luca Gregoratti, Head of the ESCA microscopy beamline. Experience: chemical and electronic characterization of materials with photoemission spectromicroscopies and the most used surface science techniques; in particular: nanosensors, carbon-based nanostructures, solid oxide fuel cells, transparent conductive oxides, catalytic model systems for gas catalysis, thin films, etc. Coordinator of national and regional projects. Main inventor of two patents related to an innovative anticounterfeiting technology owned by Sincrotrone Trieste.

Alessandro Fraleoni Morgera, Researcher. Experience: Expert in synthesis and characterization (among other techniques, UV-Vis and infrared spectroscopy, NMR, chromatographic analytical techniques, thermal analysis) of organic semiconducting compounds, as well as in organic single crystals growth from solution. Experienced in the fabrication of polymer-fullerene solar cells using various deposition techniques (spin-coating, casting, PVD), and in their characterization (profilometer, scanning probe microscopy, electrical-photoelectrical characterizations). Expertise on the topic of anisotropic transport in organic single crystals and charge transport in semiconducting polymers. Participation as a partner in several regional and national research projects in the field of organic photovoltaics.

11. ON Semiconductor Belgium BVBA (ONSEMI-B)

Organisation profile

With its global logistics network and strong product portfolio, ON Semiconductor is a preferred supplier of efficient power solutions to customers in the power supply, automotive, communication, computer, consumer, medical, industrial, mobile phone, and military/aerospace markets. The company's broad portfolio includes power, analog, DSP, mixed-signal, advance logic, clock management and standard component devices. Global corporate headquarters are located in Phoenix, Arizona. The company operates a network of manufacturing facilities, sales offices and design centers in key markets throughout North America, Europe, and the Asia Pacific regions.

ON Semiconductor has a strong presence in Europe and the Belgian legal entity, comprises manufacturing facilities and design centers. A large R&D effort is dedicated to analogue and high voltage devices, process technology and reliability, innovative design and test techniques and new circuit concepts. Engineers from ON Semiconductor in Belgium have co-operated with many European partners in the frame of IST and EUREKA projects.

Main role in the project

High voltage (100+V) energy efficient power conversion requires power switching devices with low switching and conduction losses. The higher the switching frequency, the larger the relative importance of switching losses compared to conduction losses. Switching frequency typically reduces with voltage rating.

ON Semiconductor plans to develop state-of-the-art power switches beyond the so-called silicon limit. In the 100-200 V range, these devices are based on capacitive depletion of the drift region using 8-15 μm deep trenches. Split-gate structures will be introduced to reduce switching losses. The new power devices are aimed for high efficiency, which is translated in record-low Ron and Ron.Qg values: 100 V range: Ron.Qg < 200 mΩ.nC.

Key Staff Members Profile

Dr. Filip Bauwens holds a M.Sc. degree in applied physics from the University of Gent, Belgium (1995). In 2000, he received a Ph.D. in nuclear physics from the same university. In 2001, he started his career in microelectronics when joining ON Semiconductor (formerly AMI Semiconductor), Oudenaarde, Belgium. He manages a team of device engineers that are mainly involved in the prestudy of new smart power technologies and discrete power devices, including process specification, assessment of electrical and degradation behavior, and detailed TCAD studies. He is author or co-author of over 20 international journal papers or conference proceedings.

Peter Coppens received the M.Sc. degree in physical engineering from the University of Gent, Belgium, in 1992.

He joined AMIS (former Alcatel Microelectronics) in 1994 for the development of CMOS 0.7, 0.5 and 0.35 technologies. From 1998-2005 he was employed as a process module engineer for the development of metal-insulator-metal capacitors and deep trench isolation. Since 2006 he joined the device integration team within technology development to take the project lead of ON's integrated and discrete technologies.

Peter Moens received a M.Sc. and a Ph.D. in solid state physics from the University of Gent, Belgium, in 1990 and 1993 respectively. From 1993 till 1996, he worked as a post-doctoral fellow in collaboration with Agfa-Gevaert. In 1996, he joined ON Semiconductor where he is involved in the power device development, both smart integrated power as well as high voltage discretes, including wide bandgap materials. He authored over 100 papers in international scientific journals and conference proceedings, and holds several patents. Dr. Moens is member of the technical program committee of ISPSD, IRPS and the ESD/EOS Symposium, and serves as the chair of the HV reliability subcommittee of IRPS. He also served as the technical program chair of ISPSD2009.

14. SolarTec International AG (STIAG)

Organisation profile

SolarTec International AG is the photovoltaic's company which transfers challenging technological concepts into economically efficient and sustainable PV-solutions. We focus our business on two areas:

Core competences are concentrating photovoltaic's (CPV), planning and worldwide realization of turnkey PV power plants (solar parks). We are a premium-partner for worldwide planning, realization and operation of PV-power plants and Competence Center for highly-efficient and economical systems in Concentrating Photovoltaic's (CPV).

We commit ourselves to solutions combining our technological expertise with responsibility for securing tomorrows energy with economically reasonable investment of resources and capital. SolarTec International AG focuses on Concentrating Photovoltaic's (CPV), as well as worldwide planning, turnkey realization and management of PV power plants. SolarTec International's CPV activities aim at the enhancement of highly efficient complete systems. Being partner of the EU-Project APOLLON, SolarTec International AG is putting a maximum amount of effort on the development of marketable CPV systems at highest efficiency rates.

Our global PV power plant activities are based on the teams` experience, as well as on our references respective. The SolarTec International plant work focuses on enterprises in the high yield regions of Europe, Asia/India, the USA and Africa.

In all our business fields, quality assurance, work & environmental management are given maximum attention, in order to ensure all our partners the maximum in safety, reliability and sustainability.

Our proven team's specific expertise and experience meets increasing interest by branch experts. Following this demand, SolarTec International AG will focus on presence at branch symposia, conferences and trade-shows.

Main role in the project

STIAG will contribute to workpackage WP3: Efficient Power Conversion. In close cooperation with Telefunken (TEL), FRAUNHOFER and RWTH. STIAG will investigate how to increase the performance and efficiency of CPV inverters by using improved modules and advanced inverter design.

Key Staff Members Profile

Matthias Sturm is experienced designer of CPV systems with installations on world wide basis. He is head of a engineering team that is equipped with measurement and evaluation tools which are able to validate and demonstrate the progress of new converter systems and make comparisons to previous state of the art.

Radim Barinka, M.Sc., R&D and device manager, is the key person of the Solartec company regarding the solar cell production technology. He has been working there since 1996. Now he works as the R&D director and process manager in solar cell fabline. Further, he is active in the research and development of new and modified solar cell and solar module structures. He also participates in the field of popularization, dissemination and education in the photovoltaic branch in the Czech Republic.

15. TELEFUNKEN (TEL)

Organisation profile

Telefunken Semiconductors with headquarter in Heilbronn, Germany has special and long-term knowledge in the design and production of high performance RF and power technologies and corresponding circuits. One focus of Telefunken is on mixed signal circuits with supply voltages up to 80 Volt and switched currents of 1 Ampere. For example the application areas body control, ABS and Airbag systems in the car industry are covered by products of our customers, as well as keyless entry and IR/RF data control. For this application field a special technology line has been developed and is in production in the Heilbronn facility. This line includes Smart Power technologies on Bulk and SOI substrate material. A special focus is on high temperature (200°C) applications for automotive and industrial usage and on integration of non volatile memory (EEPROM) cells. Telefunken is supporting worldwide customers with its foundry service and is offering own products for selected market segments.

Main role in the project

Telefunken will provide SmartPower SOI technology for high efficiency systems, with very low standby losses, for intelligent power control. The technology is available for partners with design tasks. Telefunken will offer a MPW (Multi Project Wafer) -service for concerned partners. Telefunken will contribute a demonstrator design with focus on effective DC energy supply systems and high voltage capability. Activities will be located in WP3 with involvement in Tasks 1 to 4.

Key Staff Members Profile

Volker Dudek received the degree in physics in 1988 from the Technical University of Darmstadt. He worked in his diploma thesis on VLSI multilayer metallization systems at the Electrical Engineering Department. He joined the Institute for Microelectronics Stuttgart in 1988, where he was active in quality, reliability and process integration departments. From 1992 to 1999 he was the Front-End Processing manager at IMS. He got the PHD from the Mechanical Engineering Department of the University of Stuttgart for his work titled “Lithography independent MOS-Transistors with channel-length below 100nm”.In 1999 he joined Atmel-Heilbronn as the leader of the Smart-Power BCD process integration group. Since 2004 he is the Technology Development Director of Atmel-Cooperate. Since 2005 he was also the Director of the Foundry Business Unit. Since 2009 he is responsible as VP and CTO for technology developments and foundry business in Telefunken Semiconductors.

Winfried Rabe received the Dipl.-Ing. degree in 1977 from the Ruhr University Bochum. He joined Telefunken, located in Heilbronn, Germany and developed discrete and integrated RF circuits in several technologies. In these activities he worked out several publications and patents. After management of RF development groups and departments, he was appointed as a project manager and was responsible for R&D-projects of Atmel Germany. He actually is a manager with responsibility for innovation management in Telefunken Semiconductors.

Uwe Gieselmann received his Dipl.-Ing. (FH) in 1994 from the Fachhochschule Osnabrück. He joined Siemens HL in Villach, Austria and developed ASICs for automotive and smart power applications. 1996 he changed to Sican/Sci-worx in Hannover and continued the development of ASICs and ICs for smart power applications for different customers and with several technologies. 2009 he joined Telefunken and is the Manager of IC Architecture in the Design Center in Hannover.

16. Fraunhofer Gesellschaft (FRAUNHOFER)

Organisation profile

At present, the non-profit Fraunhofer-Gesellschaft maintains more than 80 research units in Germany, including 59 Fraunhofer Institutes. The majority of the 17,000 staff members are qualified scientists and engineers, who work with an annual research budget of €1.6 billion. Two thirds of the Fraunhofer-Gesellschaft’s contract research revenue is derived from contracts with industry and from publicly financed research projects. With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process.

