The Strategic Research Agenda of the European PV Technology Platform:

Methodology, Contents and Lessons learned

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on behalf of

PV Technology Platform WG3:

Science, Technology & Applications

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The PV Technology Platform

PhotoVoltaic TECHNOLOGY PLATFORM

http://www.eupvplatform.org

- Contribute to a rapid development of a world-class **cost competitive European PV** for a sustainable electricity production
- Involve stakeholders in the **formulation of research programmes**
- Ensure strong links and coordination between **industry**, **research** and **market**.
- To **implement the strategic plan**

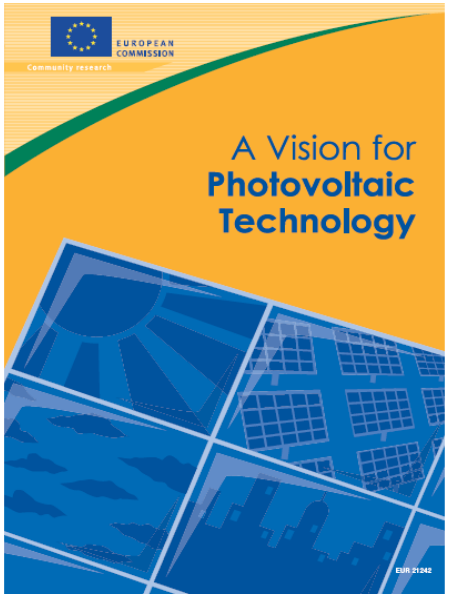
Photovoltaic Solar Energy:

The Road Ahead

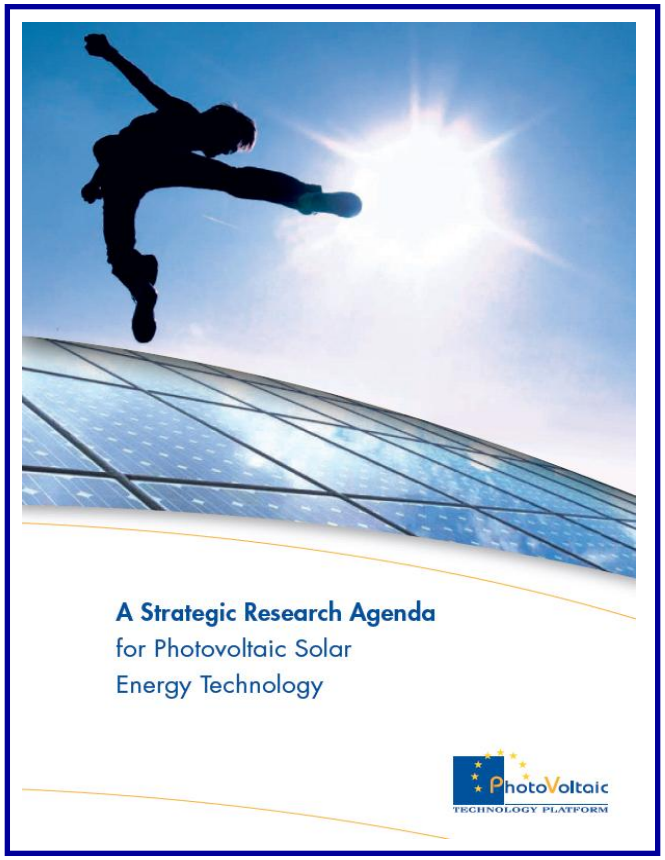
European Photovoltaic Technology Platform

2008

PhotoVoltaic TECHNOLOGY PLATFORM



2005



2007

Implementation Plan

for the

Strategic Research Agenda

of the

European Photovoltaic Technology Platform

2008

www.eupvplatform.org

Rationale for a Roadmap

PhotoVoltaic TECHNOLOGY PLATFORM

- ITRS-roadmap in the field of micro-electronics
  - Alignment of stakeholders
    - Device manufacturers
    - Material suppliers
    - Equipment manufacturers
    - Electronic circuit and application developers
  - Based on a well-established underlying physical law (scaling of transistors –law of Moore)
  - Has led to a tremendous increase of functionality/unit area
- Challenge: is something similar possible for PV?
  - Broad spectrum of PV-technologies
  - More external parameters (e.g. incentives for market growth)
  - Horizontal issues (integration of RES in the grid)

Contents

- SRA briefly revisited:
  - Drivers and enablers for PV to be addressed by research
  - SRA governing principles
  - Methodology
  - SRA aims & content summarized
- Lessons Learned

Contents

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Drivers and enablers for PV development

- Electricity generation cost *and* value
- Environmental quality
- Applicability
- Socio-economic factors

