Cu-PV project 2012-2015: cradle to cradle sustainable PV modules

Cradle-to-cradle sustainable PV modules

Brussels
Bart Geerligs
20 March 2017

www.sustainablepv.eu/cu-pv

Contents

- Sustainability of PV (“photovoltaics”: solar electricity)
- The Cu-PV project: integrated technology approach on the main sustainability issues
- Partners and roles
- Conclusions and outlook

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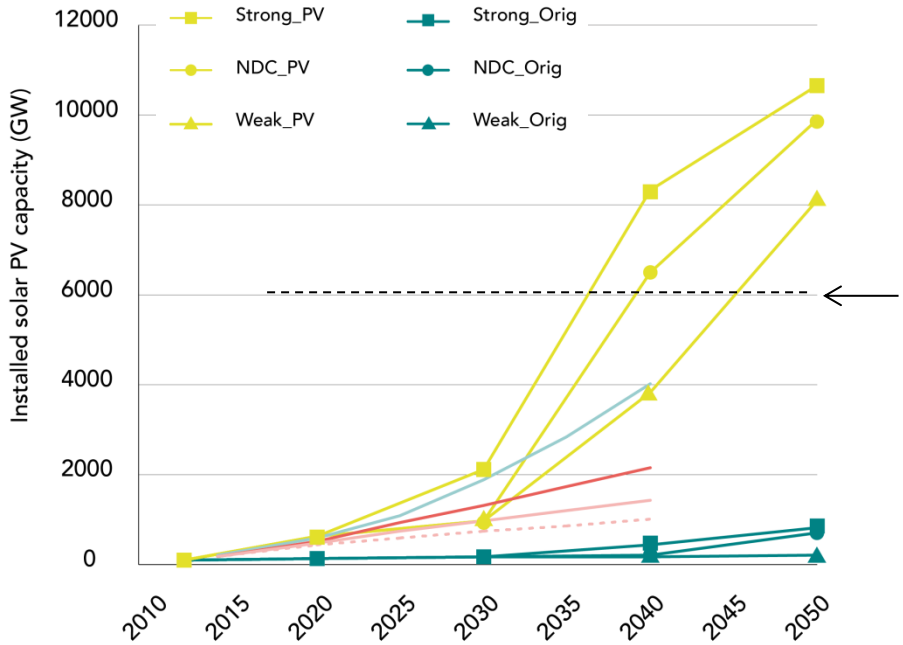
ASSOCIATION PV CYCLE

Significant growth of PV

- CO2 footprint of PV is small: 38-82 g CO2-eq/kWh
- Nevertheless, reduction of footprint will be beneficial



if present technology: 6-14 Gton CO_2-eq, of which 68% for the silicon wafer

Carbon Tracker - Expect the unexpected, 2017
Sources: IEA World Energy Outlook 2016,
BNEF New Energy Outlook 2016, and CTI-Imperial analysis 2016.

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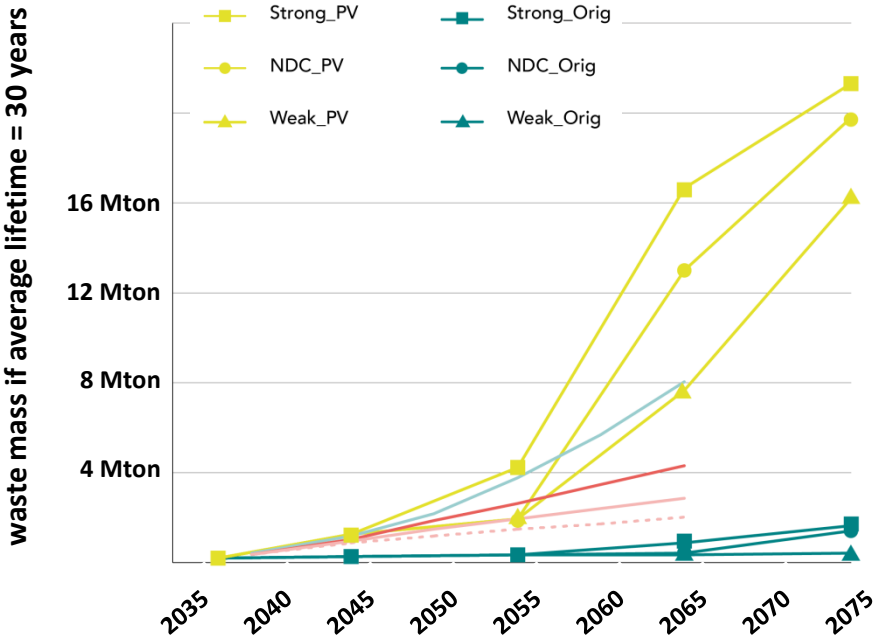
Significant growth of PV