Founded in 1985, Fraunhofer Institute for Integrated Circuits IIS in Erlangen, Germany, ranks first among the Fraunhofer Institutes concerning headcount and revenues. Fraunhofer IIS with its headquarters in Erlangen has further branches in Nuremberg, Fuerth, Ilmenau and Dresden. In close cooperation with partners and clients the Institute provides research and development services in the following areas: Digital radio broadcasting systems, audio and multimedia technology, e.g. mp3, digital cinema systems, design automation and integrated circuits, wired, wireless and optical networks, localization and navigation, high-speed camera systems, imaging systems and nanofocus X-ray technology. Fraunhofer IIS also has a strong background in sensor solutions, communications technology and system architectures for energy scavenging and energy efficiency.

Main role in the project

Fraunhofer IIS will closely work together in the flow with Telefunken and Solartec for advanced control and monitoring systems for CPV modules or sub-modules. Fraunhofer IIS will contribute power tracking algorithms, digital and analogue IC design, embedded systems design and communication technologies appropriate for harsh environments to achieve power and cost efficient control modules. He has been involved in various international projects.

Key Staff Members Profile

Karlheinz Ronge studied Electrical Engineering at the University of Erlangen / Germany and graduated with a Dipl.-Ing. degree. He joined Fraunhofer-IIS in 1984. Since 1993 he is head of the Department Digital IC Design. He is author and co-author of papers and publications about digital IC design and networked embedded systems. He contributed to system level design of ICs, hardware /software codesign and communication interfaces in several application areas. Currently he works on power efficiency aspects and low power design mainly at system level covering the whole electrical supply chain (smart gird). He is also coordinator for all energy efficiency activities of the institute.

Peter Spies studied Electrical Engineering at the University of Erlangen / Germany and graduated with a Dipl.-Ing. degree in 1997. Since 1998, he is with Fraunhofer IIS, power efficient systems department. He was working on the field of multi-standard front-ends and system simulations for communication applications. Since 2001 he is group manager of the “integrated energy supplies” group where he is doing research and design in the field of power and battery management, energy transmission and energy harvesting. Focus of his group is integrated circuit and system development as well as software design. Most important applications are wireless sensor networks and hybrid and electrical vehicles.

17. RWTH Aachen (RWHT)

Organisation profile

RWTH Aachen University is the largest university of technology in Germany and one of the most prestigous technical universities in Europe.

It currently has around 31,000 enrolled students, most of them in the field of engineering. 400 professors with 2,000 researchers offer more than 100 courses of studies. The Faculty of Electrical Engineering and Information Technology consists of 23 chairs, 2 additional research departments and 5 junior professorships each with its own research area.

The chair of Integrated Analog Circuits and RF Systems supports the Wireless Research Center of the Faculty in the areas of circuit design, system concepts and design methodology for on-chip RF sub-systems. Current research includes a S-Band Ship Radar System (RASKEL, SAM Electronics and FGAN-FHR), an UWB LNA for sensing and localisation (Ukolos Halos, DFG), a combined GPS/Glonass/Galileo receiver (Shared RF), Sigma-Delta Converters (DAAD), Novel Receiver and Transmitter Architectures for Nanoscale CMOS Integration (4 x UMIC, BMBF), DC/DC-Converters (pathfinder) and readout circuits for MEMS (proposal). A major task in the current research is located in the cluster of excellence of the German government Ultra High Speed Communication and Information (UMIC) with 8 researchers.

RWTH IAS currently has a staff of 1 acting manager, 14 PhD students, 1 laboratory engineer, 14 student workers, 2 technicians, 1 mechanician, 2 apprentices and 2 secretaries. IAS is equipped with more than 40 PC/SUN workstations, multiprocessor computing servers with an adequate number of MATLAB, Cadence, Mentor, ADS, RFDE licenses. The chair has an RF measurement lab including an on-wafer prober, vector network analyzers up to 50 GHz, three 6 GHz vector signal generators, a 40 GHz signal generator, and a 40 GHz signal analyzer.

Main role in the project

RWTH will work on new sub-module based energy efficient DC/DC converter. Shadowing and individual cell failures are overcome by this new concept enabling the earlier market entry for promising solar cell technologies like organic cells.

Furthermore RWTH Aachen will support Telefunken by developing fully integrated MPPT and inverter circuits. Using the partners SmartPower SOI technology the efficiency will be enhanced, standby losses will be reduced.

Key Staff Members Profile

Prof. Dr. Stefan Heinen received Diplom-Ingenieur Degree in 1988 as well as his Dr.-Ing. Degree in 1992 from Gerhard- Mercator University Duisburg. Dr. Heinen started his career 1992 as RF IC designer in the Siemens semiconductor group. He has been responsible for various commercial R&D programmes in the RF area covering cellular as well as cordless applications. He founded the RF group in the Duisburg Design Center of Infineon Technologies (former Siemens Semiconductor), which has a world leading record in RF SoC integration. The Bluetooth single chip and the first GSM single chip have been developed in that group. In 2002 Dr. Heinen accepted a full professorship at RWTH Aachen University and founded the Chair of Integrated Analog Circuits and RF Systems. Prof. Heinen is an IEEE fellow since 2007.

Dr. Ralf Wunderlich received the Diplom-Ingenieur Degree in 1997 at the Technical University Dortmund, Germany (TUD). Ralf Wunderlich joined the RWTH IAS in 2002 after completing his Ph.D. at the TUD on the topic of an integrated CMOS only Hall sensor system for precision length measurement. Currently he is involved in the described research activities, in teaching and in student concerns. He is leading the chairs power management and sensor group. As an acting manager he is responsible for all organizational and professional affairs.

18. Infineon technologies AG (IFAG)

Organisation profile

Infineon Technologies AG, Neubiberg, Germany, offers semiconductor and system solutions addressing three central challenges to modern society: energy efficiency, communications, and security. In the 2009 fiscal year (ending September), the company reported sales of Euro 3.03 billion with approximately 25,650 employees worldwide.

Infineon has long years of experience in semiconductor solutions for automotive and industrial applications and develops, manufactures and markets innovative semiconductor products and complete SoC solutions. Infineon is market leader in automotive semiconductors (sensors, power semiconductors and microcontrollers) in Europe and worldwide. Infineon is worldwide one of the leading companies in power electronics as with the CoolMos technology, the IGBTs and the SiC technology and No 2 worldwide as manufacturer of high power IGBT modules. Research activities have been conducted on Catrene / ENIAC level like HotCar, SPOT-2 or SmartPM and on national (BMBF) level like INGA, SIC_JFET or Super-junction BE.

Main role in the project (divided to the task involved)

Infineon is heavily involved in WP3 “Efficient power conversion”. Infineon is researching in close cooperation with SMA and TUC on the development of a highly efficient power converter for photovoltaic systems. The research part of Infineon is on component and module level. Infineon will research on new concepts, related designs and evaluation prototypes on module and device level. Fast switching Power modules with extremely low inductivities on the base of SiC diodes will improve system efficiency significantly. Modelling, simulation, characterisation and evaluations concerning functionality, reliability and technology ability will be part of the research of Infineon.

Key Staff Members Profile

Markus Thoben received his diploma and PhD degree in electrical engineering from the University of Bremen, Germany in 1995 and 2002. From 1999 to 2004 he joined DaimlerChrysler research institute in Frankfurt a.M., where he worked on the field of reliability and concepts for power electronics and ECU-hardware. From 2004 to 2008 he worked on the field of concept engineering for power modules at Infineon Technologies AG in Warstein (Germany). He is currently project manager for funded project related to hybrid vehicle power module at AIM. Since July 2008 he is responsible for the simulation group in the power module development at Infineon Technologies AG.

19. SMA Solar technology AG (SMA)

Organisation profile

SMA Solar Technology AG develops, produces and sells solar inverters and monitoring systems for photovoltaic applications. SMA is the world's largest producer in this segment and is the only vendor that has a product range with the matching inverter type for any module type and any power class. This applies for grid tied applications as well as island and backup operation.

SMA Solar Technology AG was founded as an independent company out of Kassel University in 1981 with the vision to develop and produce intelligent computer-based control systems for decentralized energy supply. Due to the know-how from more than 25 years of experience in the development and fabrication of systems technology for photovoltaics, wind energy and combined power generation plants, continuous product improvements and the use of absolutely new technologies, SMA is a pioneer in the field of solar technology. Intensive research and developments resulted in innovations that have set standards especially for decentralized power supply systems. With the „Sunny Boy" inverter SMA is worldwide market leader in the field of innovative device technology for the use of renewable energy sources.

SMA Solar Technology AG is headquartered in Niestetal, near Kassel, and is represented on four continents by 13 foreign subsidiaries. Today the group employs more than 4,500 people and had a total sales volume of EUR 935 million in 2009.

Main role in the project

SMA will contribute to workpackage WP3: Efficient Power Conversion. In close cooperation with Infineon AG (IFAG) and TU Chemnitz (TUC) SMA will investigate how to increase the performance and efficiency of PV inverters by using improved low-inductance modules and a low-inductance inverter design. Task of SMA will be the investigations on low-inductance inverter design as well as testing the different approaches and modules of the partners in the application context of PV inverter topologies and for the special requirements of PV inverters. A special focus will be on reliability and lifetime as well as on the validation of the expected advances from the point of view of an inverter manufacturer (especially efficiency, EMC characteristics and reduction of costs). Further more SMA will realize an experimental PV inverter to test and demonstrate the advances achieved.

Relevant experience for this project:

SMA is developing PV inverters and inverters for other kinds of renewable energies and battery storage systems since more than 25 years. Furthermore SMA is leader in innovation and the global market leader for PV inverters and has the worldwide largest collection of know how and practical experience concerning grid connected PV inverters and AC-coupled hybrid systems. Due to this, SMA has all experience needed, appropriate laboratories and excellent engineers to successfully fulfil all its tasks in the proposed project.

Key Staff Members Profile

Regine Mallwitz was born in Guestrow 1970, Germany, and received the Dipl.-Ing. degree at the "Otto-von-Guericke" University Magdeburg in 1994 after working on pulse power problems in excimer lasers. After developing gas and solid state lasers at LAMBDA PHYSIK GmbH Goettingen and LISA Laser Products OHG Lindau, Germany, she received the PhD degree in 1999 at the University of Kassel. 1999 she entered the company eupec GmbH Warstein (now Infineon) as R&D engineer and was responsible for the development of 1700V IGBT module family and new module designs respectively until 2004. Since 2005 she is with SMA Solar Technology AG. Her special scientific interests are the application of power semiconductors and integration of power electronic devices especially in solar inverters.