SRA governing principles

- Dedicate short-term research to competitiveness of EU PV industry
- Address all parts of the value chain and distinguish short, medium and long term
  - pre-define budget shares for ST, MT and LT
- No technology exclusivity
- Set common (indicative) cost targets as a function of time for all (flat-plate) module technologies

Methodology

- Different Workgroups were formed
- These different Workgroups worked out
  - Questionnaires about specific PV cell and module technologies
  - Questionnaires about other parts of the PV value chain
  - Questionnaires were sent to experts outside working groups
- Feedback from >300 researchers and industrialists was collected
- Consolidated in a summary,agreed upon within the Working Groups (=appendices to the SRA)
- Executive summaries were written by Working Group responsibles and included in the Final SRA

= "Meet in the Middle" process

SRA aims quantified

Overall short term target:

reach grid parity (on consumer level) in Southern Europe by 2015

- typical turn-key system price ≤ 2.5 €/Wp
- typical turn-key system cost < 2 €/Wp

⇒ grid parity in most of Europe by 2020

SRA aims quantified

characteristics of PV technology

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Rounded figures	1980	2007	2015 / 2020	2030	Long term potential
Typical turn-key system price (2007 €/Wp, excl. VAT)	**>30**	**5** *(range 4~8)*	**2.5 / 2.0**	**1**	**0.5**
Typical electricity generation costs S Europe (2007 €/kWh)	**>2**	**0.30**	**0.15 / 0.12** *(competitive with retail electricity)*	**0.06** *(competitive with wholesale electricity)*	**0.03**
Typical commercial *flat-plate* module efficiencies (total area)	**up to 8%**	**up to 15%**	**Up to 20%**	**up to 25%**	**up to 40%**
Typical commercial *concentrator* module efficiencies	**(~10%)**	**up to 25%**	**Up to 30%**	**up to 40%**	**up to 60%**
Typical system energy pay-back time Southern Europe (yrs)	**>10**	**2**	**1**	**0.5**	**0.25**

Grid parity in Europe – 2007

(lines to guide the eye)

