Urban Energy Innovation

Theme #4: Solar Urban

30th of May 2018

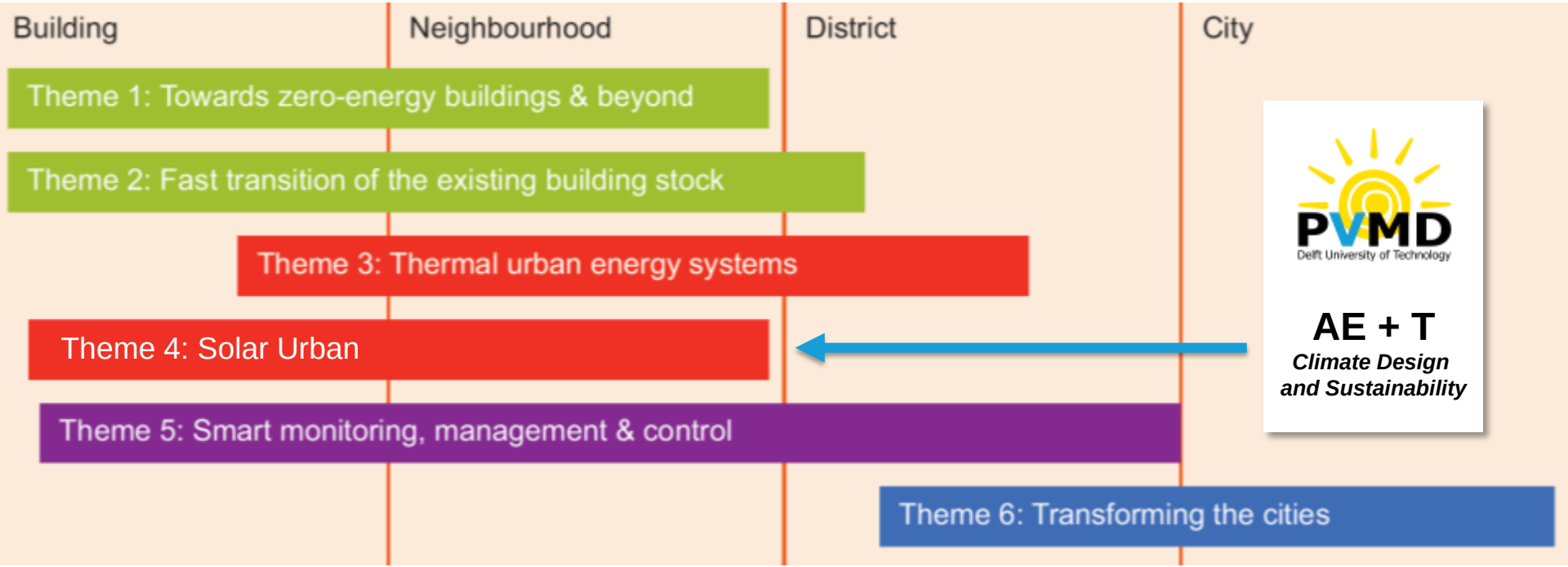
Delft, the Netherlands

PVMD
Delft University of Technology

AE + T
Climate Design and Sustainability

TU Delft

Delivering carbon-free urban energy system in 2050



Climate Design and Sustainability vision

Integration of sustainable climate concepts in architectural design and urban planning

Architectural Engineering and Technology

department

Photovoltaic Materials and Devices group vision

Sustainable and green global electrification for smart cities

Electrical Sustainable Energy

department

PVMD Delft University of Technology

DCE&S DC systems, Energy conversion & Storage

IEPG Intelligent Electrical Power Grids

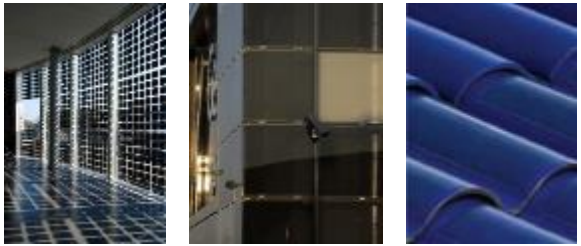
Urban / Architectural Integrated PhotoVoltaics