- Also waste volume has to be anticipated (with some delay)



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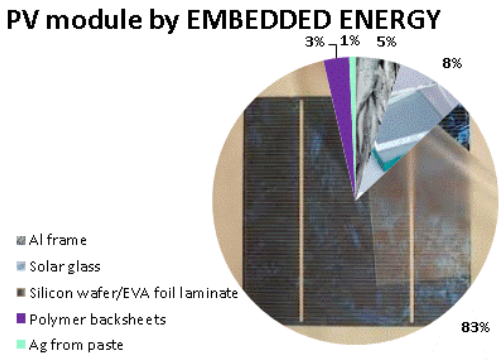
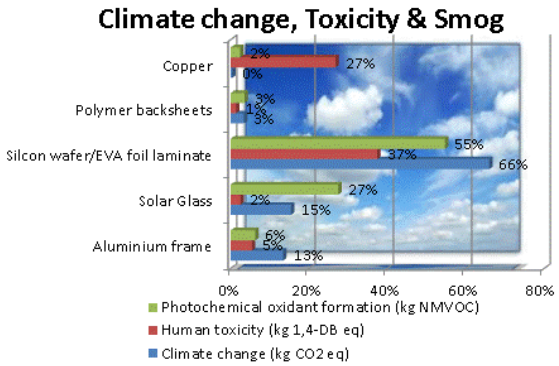
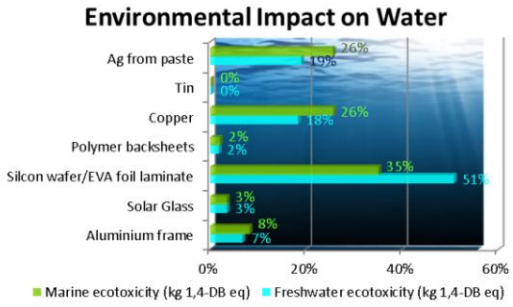
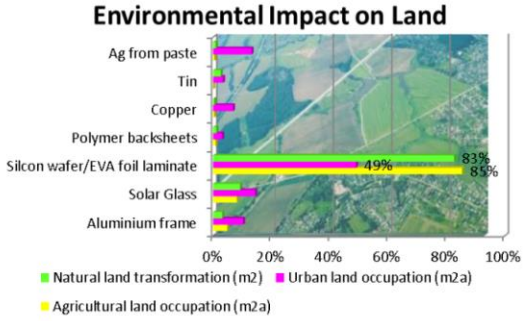
LCA analysis of PV