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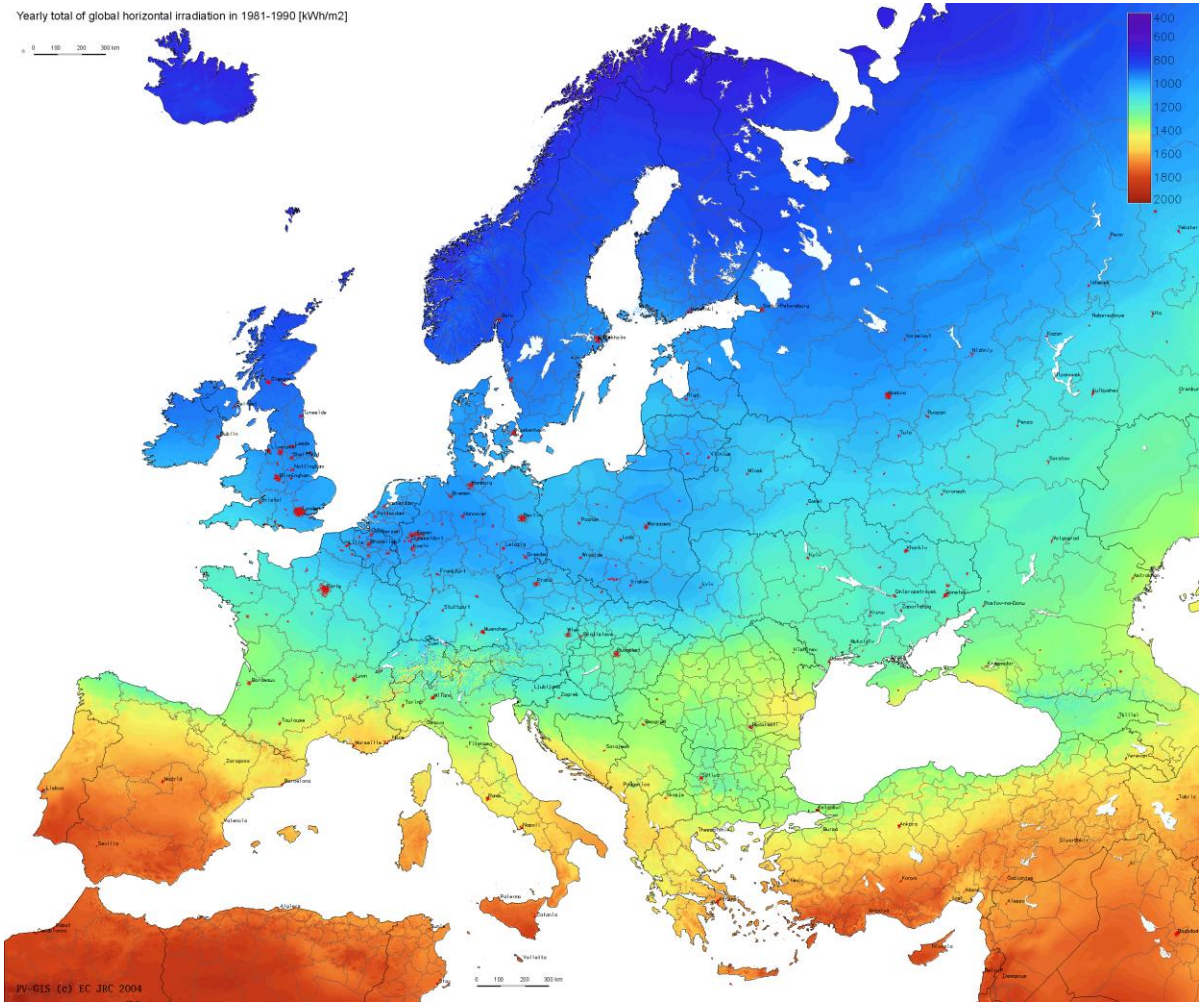
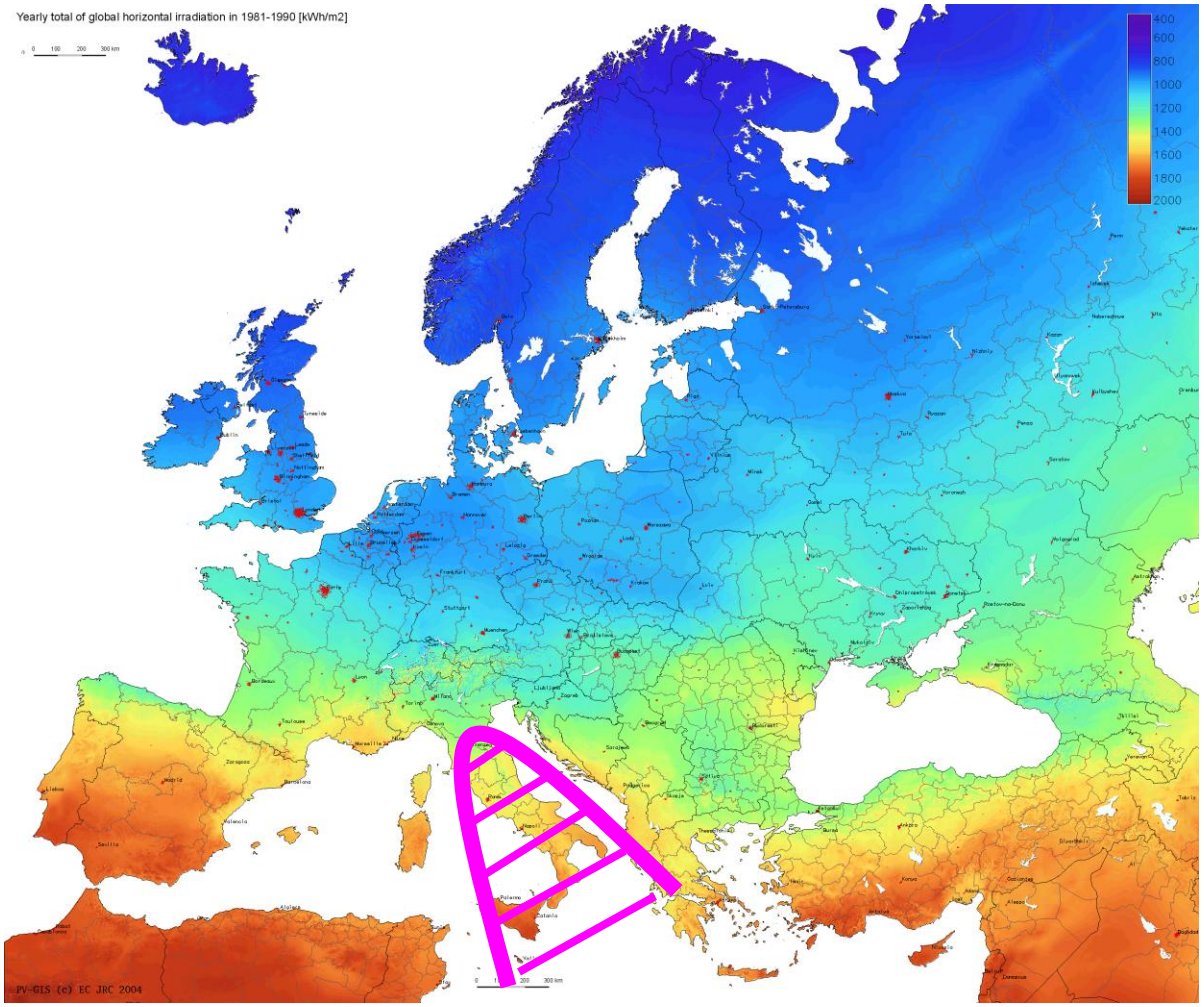


irradiation (kWh/m²·yr)	PV generation cost (€/kWh)
600	0.83
1000	0.50
1400	0.36
1800	0.28

insolation map: Šúri M., Huld T.A., Dunlop E.D. Ossenbrink H.A., 2007. Potential of solar electricity generation in the European Union member states and candidate countries. Solar Energy, http://re.jrc.ec.europa.eu/pvgis/