Infotainment spot

by TU Delft

Built-Added Photovoltaics (BAPV)

Building Integrated Photovoltaics (BIPV)



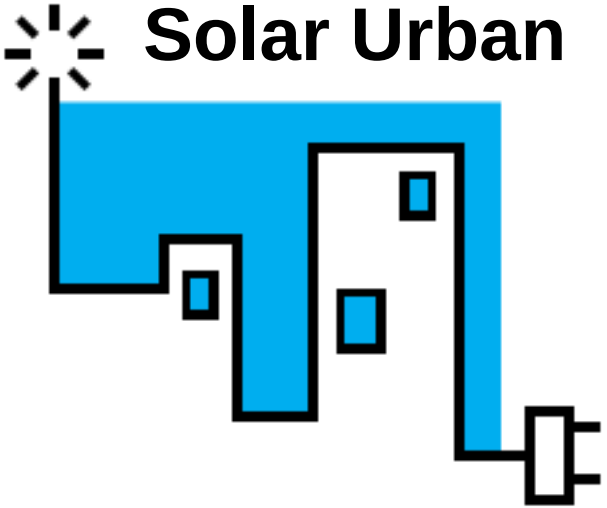
… and much more!

Solaroad by TNO

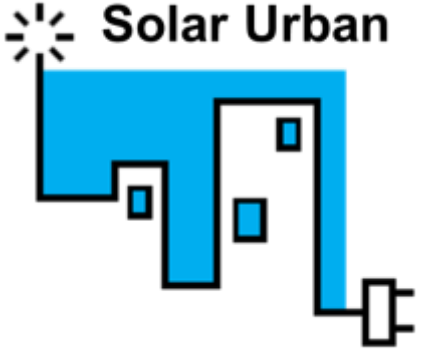
E-bike charging station
by TU Delft

Utilisation of solar energy everywhere

Solar Urban



Research challenges

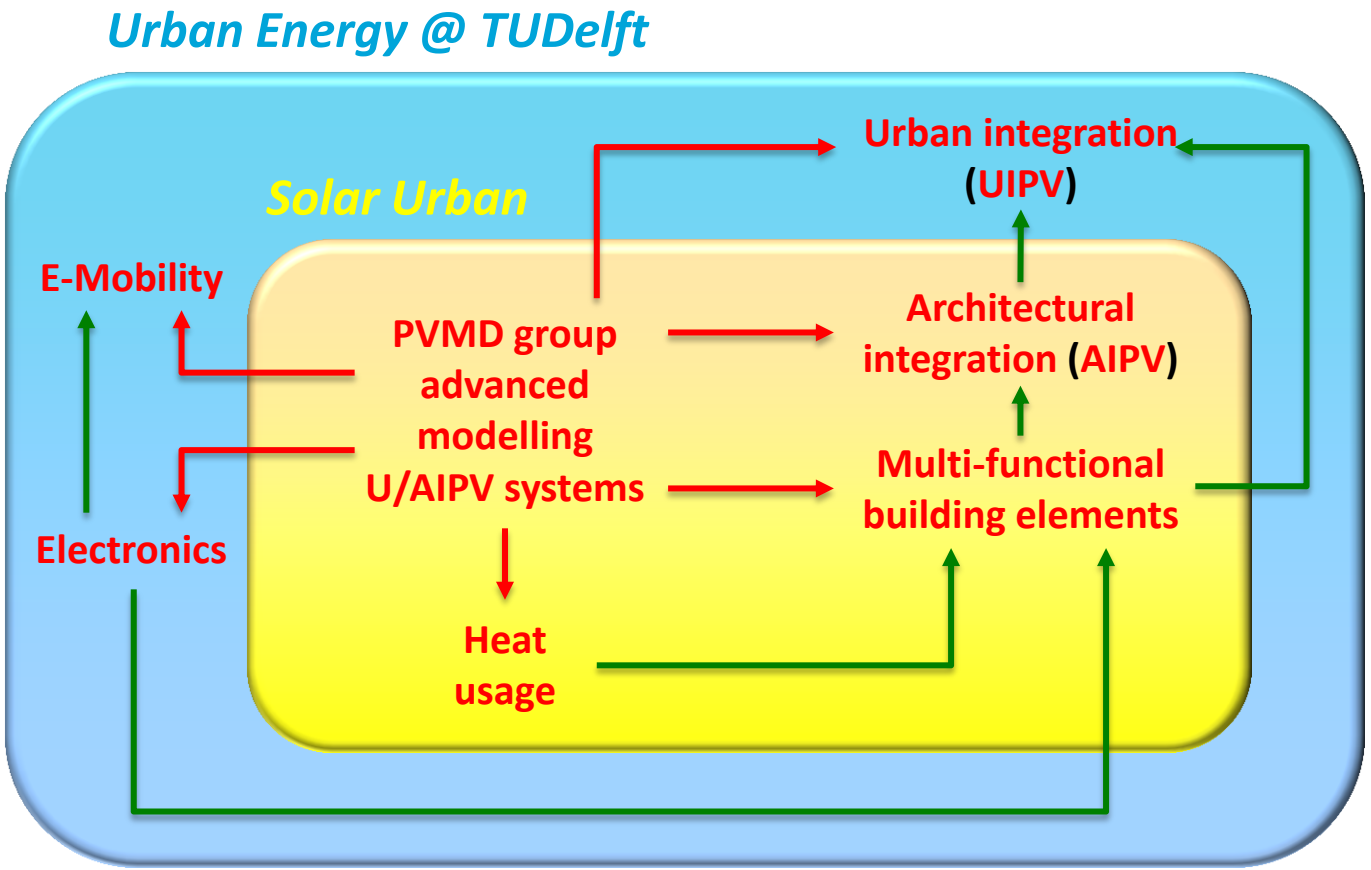


Photovoltaic (PV) solar energy fully integrated in building elements

Modelling of design and energy yield of U/AIPV systems