Matthias Victor was born in Bremen, Germany in 1970 and received the Dipl.-Ing. degree at the Technical University Braunschweig in 1996. Afterwards he continued working at TU Braunschweig as a research assistant in the field of power electronics for railway applications. He investigated a medium-frequency-transformer system as a replacement for the conventional 16,7Hz transformer based on 3,3 kV IGBTs and received his PhD degree in 2002. He joined SMA in 2001 as an electrical engineer for power electronics and is since 2004 responsible for advanced developments. Today he is Vice President for Technology and IP-Management for solar inverters.

20. Technische Universität Chemnitz (TUC)

Organisation profile

Chemnitz University of Technology has over 10000 students. It is the third largest university in Saxony. Around 750 international students from all over the world are enrolled each year. It was founded in 1836 as Royal Mercantile College ("Königliche Gewerbeschule") and became technical university in 1986. The university is organised into the following 8 faculties: Natural Sciences, Mathematics, Mechanical Engineering, Electrical Engineering and Information Technology, Computer Science, Economics and Business Administration, Humanities and Behavioural, Social Sciences.

The Chair for Power Electronics and Electromagnetic Compatibility at the Faculty Electrical Engineering and Information Technology hat its main research fields in power devices, their ruggedness and reliability: effects at the edge of the SOA (dynamic avalanche, short cicuit), designs for improved SOA, reliability of power devices, new packaging technologies, active power cycling, derivation of models for lifetime calculation

Further research projects are in the field of energy storage, reliability of advanced double layer capacitors, active load cycles, lifetime determination, and in the field of DC-DC converters for hybrid vehicle applications, technologies for improved efficiency of power electronic converters and inverters.

The chair, headed by Prof. Josef Lutz, currently has a staff of 1 senior researcher, 7 PhD students, 5 students in diploma- resp. master thesis, and 2 technicians.

Main role in the project (divided to the task involved)

TU Chemnitz will be involved in the development of a high efficiency solar inverter in cooperation with IFAG and SMA, and will contribute to improved devices and an improved low-inductance module. To improve the SiC MPS diode, a new top-side contact structure with increased heat capacity will be calculated. Measurements of the switching characteristics and of the overload behaviour will be performed.

In the module development, TUC will perform thermal simulations to ensure a homogeneous thermal load at indented application conditions and to achieve a high temperature cycling and power cycling capability. The arrangement with the best trade-off between homogeneous temperature and lowest electrical inductance is to be found.

Key Staff Members Profile

Prof. Dr.-Ing. Prof. h.c. Josef Lutz has received a Diploma in physics 1981. During 1983-2001 he has been with Semikron Electronics Inc., Nuremberg. First he worked in the development of GTO Thyristors, then in the development of fast recovery diodes. He introduced the Controlled Axial Lifetime (CAL) diode and is holder of several patents. In 1999 he obtained his PhD in electrical engineering at the University of Ilmenau. Since August 2001 he is Professor for Power Electronics and Electromagnetic Compatibility at the Chemnitz University of Technology, Germany. He is member of the International Steering Committee of the EPE (2007, 2009, 2011 Topic Chair "Power Devices"), of the advisory board of the PCIM, of the program Committee of the ISPS and of the Scientific Committee of the CIPS. He was awarded the degree of Honorable Professor by the North Caucasus State Technical University Stavropol , Russia, in 2005.

Susanne Fichtner is PhD Student, Member of the scientific staff. She has a Bachelor in Computational Science from Chemnitz University of Technology and graduated as Master in Physics at University of Leipzig in August 2011. During her studies she specialized on numerical simulations and semiconductor physics.

21. Leitat Technological Center - Acondicionamiento Tarrasense (LEITAT)

Organisation profile

LEITAT is a private-non profit Technological Research Centre specialized in production technologies. LEITAT develops R+D activities in the areas of materials sciences, environment, biotechnologies and renewable energies with deep knowledge and experience on the technological transfers to several industrial sectors. LEITAT is member of several Technological platforms, including Smart Systems Integration (EPOSS) and European Technology Platform for Advanced Engineering Materials and Technologies (EuMaT).

Main role in the project

Due to LEITAT expertise, our role will be basically into two areas:

1) Innovative solar cell and energy harvesting (WP1), where LEITAT will contribute to:

- Design and development of optimized photovoltaic modules of third generation photovoltaic based on organic and hybrid organic-inorganic systems (such as dye-sensitized solar cells).
- Development of low-cost and large area manufacturing process based on screen printing technology and/or spraying.
- Design and development of low-cost and non-tracking photovoltaic systems based on luminescent solar concentrators.
- Design and development of novel systems for photovoltaic panel refrigeration.
- Study and development of recyclability methods for photovoltaic panels (C-Si, thin film and emerging technologies).
- Preliminary IEC tests for panel certification (61215 C-Si, 61646 thin film). Development of specially designed tests for emerging technologies towards future certification.
- Other methods of energy harvesting for powering WSN (solar panel monitoring).

2) Smart energy distribution, utilization and management (WP4), where LEITAT will contribute to:

- Development of individual measurement and control elements connected to a micro-grid controller.
- Implementation of local network for energy generation and storage, especially using electrochemical supercapacitors.
- Wireless Sensor Nodes network for generation monitoring, failure detection and energy management.

Key Staff Members Profile

David Gutierrez is PhD in Chemistry (Autonomous University of Barcelona). His research experience is centred in the study of soft chemistry process for particles synthesis and the preparation of layer inorganic oxides (mainly titanium oxide), and in their application to sensors and solar cells sensibilized. He was a researcher in the Stuttgart Technology Center (Sony Deutschland GmbH), he has worked in international projects, he has participated in different European congress and he has papers in different scientific journals in the field of materials, photoquimics and chemistry. He has been associate professor in the Chemistry Department of the Autonomous University of Barcelona.

22. Slovak University of Technology Bratislava (STUBA)

Organisation profile

Slovak University of Technology in Bratislava (STUBA) consists of 7 faculties, is attended by almost 18 000 students and belongs to leading universities in microelectronics education and R&D activities in the New Member States of EU. The Microelectronics Department of Slovak University of Technology in Bratislava is active in a field of microelectronics, optoelectronics and sensors. Its membership in EUROPRACTICE provides access to advanced TCAD modeling and simulation as well as IC design tools (Synopsys, Cadence, H-Spice). Structure and device characterization and failure analysis either by electrical (I-V, C-V, DLTS measurements in a wide temperature range with optional magnetic field, microwave characterization) or analytical tools (SEM, EBIC, CL, AES, AFM, SIMS, micro-Raman spectroscopy) is another strong field of department activities. The comparison and good correlation of experimental and simulated results is used for physical models calibration, physical interpretation of obtained experimental results and prediction of the properties of new semiconductor devices and IC's. The solved projects comprise the thin film sensors and subsequent signal processing for healtcare and environmental applications, analogue and mixed signal design, smart power MOS device design and characterization, GaN based devices, organic semiconductor transistors and LED's, diamond and carbon nanotubes growth. The well equipped laboratories, expertise and enthusiasms of department staff ensure the successful project solution. They are about 40 teachers and researchers and more than 20 PhD students at the department. They actively participated in projects in 5th, 6th and 7th FP projects as well as NATO and COST projects. More than 20 projects funded by national authorities and/or within bilateral international collaboration are being solved at the department yearly.

Main role in the project

STUBA has expertise and take the role in WP1 related to tandem solar cells using InxGaI- xN hetero-junctions with silicon as the active junction. In particular:

- Nanotechnology approach and applications of various nanostructures prepared from III-V semiconductors to improve the solar cell efficiency. We will concentrate our efforts on the short wavelength part of the solar spectra. Modification of a top layer of the majority tandem solar cells consisting ternary semiconductor compound InGaP by application of the GaP nanowires will shift absorption edge of the solar cell structure further to the shorter wavelengths. Another improvement will be obtained by preparation of GaP-ZnO heterojunction. ZnO is a wide band-gap semiconductor (Eg=3.37 eV) and its application will allow to shift the absorption edge more to the bluepart of the solar spectra. Nanocrystalline ZnO layers will be prepared by magnetron sputtering or pulse laser deposition.
- Structural analysis essential to the development InGaN layers and InGaN/Si structures for optimization of design of tandem solar cells giving efficiencies nearing 30%. This include precise nanoscale structural analysis of the physical geometry, morphology of materials and and structures by Field Emission Gun Scanning Electron Microscope (FE-SEM- SE, EDS, EBIC and CL modes), Time-of flight secondary ion-mass spectrometer (ION-TOF SIMS) supported by collaboration with ILC (International Laser Center, Bratislava), AFM technique (PARK XE-100) in different modes and micro-Raman spectra and mapping (LabRam) to analyse the effect of strain on continuous films of III-Nitrides with low strain and low dislocation density.

STUBA has an expertise in various methods of electrical and optical characterisation of optoelectronic devices. The complex electrical (I-V, photocurrent) and optical detection spectroscopy will be realised to optimize the device structure and properties as well as measurements of electrical and optical parameters stability and degradation of structures and devices by I-V (Agilent sources& semiconductor parameter analyser), C-V, DLTS methods (80-450 K) and optical spectroscopy methods (15-300 K). This will be particularly important for trade-off between device architecture, processing speeds, efficiencies and innovations in solar cell design and subsequent fabrication techniques.

Optimization of technological processes of LED structures, optical lithography, deposition and modification of optimized ohmic contact, testing and development of etching processes and structure modification.

Potential alternative solution: InGaAs/GaAs/ InGaP solar cells, including tunnel junctions.