Grid parity in Europe – 2010

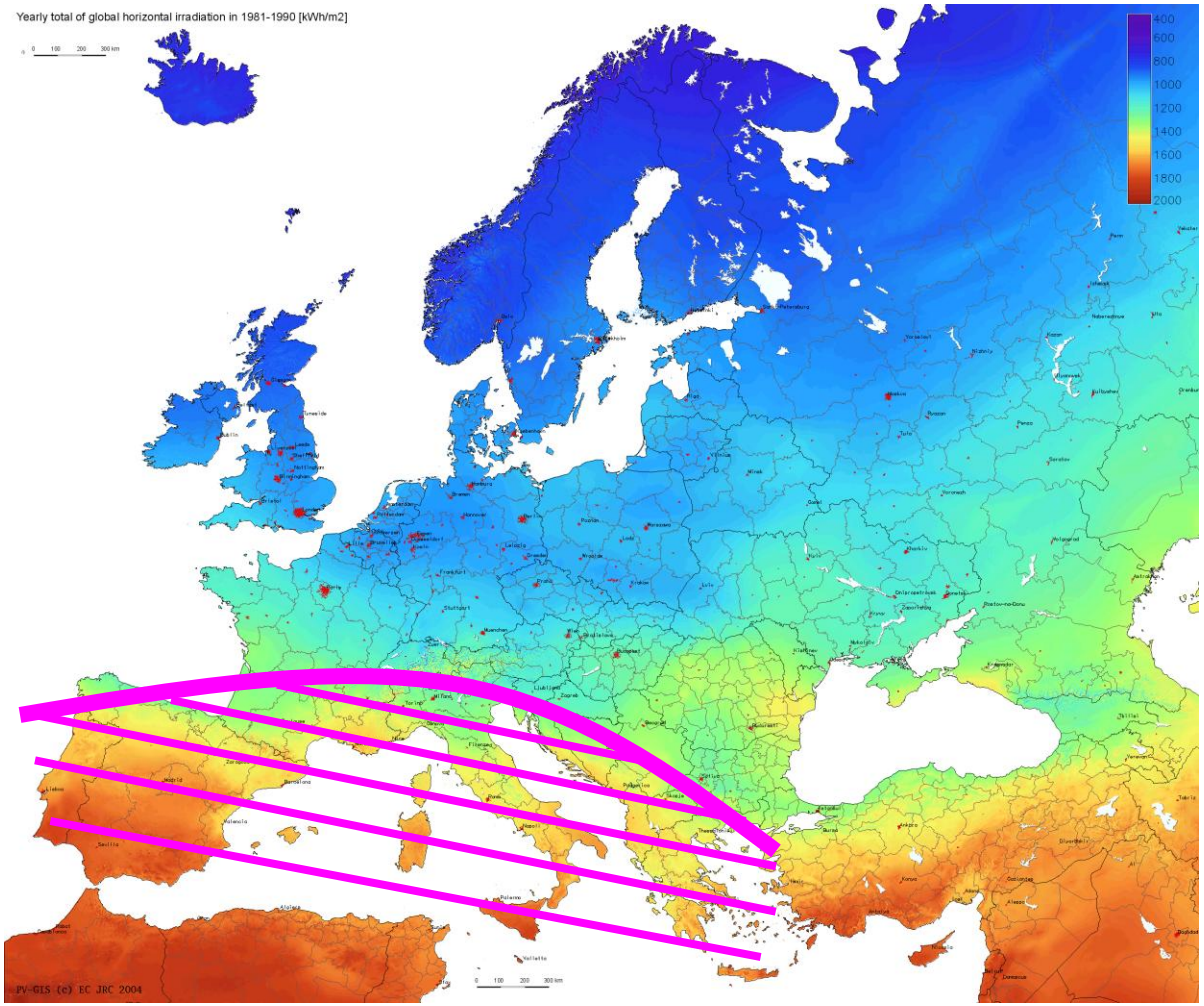
(lines to guide the eye)



irradiation (kWh/m²·yr)	PV generation cost (€/kWh)
600	0.50
1000	0.30
1400	0.21
1800	0.17

