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OUTDOOR PERFORMANCE OF INFRA INTEGRATED PV

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EU PVSEC 2020, 9-9-2020

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MESH was subsidised by the Energy top sector scheme iDEEGO, facilitated by the Netherlands Enterprise Agency (RVO).

CREATING TOMORROW

AIM AND RELEVANCE

- The Netherlands is aiming for the roll-out of more solar PV. However like many densely populated countries, the country is running into issues of lack of space.
- Infrastructural works like highways provide space without compromising the landscape.
- New is the combination of solar PV with traffic barriers.
- This has a big potential since the Dutch main road network had 7.500 km of guiderail and the construction to put PV on is already there.

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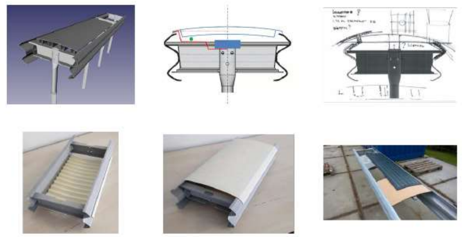
APPROACH

- In order to meet the various requirements for traffic safety and generating electricity, the Systems Engineering methodology was leading
- First built a small, but full scale prototype and invited safety experts to evaluate the design
- With this feedback we made a redesign for the pilot
- pilot is placed on the highway as safety barrier and tested for a year.

- In a presentation at EU PVSEC18 K.Sewalt reported on the design phase. This time we present the results of our test phase and give answers on our research questions.



CONSORTIUM

- TNO – project leader and developer of a modular casing concept and a fastening system that allows quick installation on site
- Solliance – R&D on the flexible thin film PV technology to be applied with a focus on shape and reliability
- Heijmans Infra –construction of pilot infrastructure, design of fastening interface for modular casing
- DC Current - DC management with regard to voltage, electrical safety and minimizing failure in case of collision
- Province of Noord-Holland - acts as a leading customer
- Amsterdam University of Applied Sciences (AUAS) as a knowledge institution that links education and research. Both researchers and student groups were involved

TNO innovation for life

SOLLIANCE SOLAR RESEARCH

heijmans

Provincie Noord-Holland

SYSTEMS DIRECT CURRENT BV

HVA

INNOVATION & REQUIREMENTS

The major challenges:

- No prior references
- No clear available regulations dealing with solar cells on a guiderail
- Safety

Main requirements of the MESH system:

- Keep the primary function of the guiderail intact (guiding of vehicles during collisions)
- Switch off immediately and automatically after a collision
- Not distract car drivers in any way

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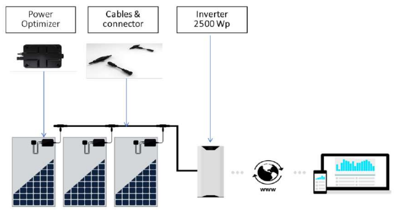
MAIN RESEARCH QUESTIONS:

- what (add-on) modifications on the guiderail are allowed ?
- can we avoid (expensive) collision tests?
- can we design an integrated mechanically and electrically **safe system** working **under all circumstances?**
- which PV technology is the most suitable for this application?
- **what is the performance of an elongated linear PV system with a slight curve of the solar cells?**
- **what is the effect of pollution by traffic on the performance ?**
- **how rugged and durable is the PV technology and its packaging under nearby traffic conditions?**
- **can we realize ease of installation, repair and maintenance ?**





PILOT STATUS




The MESH system (72 m) was built on the N23 road in the Province of Noord-Holland.
To answer the research questions on performance a monitoring system was designed to collect data from the system and a locally installed weather station and two infrared cameras to detect incidents.
The test phase started March 18th 2019 for one year.

RESULTS ON SAFETY

- No incidents regarding safety

RESULTS ON ROBUSTNESS

- No moisture penetration or defects visible
- No repairs needed
- No degradation observed in the performance of the PV

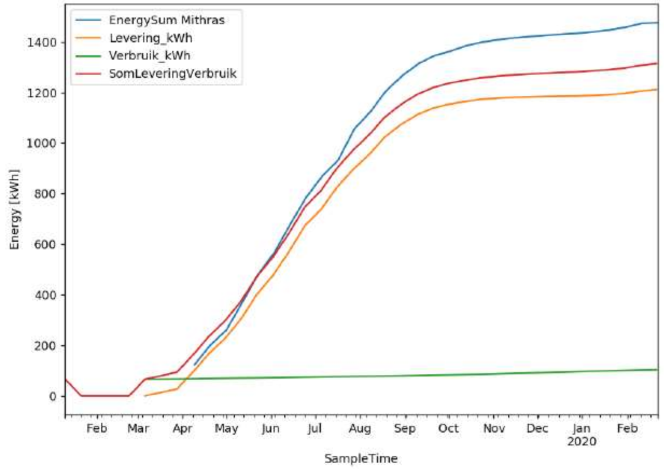
RESULTS ON ELECTRICAL PERFORMANCE

- System was simulated in SAM (from NREL), the expected performance during the test phase was ~1800 kWh (including losses in cover)
- System yield measured was 1200 kWh

TNO-rapport | 2020 R10862 | Eindrapport

Research into lower performance:

- Individual PV-modules or system components worked according to expectations
- Optimizer threshold values did not cause the difference
- Performance Ratio of the PV-modules is low (in line with low energy yield)
- From power measurements we conclude cable and transport losses of up to ~10%;



Figuur 31: Cumulatieve vergelijking energiemetingen kWh-meter en DC-systeem

The cover gave a higher loss than the assumed loss of ~20-25 %.

RESULTS ON BUSINESS CASE

2018 design stage	72m (pilot)	1km (2018)	100km (2020)
Investment (€/m)	763	425	236
Maintenance (€/y/m)	8	4	2
Yield (kWh/y/m)	73,8	88,5	118
LCOE (€/kWh)	0,62	0,29.	0.12

Long term goal: LCOE 0.12 (€/kWh) comparable to solar road

2020 realistation	Pilot design	Pilot realised	100km (2020)	100 km (2022)	1000 km (2025)
Investment (€/m)	763	1800	1700	1302	1302
Maintenance (€/y/m)	8	8	8	8	8
Yield (kWh/y/m)	36	18	80	98	108
LCOE (€/kWh)	1,27	5,85	1,16	0,74	0,67

Results:

- Higher investment costs due to high installation costs
- Lower yield
- High LCOE

DISCUSSION

- Placing optimizers under the ground level was needed for safety reasons, but raised costs of installation
- Cover leads probably to lower performance, this has to be tested
- (part of) cabling costs and losses could be avoided by local use of electricity

Re-design options:

- Place optimizers or micro-inverters directly below PV, still maintaining electrical safety
- Instead of a thick cover use rugged foil laminated on the PV module (no air gap)
- Direct use of electricity to avoid cable losses
- Utilizing full width of the guide rail with a customized CIGS module or with thin bended Si-cells, more PV will fit on a m’

CONCLUSION

- Design was allowed on a traffic barrier at road side
- No visual degradation of materials
- No repair was needed during test year
- PV performed less than expected
- Lower performance and hogher cost lower business case

Future improvements:

- Place optimizers directly below PV
- Instead of cover use foil
- Direct use of electricity to avoid cable losses
- With bended Si-cells instead of CIGS more PV will fit on a m’

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RESULTS SPECIFIC FOR AUAS

- More insight in stakeholders approach to innovation
- Work with new materials, concepts (thin film PV foils, DC) via collaboration within the consortium

- Interesting project for engineering students:
  - Practical
  - Design and business
  - Innovation
  - Collaboration in consortium