Key Staff Members Profile

Prof. Daniel Donoval received his M.S. and PhD degrees in Electronics from Slovak University of Technology (STU) in Bratislava, Slovakia, in 1976, and 1981, respectively. He has been working as a Head of Department of Microelectronics STU Bratislava for 16 years. As a professor he is involved particularly in physics, technology and characterization of advanced semiconductor structures and devices supported by modeling and simulation. In the years 1997 – 2003 he was a member and chairman of the Scientific Grant Agency of Slovak Ministry of Education. He was a referee of the projects submitted within 5th, 6th, and 7th FP of European Union. Currently he is a member of the Education & Training Coordination Board and management team of the Scientific Community Council of ENIAC Technology Platform. He is the Slovak representative in Public Authorities Board and governing Board of ENIAC JU. He is a coordinator of many R&D projects supported by national and international agencies. He authored and co-authored more than 150 papers published in international scientific journals and conference proceedings. To stimulate the technology transfer to industrial partners he organizes many conferences, workshops and participates in scientific program and steering committees of many international conferences.

Prof. Jaroslav Kováč graduated at the Slovak University of Technology (STU), Faculty of Electrical Engineering and Information Technology (FEI STU), Bratislava, in 1970. Since 1971 he has been engaged in the research of optoelectronic devices technology at the Microelectronics Department of FEI STU. In 1983 he received a PhD degree and in 2001 professor degree at STU Bratislava. Since 1991 he has been the team leader of the Optoelectronic and microwave group at the Department of Microelectronics. His interest includes technology and characterisation of optical and electrical properties of III-V devices. He was involved in many framework research projects and act as a national coordinator of 5 FP project VGF GaP and 7 FP project MORGaN.

23. POWERTEC ltd (POWERTEC)

Organisation profile

POWERTEC ltd. is a spin-off company created by young postgraduate students and closely related to Slovak University of Technology Bratislava. POWERTEC offers expertise in design of non-standard microelectronic solutions for technologies of renewable energy resources. The team members are experienced in integration of novel EC design solutions together with downscale integration to low-power IC, applicable to energy generating solar systems. The innovations are focused on applications in small and mid-scale photo-voltaic power plants, where a single PV cell could be analyzed and controlled (i.e. switched-off). The contribution of full PV field analysis leads to energy gain and higher power-grid stability. Currently POWERTEC participates in PV projects related to national energy effectiveness effort funded by national authorities.

Main role in the project

POWERTEC will contribute to WP2: “Optimization method for energy extraction” in design of modern PV cells diagnostic and controll systems. Designed ultra-low power cell control unit integrated within PV cell or realized as a stand-alone system will be suitable for analysis of every cell using communication over power line. Increasing efficiency and reliability will be the main task of our effort. The system will contribute to optimization of variable power output and should be compatible with power-grid authorities. New solutions, suitable for control of multi-supply systems for stable and efficient hybrid PV architectures and power storage modules will be researched and proposed.

Key Staff Members Profile

Martin Donoval received his master and PhD degrees in Electronics from Slovak University of Technology in Bratislava. He has carried out postgraduate studies in area of IC design. Afterwards he continued working at university as a research assistant in magnetic force affected IC sensors design and magnetic force IC sensors. He participated in establishment of spin-off company POWERTEC with focus on renewable energy sources. Today he is responsible for R&D projects management, particularly in a field of SMART electronics design. He participates in development of new prototypes and dedicated integrable electronics for highly specialized driving and controlling off-chip devices and systems in field of power management. His scientific interests are design and integration of novel SMART electronics solutions particularly for medical and environmental applications

25. SolarPrint Limited (SPR)

Organisation profile

SolarPrint Limited was founded in 2008 with unique IP for a quasi-solid, printable electrolyte, which replaces the existing liquid-phase electrolyte, together with a number of novel technologies on dye sensitised solar cell (DSSC). SolarPrint produces Dye-Sensitised Solar Cells (DSSC), made from abundant materials in a simple **all-printable process**. Efficient from any angle of incidence, even at diffuse light, DSSC works where other PV technologies fail - opening a world of **new solar-powered applications**.

The company currently has a research team of 11 full time staff members including 5 doctoral scientists and engineers. SolarPrint has established a new pilot production line in Dublin, Ireland, which was completed in December, 2009. The manufacturing tools include high-precision screen printers, programmable sintering ovens, solar simulators, dye applicators, a low-humidity clean room, chemical preparation laboratories with state-of-the-art materials synthesis instruments, together with testing and analytical equipment.

Novelty and merit of SolarPrint Technology

The patented quasi-solid electrolyte is to replace existing liquid-phase electrolyte which has been used in conventional DSSC. The electrolyte improves DSSC yield and reliability by avoiding liquid filling processing and defect leaks. SolarPrint has a complete development strategy for both rigid glass and thin, flexible DSSC based on thin-metal and transparent plastic foils by using unique technologies. The flexible DSSC has great advantages over crystalline or thin-film cells on flexibility, conformability and compactness and weight.

Applications

Commercial Electronics and Home appliances: Mobile phone and other portable devices require meaningful electrical conversion efficiencies in low light and diffused light conditions. DSSC is the only type of cell that can meet this requirement.

Transport PV (DSSC or board): SolarPrint is developing a smart sunroofs project using DSSC with one of the largest automobile makers in the world. Both glass and flexible DSSC will be used in different stages and different parts of the automobile. The on-board DSSC is expected to provide up to 10% of the energy by 2014, which otherwise should be provided by fossil fuel.

BIPV: DSSC is superior to silicon PV on building façades facing every direction including south and horizontal. DSSC on rigid glass substrate will be ideal as an alternative to any type of PV in a building façade. More important, since DSSC is also uniquely superior for indoor light harvesting, it should provide exclusive applications for indoor BIPV with unlimited possibilities for retrofitting.

Main role in the project

SolarPrint will focus on the development of DSSC production with a number of innovations, including the development of the following:

- A printable electrolyte
- A printable DSSC production technology for cost competitive high-volume manufacturing
- Improvement of cell efficiency through advanced material
- Materials formulation further for DSSC
- DSSC to meet low-light requirements for wireless sensing applications
- DSSC modules for equipment charging applications

Key Staff Members Profile

Dr. Mazhar Bari, Ph.D. & MPhil in Physics from the University of Cambridge (1996), B.Sc. (HONS) in Experimental Physics from University College Dublin (1991), MBA from The Michael Smurfit Graduate School of Business, Dublin (2003). He was the Programme Manager of a €6M SFI funded research project on Nanoscale Spin Electronics (2001-2006). Dr. Bari was involved in various EU projects when he was Programme Manager at Trinity College Dublin between 2001- 2006 (MULTIMETOX, AMORE, OXSEN, and MAGNOISE). His core expertise is in nanomaterials, thin film device fabrication and device physics. He has published over 20 papers and is the inventor or co-inventor of six patents.

Dr. David Jeng: Ph.D. in Electrical Engineering, State University of New York at Stony Brook, B.S. and M.S. in Electrical Optical Engineering and Physics, Chao-Tung University, Taiwan. David Jeng worked as research staff member with former AT&T Bell Labs during 1990-1998, high level technical officers in Taiwan during 1998-2007; He has published over 50 scientific papers and holds 12 patents.

Dr. Marin Gheorghe: Senior Chemist. Ph.D. in Chemistry, Bucharest University, M.S. in Chemistry, Politechnica University Bucharest, his Research interest covers, Nano-biotechnology, Microfluidics, BioMEMS, Bioelectro-chemistry, Micro and Nano assembling, and Materials Science. He has published over 40 scientific papers and holds 4 patents.

26. Tyndall National Institute (Tyndall)

Organisation profile

Tyndall National Institute is one of Europe's leading research centres, specialising in ICT hardware research, commercialisation of technology and the education of next generation researchers. Tyndall has a critical mass of over 420 researchers, engineers, students and support staff focused on quality research and the commercialisation of technology through industry collaboration, IP licensing and spinout generation. Tyndall's research addresses key challenges in the areas of Communications, Energy, Health and the Environment through its technologies which span the range “from atoms to systems” in the areas of photonics, microsystems and micro-nanoelectronics, backed by strong expertise in theory, modelling and design and a highly flexible wafer fabrication capability in Si CMOS, III-V's and MEMS. Established originally in 1981 as the National Microelectronics Research Centre (NMRC), the Tyndall National Institute was set up in 2004 bringing together complementary activities in photonics, electronics and networking research at the National Microelectronics Research Centre (NMRC), several UCC academic departments and Cork Institute of Technology (CIT). Tyndall currently employs 400 people, occupying 11,500 sq meters of laboratory and office space. Tyndall has ISO 9001 status supported by regular audits of all procedures from both internal and external audit teams.

Tyndall secured 40 projects under FP6, 6 STREPP co-ordination projects, 1 Large Scale co-ordination Network of Excellence and 27 STREPP partner projects. Supporting these contracts are dedicated and experienced Financial, I.T, H.R, Admin and Intellectual Property teams. Financial team supporting this project will be Finance Manager and EU Projects Administrator both of whom have extensive experience in managing small and large scale EU Strepps and NOE projects. On line intranet based purchasing solutions interfacing directly to finance and personnel systems support the day to day operations within Tyndall. Experienced administration team in place to support technical project manager with any day to day admin requirements. Intellectual Property will be supported through Ms Ondine Braddell and Mr. Michael Gruffery both of whom have extensive experience within the areas of intellectual property and consortium agreements. Ms Braddell will be responsible for preparation, completion and co-ordination of Consortium Agreement for this proposal should it be successful.

Main role in the project (divided to the task involved)

Tyndall will contribute to ERG in WP1 and WP3 in the following ways:

- Design and development of InGaN on Si MOVPE growth technology for next generation multi-junction solar cells in concentrator PV systems
- Wireless sensor technology development for CPV system ambient monitoring and performance control for CPV solar cells

Key Staff Members Profile

Donagh O'Mahony is a Staff Researcher with the III-V Materials and Devices group at the Tyndall National Institute, Cork, Ireland. His research experience lies in the area of III-V photonic and power device development for high operating temperatures, including R&D activates for the European Space Agency. He is currently involved in the development III-V solar cells for concentrator PV. He has previously worked as a visiting scientist at the Paul Scherrer Institute, Switzerland and as a PhD and post-doctoral researcher Trinity College Dublin, Ireland.