Grid parity in Europe – 2015

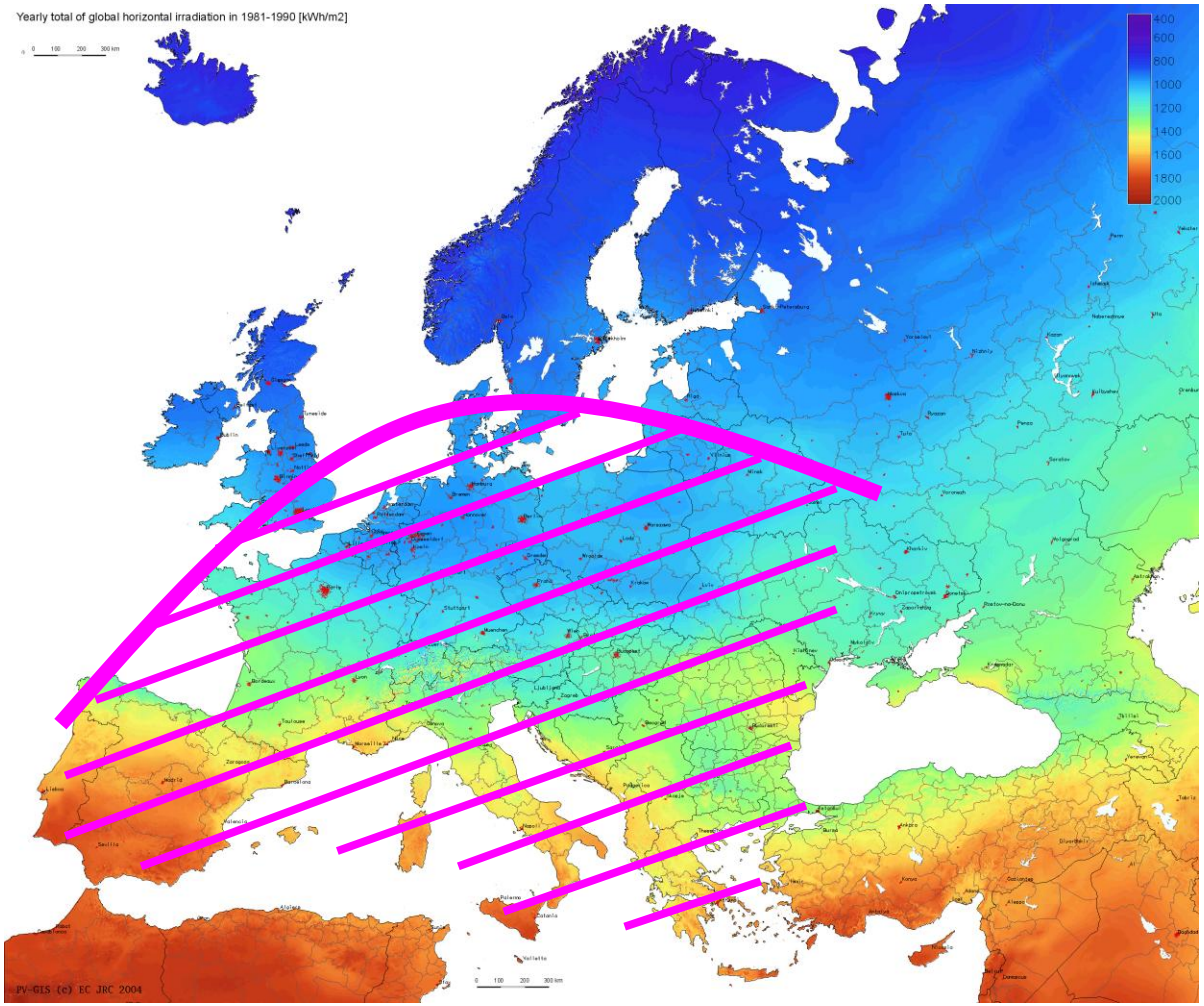
(lines to guide the eye)



irradiation (kWh/m²·yr)	PV generation cost (€/kWh)
600	0.42
1000	0.25
1400	0.18
1800	0.14