PV solutions for architectural heritage, domotics, e-mobility and heat management

Topics covered



Advanced modelling of U/AIPV systems

- Cell level
  - Ray tracing
  - TMM
  - Coherent propagation
  - Polarizations
  - Angle of incidence
- Module level
  - Bifaciality
  - Sensitivity Map
  - 3D Mounting

PVMD modelling Toolbox v. 1.0* + Dutch PV Portal 2.0**

2020

2025

Short-term challenges

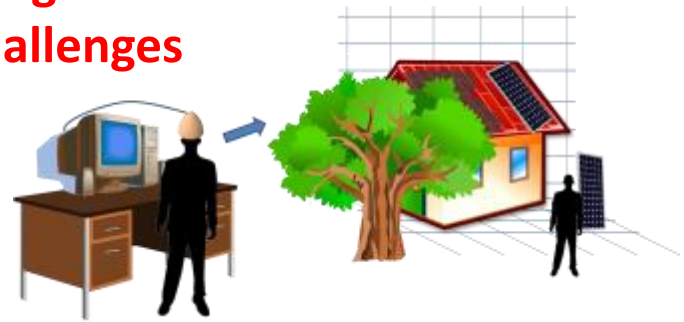
ASA 7.0

Dutch PV Portal **3.0**

Home | PV system design | Data portal | National solar energy production | Case study | Background info