Peter Parbrook is Stokes Professor of Nitride Materials, at the Tyndall National Institute in conjunction with the Department of Electrical and Electronic Engineering at University College Cork. Before this he held academic positions at the University of Sheffield and the Toshiba Central Research and Development Center in Japan. His research aims to improve the properties of devices made from gallium nitride and related materials. He has authored /

co-authored more than 120 publications in international journals and holds around 10 patents. He is a member of the International Advisory Committee for the International Workshop on Nitride Semiconductors conference series, and in 2011 will co-chair the International Conference on Nitride Semiconductors (ICNS).

Mike Hayes Profile BE (electrical) 1987, MEng Sc 1994. Held several roles at Artesyn Technologies (1987-2006) including senior design engineer, program manager and custom engineering manager. In 2008 joined Tyndall as a Program Manager, focusing on building energy management and energy efficiency applications, actively involved in several related EU and industry funded research projects. Also actively involved in energy harvesting research at Tyndall.

27. NXP Semiconductors (NXP)

Organisation profile

NXP Semiconductors provides High Performance Mixed Signal and Standard Product solutions that leverage its leading RF, Analog, Power, Digital Processing and manufacturing expertise. These innovations are used in a wide range of automotive, industrial, consumer, lighting, medical, computing and identification applications. Headquartered in Europe, the company has about 28,000 employees working in more than 25 countries and posted sales of USD 3.8 billion in 2009. News from NXP is located at www.nxp.com

Main role in the project

NXP-NL will contribute to WP3 by specifying and designing innovative semiconductor solutions for panel-based power-management topologies for solar systems to increase the overall energy output of a solar system by making optimum use of the specialized power IC technologies available in the company.

Key Staff Members Profile

Toby Doorn is a senior scientist at NXP Semiconductors Research where he is involved in the development of power conversion systems for solar applications. He joined NXP Semiconductors Research after receiving a M.Sc. degree in Analog IC design in 2004 at the University of Twente, the Netherlands.

Henk Jan Bergveld was born in Enschede, the Netherlands, in 1970. He received the M.Sc. degree (cum laude) and the Ph.D. degree (cum laude) in electrical engineering from the University of Twente, Enschede, in 1994 and 2001, respectively. He joined Philips Research Laboratories, Eindhoven, the Netherlands, in 1994. His research interest was modeling of rechargeable batteries to design better battery management systems. This work resulted in his Ph.D. degree and the book Battery Management Systems – Design by modeling (Boston, MA: Kluwer, 2002). He is currently a Principal Scientist and team leader power management with NXP Semiconductors.

31. Boschman Technologies (BTE)

Organisation profile

Boschman develops new processes for the encapsulation of advanced packages and delivers the encapsulation equipment to the worldwide semiconductor and electronics industry. The focus in the worldwide semiconductor and electronics industry is on one hand on the miniaturization of packages and on the other hand the change of the standard packages to IC's with a sensing function. From fingerprint sensor, camera sensor, humidity sensor, temperature sensor, (tire) pressure sensor to the bio- medical sensors, the MEMS packages.

Boschman provides in a close cooperation with the semi- industry new processes and equipment for the MEMS / Sensor packages. The "basic " technology of molding with film started more than 10 years ago and the semiconductor industry looks with favour on the advanced processes of encapsulation. Boschman has the technology to (partly) encapsulate the MEMS/Sensor packages in such a way that the sensor area of a chip can perform its function in a perfect encapsulated environment.

Main role in the project

Boschman as a MKB company wants to widen the unique position in the sensor packaging to the world of renewable energy (CPV). High tech developments need a close cooperation between different disciplines in the value chain. Development and integration of key competences and technologies are needed for cost effective packaging solutions. This are the ingredients for Boschman to participate in a project with also international partners.

Boschman's contribution will be focused on Innovative encapsulation methods for Concentrated Photo Voltaic (CPV) receivers. Our aim is to develop a method whereby the costs of the receivers will be reduced dramatically. In the state of the art, general packaging technologies are lacking new innovations compared to front end (die) development (More Moore investments). On the other hand packaging is become much more important due to the need of specific packaging solutions for the More than Moore roadmap, use of advanced materials and the increase of packaging costs. For nowadays advanced packages packaging represents often already more than 50% of the costs. CPV is a new technology domain with potential to compete with PV technologies in the future. One of the major drivers is costs. Our effort is focused to realize a breakthrough in costs for CPV packaging. Nowadays very expensive materials are used to package the CPV-cells, i.e. ceramic carriers, very expensive dam-fill materials, etc. In BTE's solution we will develop a new innovative technology which will not use these materials and at the same time use as much as possible semiconductor assembly technologies to increase productivity. It is expected that, after successful completion, we can reduce the packaging costs with a factor 2 (at least) and reduce needed investment with a factor 10.

Key Staff Members Profile

T. (Ton) van Weelden (1947) MSc in Mechanical Engineering. Vice President Product Management and Process Research. 18 years with Philips Electronics in the semiconductor field. From 1994-2000 Vice president of BDM Netherlands, part of ESEC Switzerland. Boschman acquired BDM in 2000. Ton is one of the founding fathers of the Film Assisted Molding technology and is an internationally reputed expert in this field.

Dr. Lingen Wang (1974) Bachelor of Science in Mechanical Engineering, Master of Science in Mechanical Engineering and Ph.D Department of Precision and Microsystems Engineering, Delft University. Lingen is working as research engineer at Boschman Technologies B.V.

34. Enecsys **(ENECSYS)**

Organisation profile

Enecsys are developing Solar PV micro-inverters. The Enecsys micro-inverter, installed on the rack at the back of each solar module, offers a unique and excellent value proposition compared to conventional string or central inverters. Benefits include significantly increased energy harvest and lower lifetime cost of solar photovoltaic systems, increased inverter reliability to match the life of solar modules, comprehensive web-based monitoring and a communications system that analyzes and reports the performance of each solar module within the PV array to enable system performance optimization, simplification of PV array design, ease of installation, and improved safety.

Enecsys Limited, was founded in 2003 and is headquartered in Cambridge UK. The Company develops, manufactures and markets innovative grid-connected micro-inverters for solar photovoltaic systems in residential and commercial applications. The patented technology was originally developed at Cambridge University.

Main role in the project

Enecsys is focussed on developing micro-inverters products. Enecsys will continue to develop explore novel circuit topologies for a range of solar PV technologies including CPV. Drivers for the design will be overall weighted efficiency (Euro), cost and lifetime. As part of the design process Enecsys will evaluate the latest development in power semiconductor devices including new Si and GaN devices and where feasible incorporate into the designs. Enecsys will also focus its efforts on the use of ASICs to try to simplify and reduce cost of the micro-inverters. Enecsys will attempt to work with partners in creation of such ASICs. The project will also entail exploring new algorithms for MPPT. In addition Enecsys will evaluate the latest advances in monitoring and where possible use the most appropriate methods for the newly developed micro-inverter.

Key Staff Members Profile

Dr. Asim Mumtaz received his degree in Electronics Engineering from the University of Durham. He received his MPhil and Ph.D. from the Department of Engineering at the University of Cambridge. He is currently working as Principle Engineer at Enecsys Limited, where he is focussing on product development.

35. University of Sheffield (USFD)

Organisation profile

This work will be carried out within the department of Electronic and Electrical Engineering (EEE), which is one of the top rated departments in the UK. It undertakes fundamental and applied research across four vibrant groups: Communications, Vision and Information Engineering, Electrical Machines and Drives and Semiconductor Materials and Devices. State-of-the-art clean rooms for growth, fabrication and characterisation are available in the department. The University hosts a Doctoral Training Centre in Energy and is also part of the Centre for Low Carbon Futures (CLCF) to promote leading research in low carbon technologies and policy across the Yorkshire Universities. Solar Cell simulators are available within the group of the PI (MMS) for characterisation of cell performance and stability. Commercial TCAD tools are available for design of solar cells and correlation of experiment with theory.

Main role in the project

Sheffield will investigate the junction between antireflection layers and the underlying p-silicon to enhance light trapping in thin film solar cells. Moreover, solar cells after the initial few hours of “burn-in” and in long term field conditions suffer from degradation of performance which results in a reduction of efficiency. This amounts to considerable loss of efficiency when evaluated on a global scale. We will therefore investigate the stability using automated long term stress at constant temperatures using our solar simulator. The underlying causes of degradation will be delineated via a combination of electrical and physical characterization, together with TCAD simulations. Methods to overcome stability will be explored.

Key Staff Members Profile

Prof. Maria Merlyne De Souza (MMS) FInstP, FIET holds a Chair in Microelectronics at the EEE department, University of Sheffield since ‘07. She received a BSc (Physics, Maths) from University of Bombay (‘85), B.Eng (Electrical and Communications Engineering) IISc, Bangalore (‘88) and Ph.D from Cambridge University Engineering Department (’94). She has authored over 175 articles in multidisciplinary research cross-spanning technology, materials and physics. She has served on the editorial board of “Microelectronics Reliability” (2001-2006), IEEE-IRPS 2003-09, ESREF 2008 and is Associate Editor of IEEE-transaction Nanotechnology 2009. She has been reviewer/panel member for the European Science Foundation (08-)and the Finnish Academy of Sciences. In summer 2008, she was an Invited Fellow of the AIST (Advanced Industrial Science and Technology) Institute, Tsukuba Japan.

8.3 Consortium as a whole

To achieve the goals of the project, the composition of the consortium has been defined with the purpose of bringing the complementary backgrounds and specific know-how in solar energy supply chain (energy efficiency, silicon process and integrations, design solutions and last but not least application) and related topics. All Partners have strong interest in the field and are committed in carrying out the activities of the project, each of them with a clear role to achieve sound technology solutions and exploitable products.

The ERG Consortium consists of a total of 27 distinct Partners, located in 8 different countries: 8 are wide-body industries, 9 are SMEs, 4 are leading-edge research institutes and 12 are universities with extraordinary scientific and technological records in the energy efficiency field.

The ERG Partners have experience, know-how and business interests in complementary areas and missions, ranging from semiconductor manufacturing to circuits and systems design as well as system integration, from energy applications vendor to research in the energy harvesting and distribution domain.