Grid parity in Europe – 2020

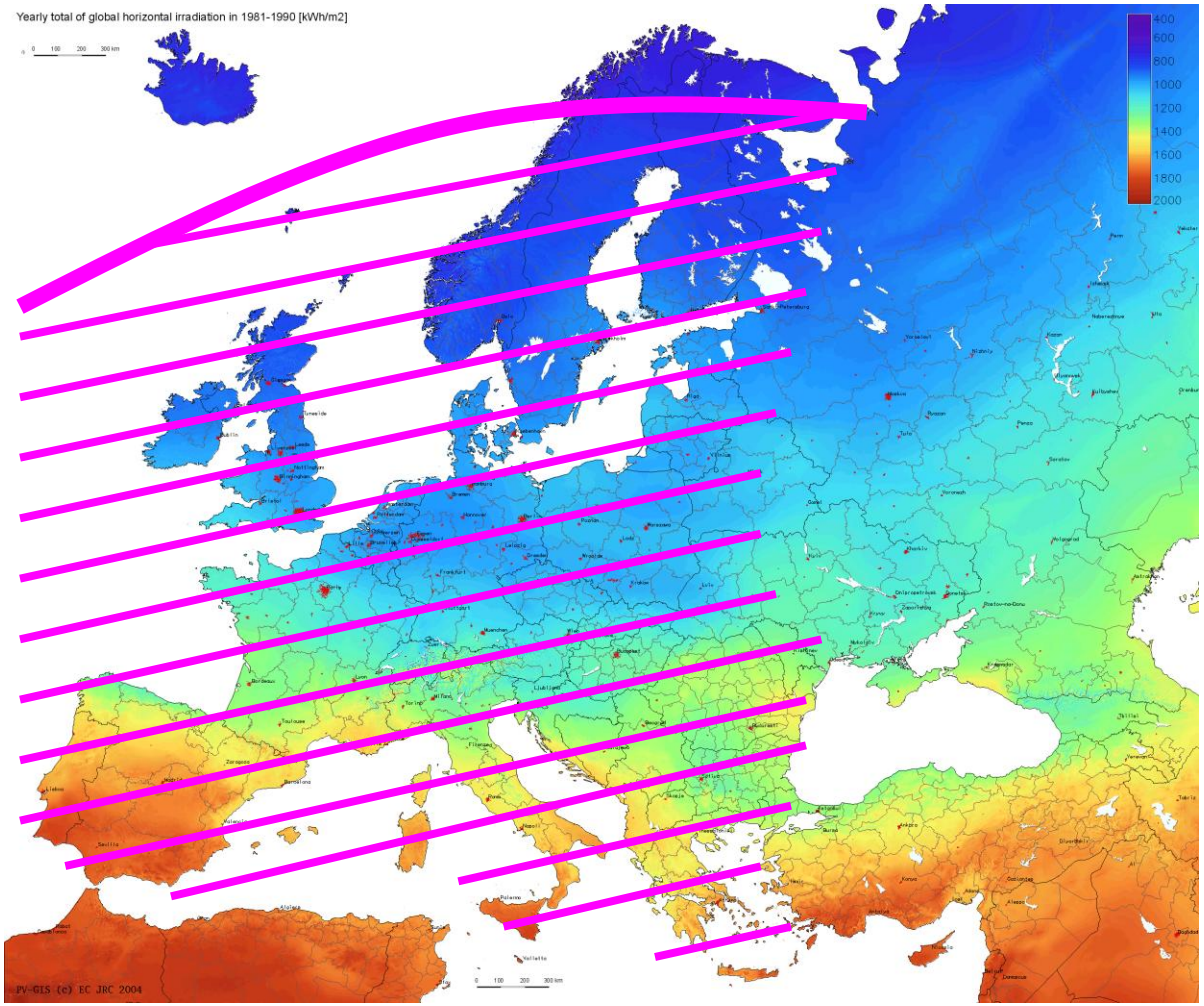
(lines to guide the eye)



irradiation (kWh/m²·yr)	PV generation cost (€/kWh)
600	0.33
1000	0.20
1400	0.14
1800	0.11

Grid parity in Europe – 2030

(lines to guide the eye)



irradiation (kWh/m²·yr)	PV generation cost (€/kWh)
600	0.17
1000	0.10
1400	0.07
1800	0.06

SRA contents summarised

R&D fields distinguished

PhotoVoltaic TECHNOLOGY PLATFORM

- **Cell & module technologies**
  - wafer-based crystalline silicon
  - existing thin-film technologies (Si, CIGSSe, CdTe)
  - emerging & novel technologies
- **Concentrator technologies**
- **Balance-of-System components and systems**
- **Standards, QA, safety and environmental aspects**
- **Socio-economic and enabling research**

SRA contents summarised

selected R&D issues

PhotoVoltaic TECHNOLOGY PLATFORM

➢ Cell & module technologies: *common aspects*




- **high-productivity manufacturing (processes and equipment)**
- **high efficiency devices**
- **low-cost transparent conductors**
- **low-cost, durable encapsulation for rigid and flexible modules**
- **environmental sustainability (energy & materials)**

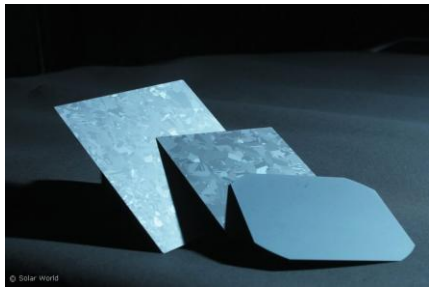
SRA contents summarised

technologies characterised

PhotoVoltaic TECHNOLOGY PLATFORM

➢ Wafer-based crystalline silicon






- ½ century of manufacturing history
- progressing by innovation and volume
- reduction of manufacturing costs is major challenge
- typical total area module efficiency:
  - 12~17% (now)
  - 18~>22% (longer term)