Long-term challenges

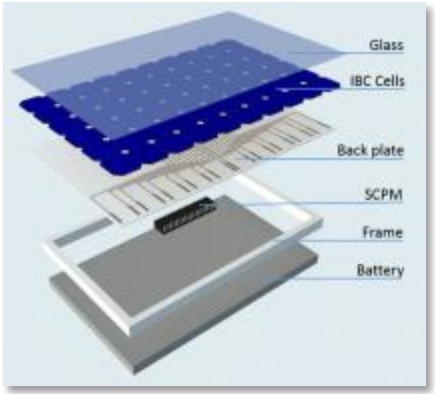
VR-enabled modelling of U/AIPV systems



[*] Based on the PVMD group comprehensive modelling of PV systems, coded by E. G. Goma (MSc thesis, PVMD, 2018)

[**] Based on the interactive website, coded by V. Schepel (MSc thesis, PVMD, 2018) , dutchpvportal.tudelft.nl

PV for Electronics



SCPM
PV module*

2020

Short-term challenges

- PV-powered IoT
- PV + storage + power management (stable voltage)
- S-O-T-A monitoring system

2025

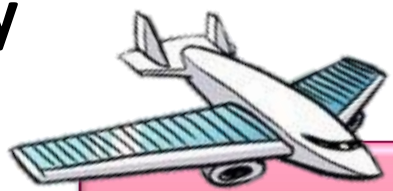
Long-term challenges

- PV-powered remote sensors network
- SCPM 2.0 (high TRL SCPM)*
- Modules with wireless power transmission

Smart module with sensing capabilities

[*] O. Isabella, H. Ziar, M. Zeman, Smart Cell-level Power Managed PV Module, Patent pending (2018)

PV for E-Mobility



Green mobility

2020

2025

Short-term challenges

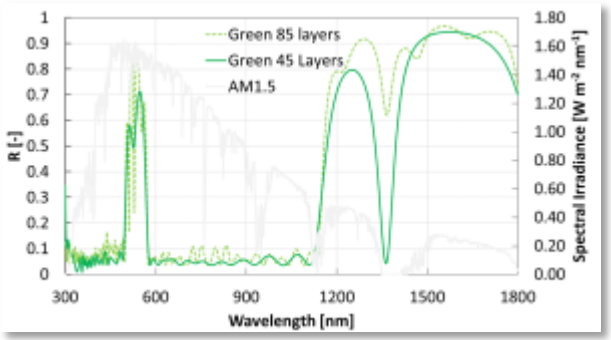
- Solar roads
- Low-cost integrated PV in noise barriers
- Curved, coloured, semi-transparent PV
- PV-powered sensing for bikes

Long-term challenges

- High-efficiency light-weight PV for integration into vehicle (e-bike, car, train, airplane)

E-bike charging station + module manufacturing equipment

PV for Heat usage



2020

Short-term challenges

- Infra Red (IR) Optic Filter (OF)
- Cooling of PV modules for higher efficiency
  - Passively-cooled PV module with IR OF
  - PV-Thermal (air/water micro-channels)
- Use and storage of heat
  - PV-PCM module (greenhouse, etc.)
  - Solar chimney concept (double skin façade-based ventilation)
  - Combination with heat-pump system

Multi-stack IR OF; active cooling; PV-T systems for residential applications (water heating)

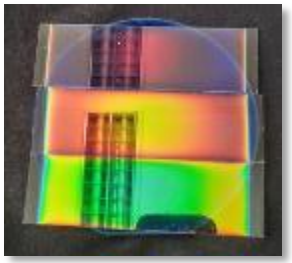
2025

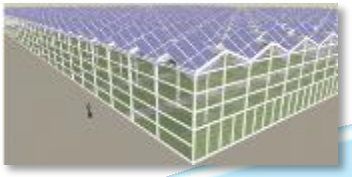
Long-term challenges

- BIPV-T Solutions for office buildings
- Large scale PV-Thermal storage systems
- Passively cooled PV modules
- PV modules as thermal insulation elements