C. Olson et al., EUPVSEC 2013

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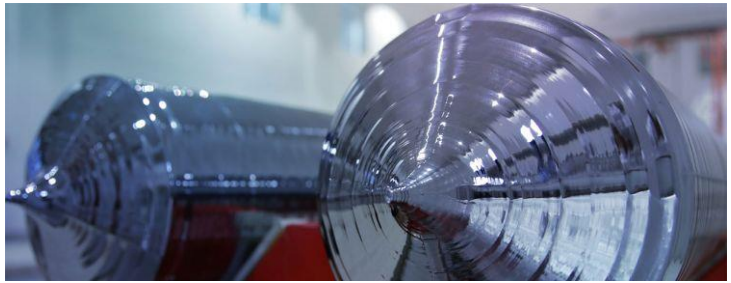
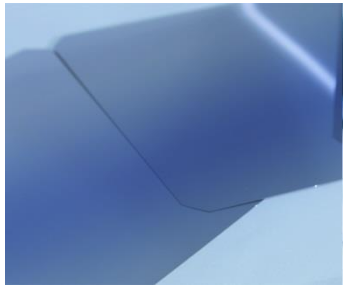
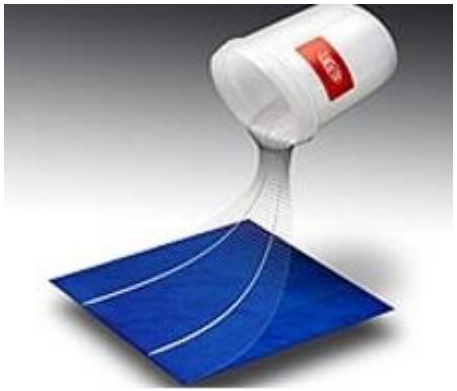
Sustainability issues tackled in the Cu-PV project

1. CO_2 footprint: mainly Si wafer: reduce thickness & recycle





2. Ag: used for metallisation: replace
3. Recycling: increase recovered value



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Project partners

- OEMs: companies making production equipment for metallisation of solar cells, and for manufacturing modules: **Xjet, Besi, Eurotron**
- End users, with own R&D:
  cell and module producer: **Siliken**
  SME intent on setting up recycling business: **Technical Plating**
- **PV CYCLE**: a non-profit member-based organisation managing waste (collection and recycling) for PV companies
- R&D institutes: solar cell and module technology, with track record in transfer to industry: **Imec, ECN**
  LCA expertise: **ECN**

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- End users, with own R&D:
  ~~cell and module producer: **Siliken**~~
  Due to financial problems **Siliken** had to withdraw at start of project, and tasks were distributed over the other partners.
  waste (collection and recycling) for PV companies
- R&D institutes: solar cell and module technology, with track record in transfer to industry: **Imec, ECN**
  LCA expertise: **ECN**