SRA contents summarised
technologies characterised

PhotoVoltaic TECHNOLOGY PLATFORM

➢ Thin-film silicon



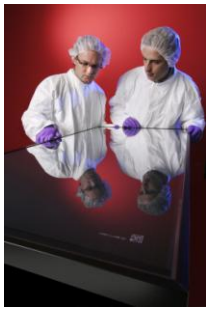

- low-cost potential and new application possibilities
- positive impact of micro- and nanocrystalline silicon
- efficiency enhancement is major challenge
- typical stable total area module efficiency:
  - 6~9% (now)
  - 10~15% (longer term)

SRA contents summarised

technologies characterised

PhotoVoltaic TECHNOLOGY PLATFORM

➢ Copper-indium/gallium-selenide/sulphide (CIGSS)



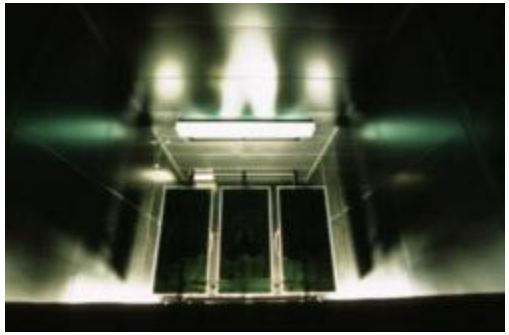

- high performance & possibilities for multi-junction devices
- reduction of manufacturing costs is major challenge
- typical total area module efficiencies:
  - 9~12% (now)
  - 15~18% (longer term)

SRA contents summarised

technologies characterised

PhotoVoltaic TECHNOLOGY PLATFORM

➢ Cadmium telluride

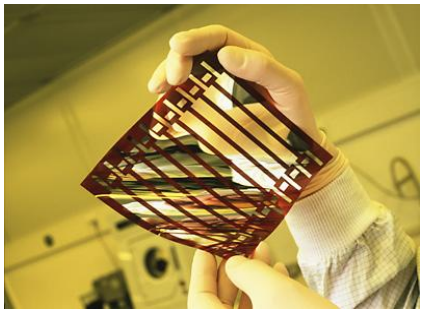




- low-cost potential
- positive impact of development of take-back and recycling systems
- efficiency enhancement is major challenge
- typical stable total area module efficiency:
  - 7~9% (now)
  - 10~15% (longer term)

SRA contents summarised
technologies characterised

PhotoVoltaic TECHNOLOGY PLATFORM

➢ Novel and emerging technologies



polymer PV

dye PV

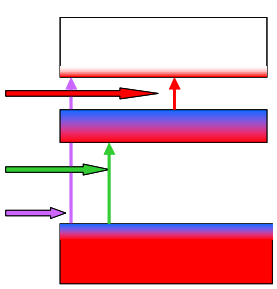
thermo PV

- current emerging technologies primarily candidates for very low cost or new application forms (i.e. not for high performance)
- first applications may appear in niche markets

SRA contents summarised

technologies characterised

➢ Novel and emerging technologies



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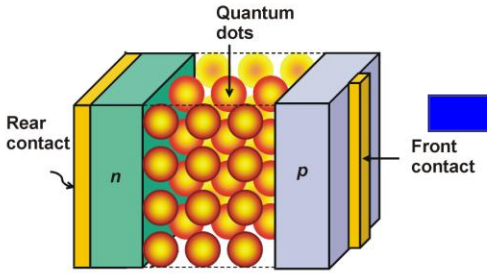
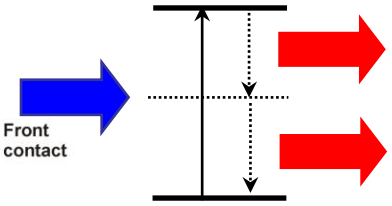
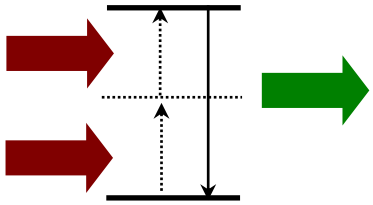




Down-convertor



Up-convertor

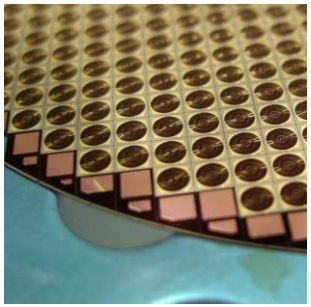
- wide variety of new conversion principles and device concepts
- mostly aimed at very high efficiencies (“full spectrum utilisation”)
- very important in view of long term potential of PV; long way to go to commercial applications
- also “supplier” to other technology families; e.g. efficiency boosters (spectrum converters) and super-high efficiency concentrator cells