Most of the ERG Partners have previously worked together on several European projects of different nature and sizes, from the previous ENIAC call 1 and 2 (MODERN, CSI, LASTPower and END) and including RTD projects (DOUBLENANOMEN, NANOGOLD, HYPOMAP, MetaPV, APOLLON, MOLESOL, SMARTOP, EPHOCELL, THERMINATOR, CLEAN), training projects, thematic networks and Marie Curie Actions (COMSON , MANON, SYMTECO, SeemPubs, PROPHET, NANOLAPS, PAGALINNET), demonstrating the capabilities of the ERG Partners of carrying out projects of European dimension, as well as their positive attitude to collaborative work and interaction with Partners on different types of activities, ranging from RTD to training, from dissemination to coordination. In many cases, the Partners of the ERG Consortium have acted as project coordinators; as such, they are well aware of execution and management policies of EU-funded projects; this is a key insurance policy to a happy end of the ERG project.

The table below combined with the summary of the effort breakdown, immediately after, show how the synergies and competences are well combined and deployed into the work plan.

			Role and Mission				Competence and Expertise			
Partic. no.	Partic. short name	TYPE	Semiconductor technology provider	System integrator	energy appl vendor	Research	Energy Efficiency	Silicon process and integration	Application and demonstration	Design Solutions
1 (C)	ST	lc	x	x		x	x	x		x
2	AMAT ITALIA	lc	x		x	x		x	x	x
3	COMPEL	lc		x		x	x		x	x
4	IUNET	ac				x	x	x	x	x
5	POLITO	ac				x	x			x
6	UNIBO	ac				x	x		x	x
7	UNICAL	ac				x	x		x	x
8	UNICT	ac				x	x		x	

9	CNR	rc				x		x		
10	ELETTRA	rc				x	x		x	
11	ONSEMI-B	lc	x			x	x	x	x	x
14	STIAG	sme			x		x		x	x
15	TEL	lc	x				x	x		x
16	FHIIS	re			x	x			x	x
17	RWTH	ac				x	x	x	x	x
18	IFAG	lc	x				x	x	x	x
19	SMA	lc		x		x			x	x
20	TUC	ac				x	x	x	x	x
21	LEITAT	re		x		x	x		x	x
22	STUBA	ac				x				
23	POWERTEC	sme		x			x		x	x
25	SPR	sme				x	x		x	X
26	NTI-UCC	ac	x	x					x	
27	NXP	lc	x			x		x	x	x
31	BTE	sme	x			x			x	x
34	ENECSYS	sme		x					x	
35	UoS	ac				x	x	x		

Effort per type of organisation Summary

TOTAL EFFORT	WP1	WP2	WP3	WP4	WPM1	WPM2	Total person months
Academies	286	70	129	145	14	11	655
Large companies	186	378	591	100	46	21	1322
SME	122	215	131	0	11	6	485
Research institutes	137	10	44	10	6	5	212
	731	673	895	255	77	43	2674

The effort has been split in the various work packages taking in consideration the objectives to be delivered according the long last experience of each partner in evaluating the work necessities for each task.

Each work package requires in depth research, in order to review and build up the knowledge which is needed for the success in the worldwide competition. For example in WP3 a complete supply chain for energy conversion is needed, starting from new architectures, based on academic research. New ideas require basic investigations of technological implementations, including experiments in actual and upcoming semiconductor technologies. As experiments never are going straight forward there will be iterations and investigations of new solutions to fix upcoming bottlenecks. After preparation of functional blocks complex integration tasks in hardware are necessary for preparation of the future industrialisation, always with focus on effectivity and balanced economy. The work package will end with industrial-like demonstrators which can present advanced technological results close to every-day usage. This complexity is requiring intensive cooperation in the chain from research over semiconductor industry to system partners, under control of market leaders with deep production background.

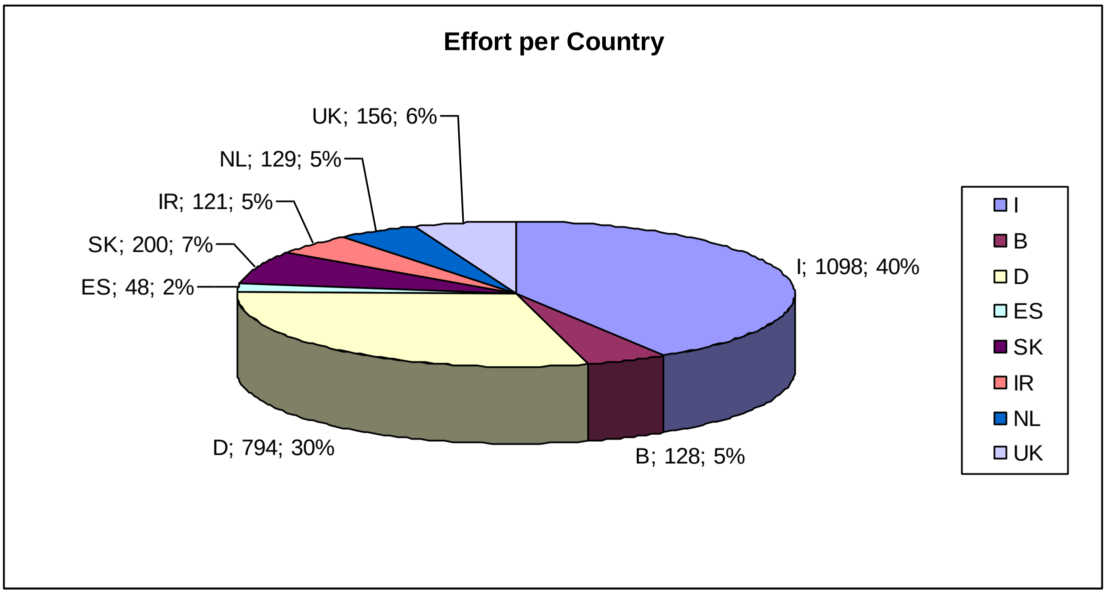
We consider very important to bring the attention of the reader on the considerable effort sustained by **SMEs** as shown in the chart below

The **applicative nature of the project** is proven by the fact that 75% percent of the effort is carried out by commercial organisation supported by 25% of research organisations. The academic component of the lat shall secure an immediate feedback of the project results into the training of next generation researchers and designers that will be ready to assess the immediate future markets.

The specific fields of competence of the partners are not overlapping. The effort table shows very clearly that the execution of the ERG project really entails a tight collaboration between the various partners, as there is no task which is participated only by a single partner. This strong synergy between the partners distinguishes the ERG project from many other application projects, in which each partner is responsible for its own share of work, to be performed almost in a stand-alone fashion. Consortium cohesion and unity of intents represent the true added value of carrying a project of European dimension, as in the case of ERG.

Total Effort per Country

Country	WP1	WP2	WP3	WP4	WPM1	WPM2	Total person months
I	431	326	28	245	46	22	1098
B	0	122	0	0	4	2	128
D	0	0	777	0	10	10	794
ES	24	10	0	10	2	2	48
IR	96	0	21	0	2	2	121
NL	50	0	69	0	7	3	129
SK	98	98	0	0	2	2	200
UK	32	117	0	0	4	3	156



The percentages reflect the industrial commitment of the various countries and governments into the present ENIAC SP objectives. Special case is the outstanding involvement of Ireland into the project compared to the industry deployment in the country.

8.3.1 Third parties

The “Consorzio Nazionale Interuniversitario per la Nanoelettronica” (IUNET, Italian Universities Nano-Electronics Team) is a non-profit, private Organization, aimed to lead and to coordinate the efforts of the major Italian university teams in the field of silicon-based Nano-electronic device modeling and characterization. Current members of IUNET are the University of Bologna, Calabria, Ferrara, Modena e Reggio Emilia, Padova, Pisa, Roma “Sapienza”, Udine, and the Politecnico of Milano. As such it qualifies as “Grouping” under the definition given in Article II.14.2.B of the “Guide to Financial Issues relating to FP7 Indirect Actions”, and therefore as third party carrying out part of work and entitled to funding, since it can be considered among: “associations, federations, or other legal entities composed of members (in this case, the Grouping is the beneficiary and the members contributing to the project should be listed).”

The partners of IUNET involved in ERG are the following: Università di Bologna, Università di Modena e Reggio Emilia, Università di Padova, Università di Pisa, Università di Roma “Sapienza”.

The specific competences and expertise brought to the project are related to modelling, simulation and characterization of device performance and assessment of the technology reliability, and is testified by the very large number of relevant papers published in international journals and the long-standing collaboration with leading industries in the field.

Allocation of Person-months among the IUNET partners:

	WP1	WP2	WP4	WPM1+WPM 2	TOTAL
IUNET				4	4
Università di Bologna	33				33
Università di Modena e Reggio		14			14

Emilia					
Università di Padova	24				24
Università di Roma “Sapienza”	33				33
Università di Pisa			14		
TOTAL	90	14	14	4	122

Allocation of budget among the IUNET partners (in euro):

	WP1	WP2	WP4	TOTAL
IUNET				0
Università di Bologna	240000			240000
Università di Modena e Reggio Emilia		120000		120000
Università di Padova	180000			180000
Università di Roma “Sapienza”	240000			240000
Università di Pisa			120000	120000
TOTAL	660000	120000	120000	900000

8.3.2 Subcontractors

As shown in the table in the section 8.4, out of the € 25.711.684 of costs of the project € 174.000 (this is less than 0,7% of the total costs).

Of this sum the largest amount of € 165.000 has been budgeted from AMAT ITALIA to outsource some very specialist activities necessary to the project researches. These activities cannot be carried on by any of the partners for confidentiality reasons and for the existing mutual knowledge and equipment-specific know how.

D&C

Design and Consulting Srl

Largo San Giorgio 21

30033 Noale - Venezia

It deals with the design of 360° Machinery, Equipment, Automation Systems, Scientific Research, developing studies, special assemblies, testing, calculations, simulations, FEM analysis and in general everything relating to project activities. AMAT is using the support of D&C to refine the design of equipment elements and for the design of non-mission critical parts such as part of the frames.

EUROGROUP

EUROGROUP S.P.A.

Via Treviso, 66 31057 Silea (Treviso) Italy

EUROGROUP s.p.a. was established in 1966 as a company specialized in the manufacture and repair of electrical installations. EUROGROUP is concerned with contract, integrated security systems, electrical, audio and video systems, automation on board, remote control, industrial software, and telecommunications and data networks. AMAT is using the support of EUROGROUP to realize the electrical systems on part of its equipments based on AMAT design and specifications.