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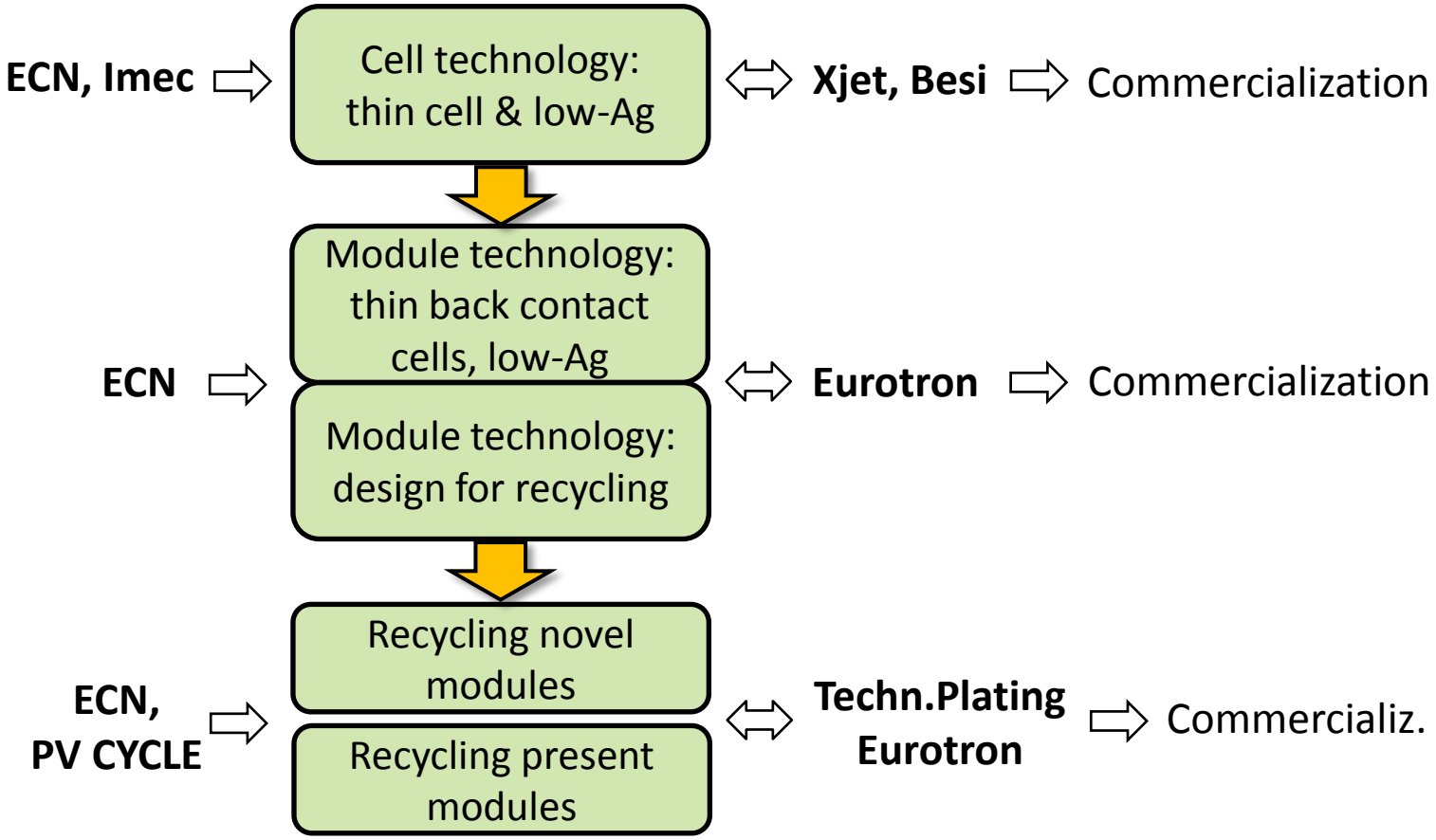
Project partners



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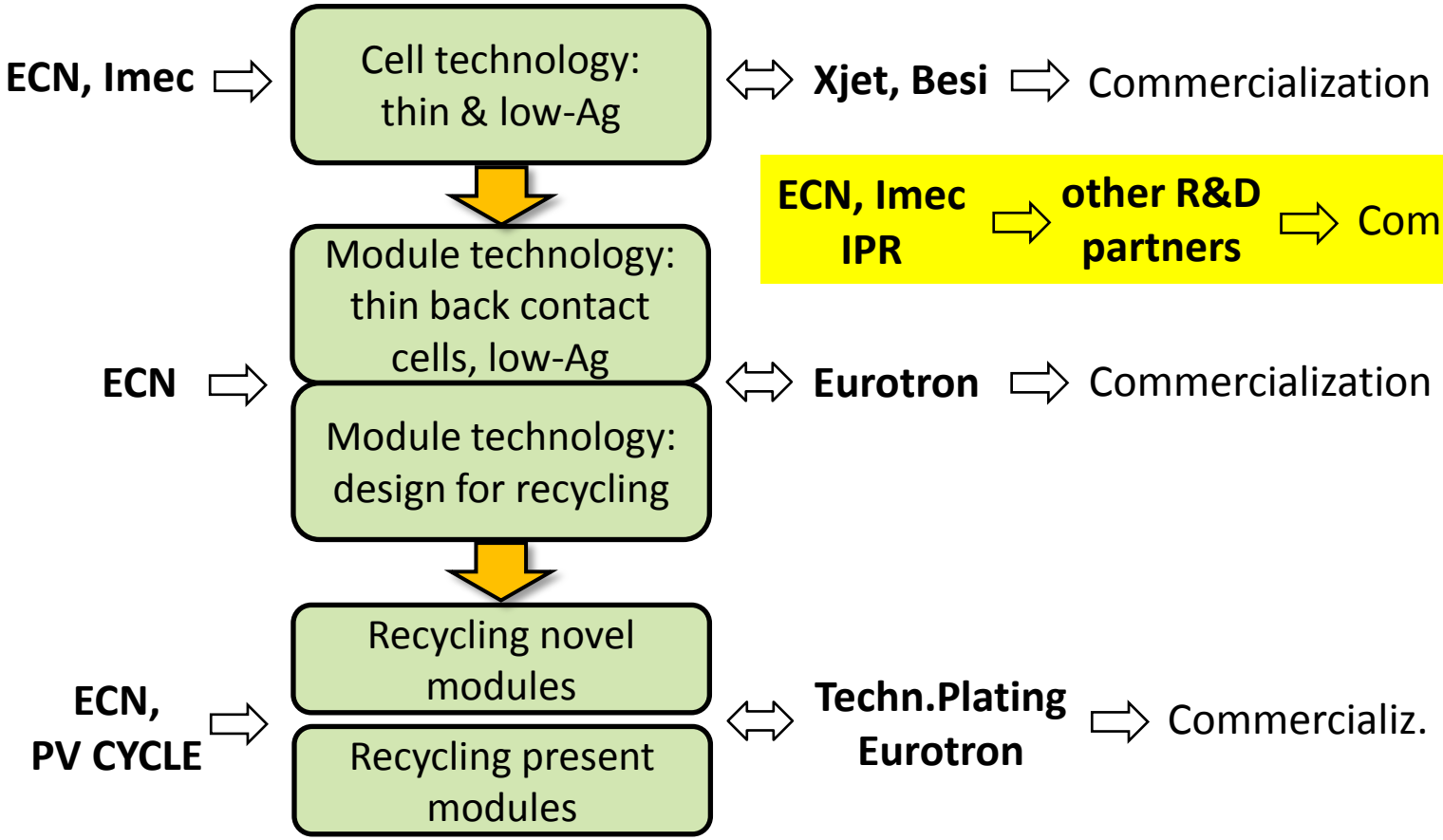