Fully functional BIPV-T systems

PV for Multi-functional building elements





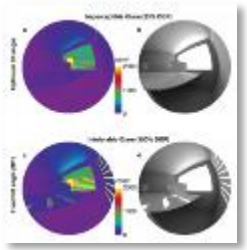
2020

2025

Multi-coloured, self cleaning, custom-shaped and flexible PV modules

Long-term challenges

- Fully customizable PV modules
- Indoor application demonstrators
- Flexible PV modules for custom structures
- Self cleaning, flexible and rigid modules
- Multi-functional solutions for historic buildings

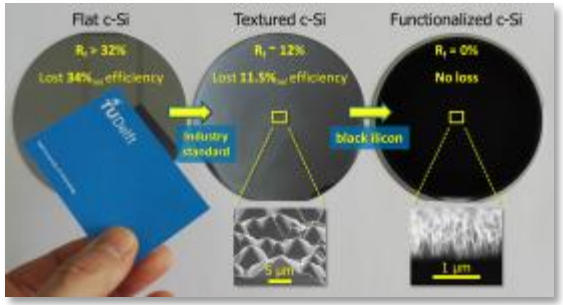


Short-term challenges

Glass/glass or foil/foil standard blue c-Si PV cells

Rigid or bendable c-Si semi-transparent modules

Flexible thin film modules



PV for Architectural integration (AIPV)

2020

2025

Prêt-à-Loger
+
Façade leasing

Short-term challenges

- Data-log pairing existing BIPV products and urban surfaces
- Suitability of PV technology for custom integration
  - Architectural assessment
  - Technical assessment
- Form / Function report based on user experience
- Development of PV-Chimney
- Development of PV-PCM

Long-term challenges

- PV integration in historical cities
- Integration of multi-functional PV elements

Omni-present functional and aesthetical PV integration in urban environment*

[*] More than 25% of urban energy needs to be supplied by Integrated PV conversion > P.R. Defaix et al., *Solar Energy* **86** (2012)

PV for Urban integration (UIPV)

2020

2025

PV everywhere

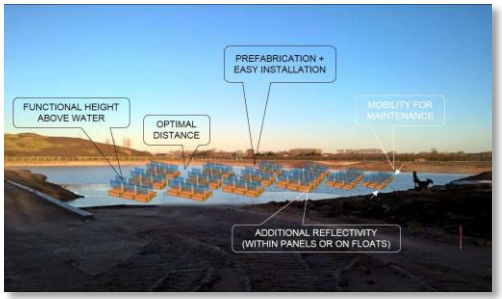
Short-term challenges

- Infotainment spot 3.0
- Solar roads
- PV pergolas
- Innovative floating PV systems
- Regional base PV technology share in utility-scale plants (to be updated each year)
- World-wide general PV selection map (to be updated each year)

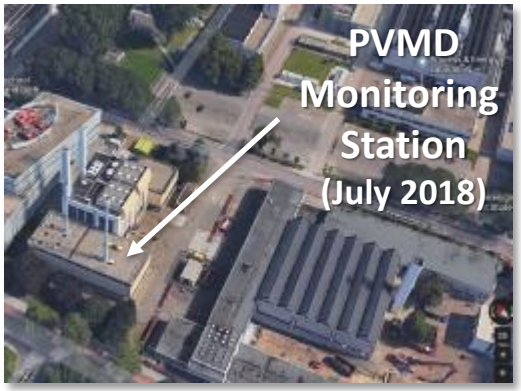
Long-term challenges

- Nation-wide distributed PV systems
- Large-scale PV systems

Infotainment spots
E-bike charging station
Prêt-à-Loger



Research activities and available facilities @ TU Delft



Research activities outside TU Delft

- **National level**
  - TKI *PVision*
  - SDE+ *Innozowa*
  - Amsterdam Institute AMS
  - Solliance / ECN / TNO
  - …

- **European / International level**
  - Cost Action *Pearl PV*
  - H2020-LCE *NextBase*
  - PVcomB, LPVO
  - imec, EPFL
  - AIST, NREL, …

Thank you for your attention!

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