8.4 Resources to be committed

The resources to be committed in the ERG project have been carefully planned since the early stage of the project proposal, targeting a big-scale/high-impact size, suitable to push forward the state of the art in solar energy technology and to aggressively exploit the market. During the setup of the project, we aimed to give to all partners the required level of resources for ensuring a high quality of work.

An indicative budget for the project is **€ 25.711.684,00** as total eligible cost with an indicative **funding budget of € 12.432.379,00** (almost 50% of eligible cost)**.**

Partic. no.	Partic. short name	Personnel	Travel	Durable Equipment	Consumables	(Category X)	Indirect costs	Sub contracting	Total costs
1 (C)	**ST**	1.579.200			631.200		789.600		3.000.000
2	**AMAT ITALIA**	882.500	40.000	150.000	40.000		222.000	165.000	1.500.000
3	**COMPEL**	550.000	12.500	70.000	262.500		179.000		1.074.000
4	**IUNET**	566.667		30.000	20.000		283.333		900.001
5	**POLITO**	600.000					300.000		900.000
6	**UNIBO**	280.000		40.000	40.000		140.000		500.000
7	**UNICAL**	296.000	29.500	36.000	51.697		88.800		501.997
8	**UNICT**	200.000		20.000	10.000		70.000		300.000
9	**CNR**	267.231	30.000	110.000	60.000		133.615		600.848
10	**ELETTRA**	210.000	15.000	5.000	5.000		65.000		300.000
11	**ONSEMI-B**	1.111.501			666.900		222.300		2.000.701
14	**STIAG**	383.000	3.000	9.000	4.950		380.800		780.750
15	**TEL**	1.244.908	16.700		319.200		1.717.49 21.704.0 15		3.298.300
16	**FRAUNHOFER**	252.897	7.840				289.263		550.000
17	**RWTH**	244.863	10.000	31.180	2.950				288.993
18	**IFAG**	3.238.565			150.022				3.388.587
19	**SMA**	1.212.300	7.500		7.500				1.227.300
20	**TUC**	172.000	6.750	2.400	17.200				198.350
21	**LEITAT**	182.400	17.460	12.000	40.000			9.000	260.860
22	**STUBA**	195.000	15.000		30.000		60.000		300.000
23	**POWERTEC**	188.000	12.000		40.000		60.000		300.000
25	**SPR**	300.000	12.000		45.000		107.100		464.100
26	**Tyndall**	229.033	40.000	4.000	71.020		103.216		447.269

27	**NXP**	1.079.100			105.000				1.184.100
31	**BTE**	469.000		17.751	50.000	18.000	234.500	15.000	804.251
34	**ENECSYS**	550.000	20.500		10.000				580.500
35	**USFD**	35.000	5.000		20.000				60.000
TOTAL		16.518.164	316.012	552.136	1.998.427		5.432.542	189.000	25.711.684,00

Effort and cost table per country

Country	Effort	Total costs
I	1098	9.576.846
B	128	2.000.701
IR	121	911.369
ES	48	260.860
SK	200	600.000
UK	156	640.500
D	794	9.733.057
NL	129	1.988.351
TOT	2674	25.711.684

A total of 27 participants coming from ten EU Countries (all ENIAC Member States) are represented in the ERG consortium (Italy, Germany, Belgium, Spain, The Netherlands, UK, Ireland, Slovak Republic).

It is clear that the major effort is made in term of human resources necessary to execute all researches and developments to achieve the ambition project objectives. The cost of the personnel is more than 72% of the project costs if you include also Other costs.

Cost table per country

Country	Personnel	Travel	Durable Equipment	Consumables	Other direct costs	Indirect costs	Sub contracting	Total cost
I	5.431.598	127.000	461.000	1.120.397	0	2.271.848	165.000	9.576.846
B	1.111.501	0	0	0	666.900	222.300	0	2.000.701
IR	529.023	52.000	4.000	116.020	0	210.316	0	911.369
ES	182.400	17.460	12.000	20.000	20.000	0	9.000	260.860
SK	383.000	27.000	0	70.000	0	120.000	0	600.000
UK	585.000	25.500	0	30.000	0	0	0	640.500
D	6.747.532	67.052	57.385	487.010	0	2.374.078	0	9.733.057
NL	1.548.100	0	17.751	155.000	18.000	234.500	15.000	1.988.351

Equipments

The partners are spending only 1% of the total costs in durable equipments i.e. € 549.956 so split: some optical instrumentation for electro-optical measurements, and microanalysis tools for electron microscopy or upgrade of the ICP-CVD equipment, some computer to build an ad-hoc cluster of machines for the implementation of the optimization algorithms, close-field probes for EMC, some instrumentation for the creation of a specific setup for the efficiency analysis of an innovative process for battery charging, 4 points probe GPSolar (contact resistance), IQE (Internal Quantum Efficiency).

Consumables

A total amount of **2.145.155 €,** which represent **6%** of the costs budget is necessary for the rental of some software licenses and to build demonstrators and prototypes.

NXP foresees silicon trial runs (Multi projects wafers) of 35K each.

SPR intend to spend for dye € 15.000, substrates € 5.000, nanomaterials € 15.000, Chemicals € 10.000, as the essential materials and consumables required for the fabrication of DSSC. Such consumables have a high unit cost when bought in non-bulk quantities.

IFAG intends to buy a set of masks IGBT 9k€, wafer 46 k€, SiC Epi 45 k€, Modules 5k€, consumables for reliability tests 12 k€, evaluation boards 17 k€, consumables for test equipment improvements 16 k€.

Some costs are due for lab materials or the Consumables will be Spare parts for electrical benches, for laser and for a diffractometer.

Within the consumables are also foreseen Costs of solar panels, electrical and mechanical components for research and development and Components electrical, Components mechanical, Powerstack (>1MW), PCB, Stencil, Mechanical design.

Other costs

The Spanish partners allocated in the Other Costs the money to pay the dissemination costs and AENEAS fees, but the most significant figure in this category is the 661k€ foreseen by the Belgian partner ONSEMI-B as “maximal 60% of Personnel Cost” allowed by the Belgian government.

Príloha 3

Špecifikácia projektu spoločného podniku

A. 1 Základné informácie o projekte		
Názov projektu	Energia pre zelenú spoločnosť: Od trvalého získavania energie k jej SMART distribúcii. Prístroje, materiály, návrhové riešenia a ich aplikácie	
Akronym projektu	ERG	
Odbor výskumu a vývoja[1]	20207 Mikroelektronika	
Charakter projektu	Aplikovaný výskum a vývoj	
Doba riešenia projektu	Od: 01.06.2011	Do: 31.05.2014
Celkové náklady na projekt (v EUR)	300 000 EUR	
Výška spolufinancovania projektu z prostriedkov MŠVVaŠ SR (v EUR)	99 900 EUR	
Podiel spolufinancovania z prostriedkov štátneho rozpočtu Slovenskej republiky na celkových oprávnených nákladoch (v %)	33,3 %	
Zodpovedný riešiteľ projektu (meno, priezvisko, tituly, č. telefónu, e-mail)	Ing. Martin Donoval, PhD.	

A. 2 Zodpovedná organizácia	**Základné údaje o zodpovednej organizácií**
Názov organizácie	POWERTEC s.r.o.
Skrátený názov	POWERTEC

[1] Podľa smernice č.27/2006-R z 21. decembra 2006 o sústave odborov vedy a techniky a číselníku odborov vedy a techniky

Adresa	Drotárska 6385/19a 811 04 Bratislava Slovensko
Samosprávny kraj	Bratislavský
IČO	44547056
Príslušnosť k rezortu	Bez príslušnosti
Typ organizácie	Spoločnosť s ručením obmedzeným
Odvetvie podľa OKEČ (odvetvová klasifikácia ekonomických činností)	71121
Štatutárny zástupca (meno, priezvisko, tituly)	Martin Donoval, Ing. PhD.

A. 3 Zoznam riešiteľov

Zoznam riešiteľov priamo sa podieľajúcich na riešení projektu

Meno a priezvisko	Tituly	Pracovné zaradenie	Dátum narodenia	IČO organizácie	Počet hodín	Podpis*
Martin Donoval	Ing., PhD.	Projektový koordinátor, manažér výskumných aktivít	[redacted]	44547056	1500	
Ján Jakabovič	Doc. Ing., PhD.	Vedúci výskumný pracovník	[redacted]	44547056	3000	
Martin Daříček	Ing., PhD.	Vedúci skupiny aplikovaného výskumu	[redacted]	44547056	1500	
František Horínek	Ing.	Inžinier aplikovaného výskumu	[redacted]	44547056	1500	
Ľubomír Sládek	Ing.	Inžinier aplikovaného výskumu	[redacted]	44547056	1500	
Drahomír Ďurina	Ing.	Produktový inžinier	[redacted]	44547056	1000	
Martin Jagelka	Bc.	Návrhár elektronických obvodov a systémov	[redacted]	44547056	1500	

- Ja vyššie podpísaný v zmysle zákona č. 428/2002 Z. z. o ochrane osobných údajov, súhlasím so spracovaním osobných údajov Ministerstvom školstva, vedy, výskumu a športu SR počas doby archivácie údajov a to v rozsahu uvedenom v zmluve. Zároveň sa zaväzujem, že pri akejkoľvek zmene údajov uvedených v zmluve budem informovať Ministerstvo školstva, vedy, výskumu a športu SR o týchto zmenách a to v lehote do 30 dní. Osobné údaje môžu byť spracovávané a archivované najviac po dobu 10 rokov po skončení poskytovania prostriedkov štátneho rozpočtu Slovenskej republiky.