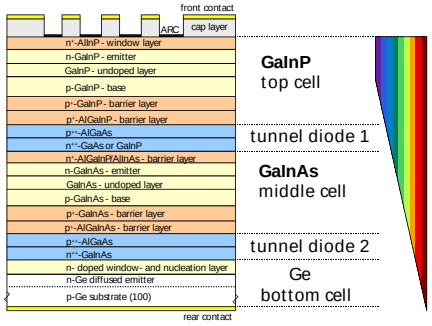
SRA contents summarised

technologies characterised

PhotoVoltaic TECHNOLOGY PLATFORM

➢ Concentrator technologies





- application form of choice for high cost/m^2, super-high efficiency cells
- only concrete way to system efficiencies >30% as yet
- manufacturing and applications now taking off
- unique application opportunities in sunny regions

SRA contents summarised

selected R&D issues

PhotoVoltaic TECHNOLOGY PLATFORM

➢ BoS-components and PV systems



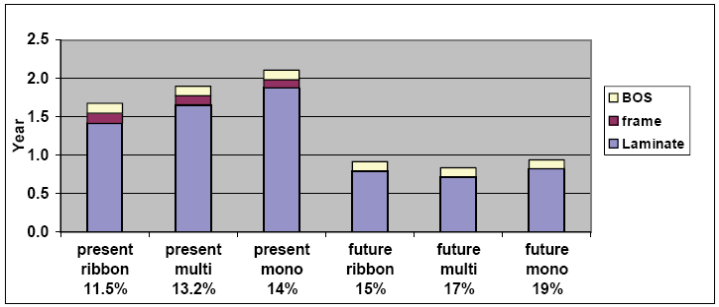

- **inverter lifetime and reliability**
- **concepts and components for grids at high PV penetration levels**
- ***storage technologies for small and large applications***

SRA contents summarised

selected R&D issues

PhotoVoltaic TECHNOLOGY PLATFORM

➢ Standards, quality assurance, safety and environmental aspects



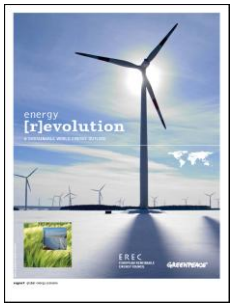
- QA guidelines for the whole value chain
- LCA studies and recycling processes

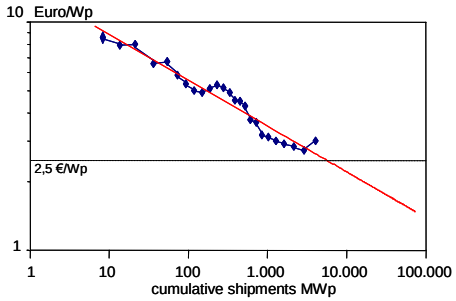
SRA contents summarised

selected research issues

PhotoVoltaic TECHNOLOGY PLATFORM

Socio-economic aspects and enabling research





- non-technical costs and benefits of PV
- required skills base for a growing PV sector

Lessons learned

- SRA built on this consensus acts now as a broadly accepted reference document
  - For European Commission
  - For R&D Programming bodies
  - Lines up the different actors
- Message given becomes relatively complex
  - No “Silver Bullet” PV-technology
  - Development in all parts of the PV value chain are necessary
  - Parallel with ITRS-roadmap for Microelectronics
- The present document is mainly the result of a consensus between academia and industry; the other stakeholder (governments, regulatory bodies) have been much less involved.

Lessons learned: the Road Ahead

- The Implementation Plan, presently under preparation, will also establish a link to the policy stakeholders
- Implementation Plan has to provide link to large-scale efforts and the inherent distributed character of Photovoltaics
  - Build further on a number of Centers of Excellence, not one large centralized body
  - Determine the detailed milestones (timescale is still rough)
  - Get linked to the Roadmaps developed by the US and Japan

Conclusions

- **SRA provides first consolidated PV R&D strategy on EU level**
  - reference document for PV R&D programming and for PV technology development
- **SRA outlines possible development of PV technology in quantitative terms**
  - valuable source of data for energy scenarios and policy making
- **SRA is now ready for implementation plan**

Acknowledgements

- **PV TP Steering Committee**
- **PV TP Secretariat** (EPIA, EUREC, JRC Ispra, WIP) **& EU support through the PV Sec project**
- **PV TP Mirror Group**
- **EC officers** (DG RTD, DG TREN & DG Enterprise)


thank you for your attention!