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Project approach

- Multiple technology development lines
  1. very close to industry – for rapid introduction & rapid benefit to industry partners
     - print seed&plate metallization; recycling of present PV modules
  2. more advanced technology – with more environmental benefit
     - PVD seed&plate metallization; design for recycling

- Interaction between the solutions for the different problems
  - New module technology to reduce silicon consumption *and at the same time* enhance recyclability
  - New cell technology to reduce silicon consumption *and at the same time* allow solutions to reduce silver consumption

- PV CYCLE as watch-dog for feasibility of recycling; and feedback from network (e.g. survey at start of project, workshop)

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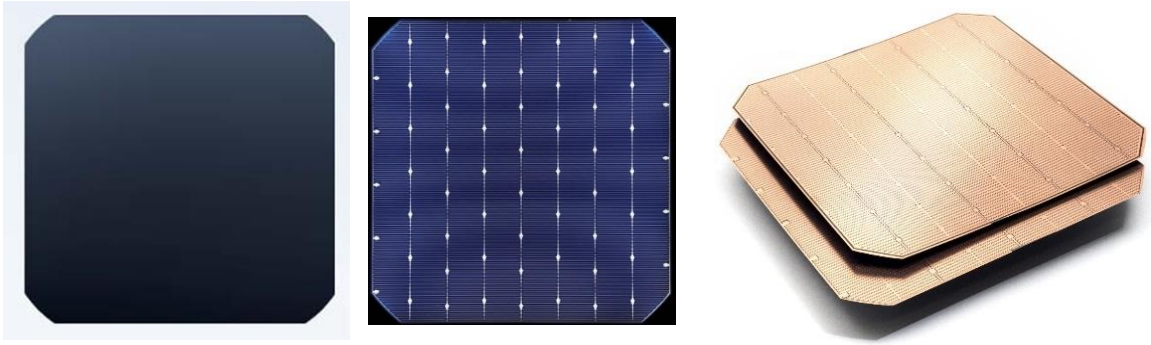
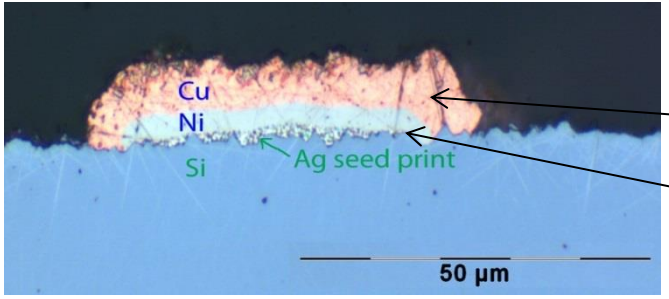
Cu-PV solar cells

- contacted on rear only - less stress in module -allowing thinner wafers



- instead of Ag contacts, using a Cu-plated layer stack



Besi-Meco NiCu plate

Xjet seed print
90% Ag reduction

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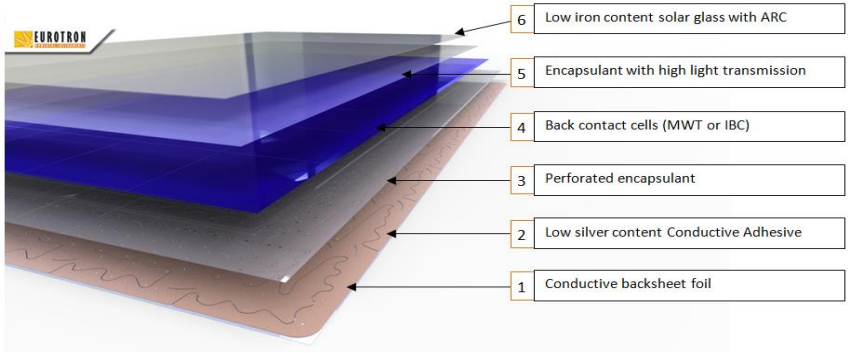
Cu-PV modules

- back-contact module technology - allowing extremely thin cells (120 µm in project, recently 80 µm)



- thermoplastic encapsulant, modified frame and backsheet - allowing full wafer/cell recovery

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Some results

- Cell technology – cell thickness from 180 µm to 120 µm;
  Ag consumption reduced by 70%/90%/>95%; efficiency to 22.5%
- Module technology – Pb-free interconnection; back-contact technology for 6” interdigitated-back-contact cells; thermoplastic encapsulation; F-free backsheet; new framing
- Recycling – for present conventional modules: enhanced separation – backsheet, silver, clean glass, (silicon) recovered; for thermoplast based modules: recovery of intact glass sheets and large fraction of intact wafers

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Plating

- Plate-on-PVD-seed metallization process for IBC developed
- Ag reduction >95% (Ag capping layer still required)
- efficiency 22.5%
- 120 µm thin cells; handling of 100 µm thin wafers
- Dissemination: conferences, exhibitions, customer contacts

Plate-on-seed line sold by Meco-Besi

Confident about market growth

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Seed printing for plating

- Plate-on-printed-seed metallization process developed for all solar cell architectures, including standard industrial
- Ag reduction 90% for inkjet printing, 70% for screen printing
- 120 µm thin cells
- Close to industrial process, proven, yet limited industry interest
- Xjet decided to withdraw from PV business
- Xjet willing to license technology

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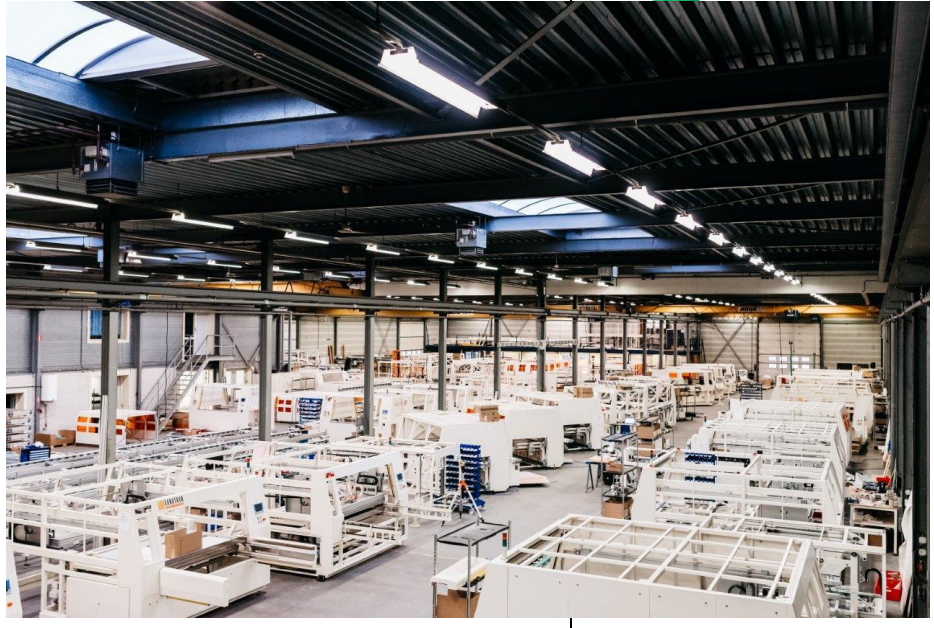
Back contact module technology

- Technology for IBC cells, 120 µm thickness (recently 80 µm), thermoplastic encapsulant, production conductive backsheet.
- Dissemination: conferences, exhibitions, customer contacts
- Several production lines sold; press release in April 2017
- Technology ready for drastic reduction of Si wafer thickness – however currently manufacturers still use normal wafer thickness



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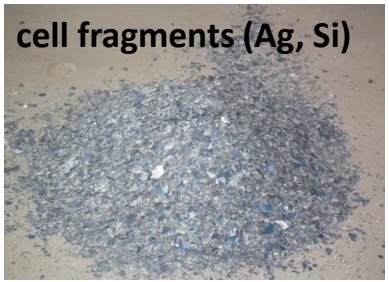
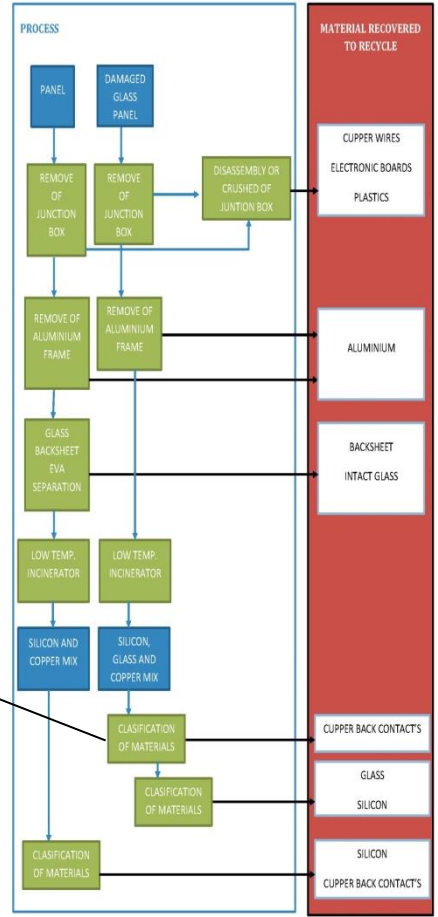
Recycling

- Semi-automated disassembly / thermal / sorting process for recycling of current PV modules
- Positive business case evaluation by Technical Plating with support from PV CYCLE and ECN – unfortunately Technical Plating encountered financial problems at end of project





Conclusions and outlook

- Mix of complementary partners along the value chain
- 3x price drop of PV modules during 2010-2012 caused problems for partners, and in general reduces adoption of innovations
- Inkjet seed printing technology was possibly too disruptive
- Back contact module technologies either moved to production or are in further test&development for production
  - wafer thickness should follow suit, if only for cost reasons
  - environmental footprint labeling would help
- Back contact cell technologies moved to industrial tests
- Adoption of project recycling technologies and design for recycling face challenges of relatively low value of component materials, and reliable supply of end-of-life modules
  - environmental footprint labeling might help

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