A.4 Zoznam riešiteľov		
Ostatní riešitelia	Celkový počet ostatných osôb	5
	Súhrnná kapacita ostatných osôb v hodinách	6000
Spolu	Celkový počet zamestnancov	12
	Súhrnná kapacita zamestnancov v hodinách	17500

B. Ciele, harmonogram a výstupy projektu
Anotácia projektu
Uvedený projekt je riešený v rámci európskeho technologického podniku ENIAC a správa sa podľa Nariadenia Rady (ES) č. 72/2008 z 20. Decembra 2008, ktorým sa zakladá spoločný podnik ENIAC a Štatútu spoločného podniku ENIAC, ktorý je prílohou tohto Nariadenia. STU Bratislava je spoluriešiteľom projektu, ktorého koordinátorom je ST Microelectronics s.r.l. Taliansko. Aplikovaný výskum v projekte ERG je orientovaný na solárnu energiu, začínajúc inovatívnymi solárnymi článkami a metódami premeny solárnej energie na elektrickú s vysokou účinnosťou a efektívneho manažovania distribúcie energie v „smart“ sieťach pre rôzne aplikácie končiac. Predmetom výskumu budú optimalizačné metódy extrakcie energie z anorganických fotovoltaických článkov na báze monokryštalického Si a heteroštruktúr širokopásmových polovodičov. V súčasnosti sa pri extrakcii a prenose energie využívajú „koncentrované“ elektrické meniče. Niekoľko panelov je spojených do série s účelom vytvorenia požadovaného napätia. Takéto vetvy sú nasledovne navzájom prepájané paralelne. Za následné výkonové riadenie „power-management“ zodpovedný centralizovaný menič. V rámci problematiky sa bude výskum zaoberať návrhom a integráciou inteligentného modulu s implementovanou konverziou a riadenia napätia pre jednotlivé fotovoltaické bunky. Vzhľadom na nízky výkon takýchto buniek bude potrebný návrh inovatívnych integrovaných obvodov a systémov schopných efektívneho riadenia jednotlivých buniek na veľmi nízkej výkonovej úrovni. Počas projektu budú navrhnuté inteligentné riadiace jednotky, schopné zvyšovania efektívnosti konverzie a prenosu výstupného výkonu fotovoltaických panelov. Budú vyvíjané nové výkonové a diagnostické prvky ako na úrovni polovodičových prvkov, tak i na úrovni návrhu elektronických a integrovaných obvodov.

Budeme sa venovať priamej diagnostike fotovoltaických panelov, ďalšiemu DC/DC konverzii priamo na paneloch a tvorbe algoritmov a prvkov na monitorovanie funkčnosti inovačných riešení.
Konzorcium partnerov zúčastnených na riešení projektu ERG pre dosiahnutie stanovených cieľov bude využívať komplementárne metódy, procesy a expertízu riešiteľov. Komplexný prístup k výskumu bude kombinovať výskum v oblasti modelovania, návrhu a technologických procesov s ich optimalizáciou využitím výsledkov komplexných charakterizačných metód a techník
Finálnym cieľom projektu je uplatnenie inovatívnych a optimalizovaných riešení a technológií pri vývoji nových procesov a produktov, vrátane fotovoltaických článkov, nových konverzných systémov pre fotovoltaické invertory a ich vybranými aplikáciami pre domácnosti, resp. industriálnymi aplikáciami partnermi v rámci konzorcia.

Kľúčové slová

Solárne články, štruktúry aSi:H na monokryštalickom Si, tandemové fotovoltaické články, moduly na riadenie premeny energie, DC/DC konvertory, „smart junction box“, „MPPT – maximum power point tracking“, „smart“ siete, progresívne analytické, diagnostické a riadiace metódy fotovoltaických buniek, FVE článkov

Ciele projektu

Hlavným cieľom projektu ERG je hľadanie komplexných inovatívnych riešení pre výskum a vývoj nových fotovoltaických (solárnych) článkov využitím heteroštruktúr na báze aSi:H a širokopásmových polovodičov na monokryštalickom Si spolu s inovatívnymi technikami na získanie energie, elektronických riešení a modulov pre efektívnu premenu svetelnej na elektrickú energiu a jej následnú distribúciu v „smart“ sieťach s aplikáciami pre domácnosti alebo industriálne využitie.
V rámci výskumu fotovoltaických článkov bude našim cieľom vývoj návrh a testovanie moderných diagnostických a riadiacich systémov fotovoltaických buniek, spojených do panelov s cieľom výskumu zabezpečiť priamu analýzu každej bunky na báze veľmi nízkej výkonovej spotreby, integrovateľných s jednotlivými FV bunkami, vytvorenými na rôznych bázach polovodičov s čiastočne odlišnými vlastnosťami. Systém prispeje ku optimalizácií výstupného výkonu pri plnom ožiarení a bude schopný riadiť každú nezávislú FV bunku.
Počas riešenia projektu bude vyšetrovaný spôsob komunikácie cez napäťovú vetvu s cieľom zvýšenia energetickej efektívnosti a spoľahlivosti. Predmetom analýz bude ďalšie vylepšenie architektúry, vhodného na riadenie stabilného prúdového výstupu.
Aplikácia rozvíjaných metód a systémov spolu s využitím pripravených fotovoltaických štruktúr a prvkov na báze navrhnutých technologických procesov prípravy inovatívnych fotovoltaických článkov je ďalším dôležitým cieľom riešenia projektu.

Harmonogram riešenia projektu

Názov etapy	Začiatok	Koniec
Analýza systému, príprava simulácií modelov	06/2011	12/2011
Špecifikácia požiadaviek systému, návrh a simulácia analyticko-diagnostických modelov	01/2012	8/2012
Návrh blokov „smart box“, s energeticky úspornými riešeniami	01/2012	12/2012
Realizácia a simulácia		

energeticky efektívnych riadiacich elektronických obvodov	06/2012	12/2012
Analýza integrovateľnosti blokov, príprava pre integráciu modulu „smart box“	01/2013	05/2013
Implementácia aplikačných obvodov v rámci FV buniek	01/2013	09/2013
Integrácia efektívnych obvodov, príprava pre testovanie kompatibility modulov a FV buniek	01/2013	12/2013
Návrh realizácie demonštrátora	08/2013	12/2013
Test integračnej kompatibility a dlhodobej funkčnosti integrovaných blokov	01/2014	05/2014
Optimalizácia energetickej náročnosti modulov, testovanie priemyselnej odolnosti	01/2014	05/2014
Príprava demonštrátora, overenie elektrických vlastností	01/2014	05/2014
Prezentácia dosiahnutých výsledkov, využitie a ochrana duševného vlastníctva	Počas celého projektu	Počas celého projektu

Očakávané výstupy riešenia

Kategória	Výstupy	Rok 2011	Rok 2012	Rok 2013	Rok 2014	Rok 2015	
Publikácie	Publikácie v recenzovaných vedeckých časopisoch a zborníkoch konferencií		1	1	1		
Aplikačné výstupy	Návrh modelu „smart“ výkonového systému pre FV a jeho optimalizácia		1		1		
	Finalizácia funkčných testovacích blokov			1	1		
	Overenie vlastností modelu a systému		1		1		
Vzdelávanie a popularizácia vedy a techniky	Počet diplomantov, ktorých práce súviseli s riešeným projektom	2	2	2	1		
	Počet doktorandov, ktorých práce súviseli s riešeným projektom	2	2	2	2		
	Popularizačné aktivity - prezentácia výsledkov na výstave (napr. týždeň slovenskej vedy)		1		1		
Pridaná hodnota	Vytvorené partnerstvo						

riešeného projektu výskumu a vývoja	medzi akademickým a podnikateľským sektorom	1		1			
	Vyvolané projekty výskumu a vývoja		1				

C. Rozpočet projektu					
Rozpočet projektu pre zodpovednú organizáciu (v EUR)					
Rok	2011	2012	2013	2014	Suma
Bežné priame náklady	**15920**	**28000**	**25600**	**10400**	**79920**
Mzdové náklady	10408	17978	16505	7279	52170
Zdravotné a sociálne poistenie	2082	3596	3301	1456	10434
Cestovné výdavky	433	1765	1465	333	3996
Materiál	1000	2000	2000	600	5600
Odpisy	0	0	0	0	0
Služby	1997	2662	2329	732	7720
Energie, vodné, stočné a komunikácie	0	0	0	0	0
Bežné nepriame náklady	**3980**	**7000**	**6400**	**2600**	**19980**
Bežné náklady spolu	**19900**	**35000**	**32000**	**13000**	**99900**
Kapitálové výdavky	0	0	0	0	0
Výška spolufinancovania projektu z prostriedkov MŠVVaŠ SR (v EUR)	**19900**	**35000**	**32000**	**13000**	**99900**
Výška vlastných prostriedkov žiadateľa	29900	52250	48500	19250	150000

D.Čestné vyhlásenie štatutárneho zástupcu	Zodpovedná organizácia

Ja, dole podpísaný/á Ing. Martin Donoval, PhD., štatutárny zástupca záväzne vyhlasujem, že:

- Všetky údaje obsiahnuté v dokumentácii projektu sú pravdivé
- Projekt bude realizovaný v zmysle predloženého obsahu
- Zodpovedná organizácia súhlasí s pravidelnou finančnou kontrolou projektu
- Zodpovedná organizácia bude archivovať všetky účtovné dokumenty súvisiace s realizáciou projektu po dobu 5 rokov po skončení jeho spolufinancovania Ministerstvom školstva, vedy, výskumu a športu SR
- Dávam súhlas na výkon kontroly príslušným kontrolným orgánom MŠVVaŠ SR
- Zodpovedná organizácia bude dodržiavať legislatívu Európskej únie a platnú legislatívu SR

Som si vedomý možných následkov a sankcií, ktoré vyplývajú z uvedenia nepravdivých alebo neúplných údajov. Zaväzujem sa bezodkladne písomne informovať o všetkých zmenách, ktoré sa týkajú uvedených údajov a skutočností.

Podpis štatutárneho zástupcu príjemcu a pečiatka

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Miesto: Bratislava

Dátum:

Príloha 4

Rozpis celkových prostriedkov štátneho rozpočtu Slovenskej republiky na financovanie oprávnených nákladov projektu spoločného podniku v jednotlivých rozpočtových rokoch jeho riešenia (v EUR)

Deň/mesiac/rok	1 / 6 / -31/12/ 2011	2012	2013	1/1 - 31 / 5 / 2014
výška prostriedkov v EUR	19 900	35 000	32 000	13 000

Podpis štatutárneho zástupcu príjemcu a pečiatka

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Miesto: Bratislava

Dátum: