Martin Heinrich, Jacob Forster
Klimaneutrale Energiewende bis 2045 im Verkehrssektor
IKzB, Online, 08.11.2022

Road infrastructure integrated photovoltaics – Opportunities by Solar integration at roads

Fraunhofer ISE

At A Glance

Directors:
Prof. Dr. Hans-Martin Henning
Prof. Dr. Anreas Bett

Staff: ca. 1400

Budget 2022: €105,8 million

Established: 1981

Fraunhofer ISE

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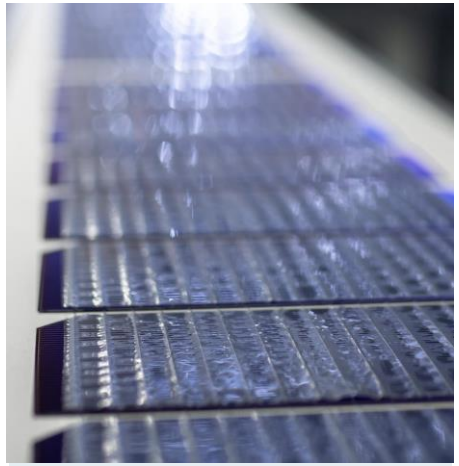
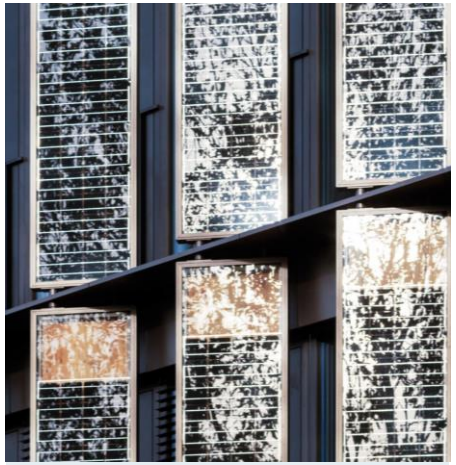
At A Glance



Photovoltaics



Energy Efficient Builings

Solar Thermal Power Plants and Industrial Processes

Hydrogen Technologies and Electrical Energy Storage

Power Electronics, Grids and Smart Systems

Fraunhofer ISE
Scope of Our Work

Research

- Materials
- New devices
- Proof-of-Principle
- Simulation and modeling
- Methods

Development

- Equipment
- Process technology
- Transfer to industrial scale
- Proof-of-concept

Implementation

- System design
- Monitoring
- Demonstration
- Testing and certification
- Quality assurance

Integrated Photovoltaic
Overview

Possibilities to integrate PV

- Building Integrated PV (BIPV)
- Agri-PV (APV)
- Floating PV (FPV)
- Vehicle Integrated PV (VIPV)
- Urban Photovoltaic (UPV)
- **Road Integrated PV (RIPV)**

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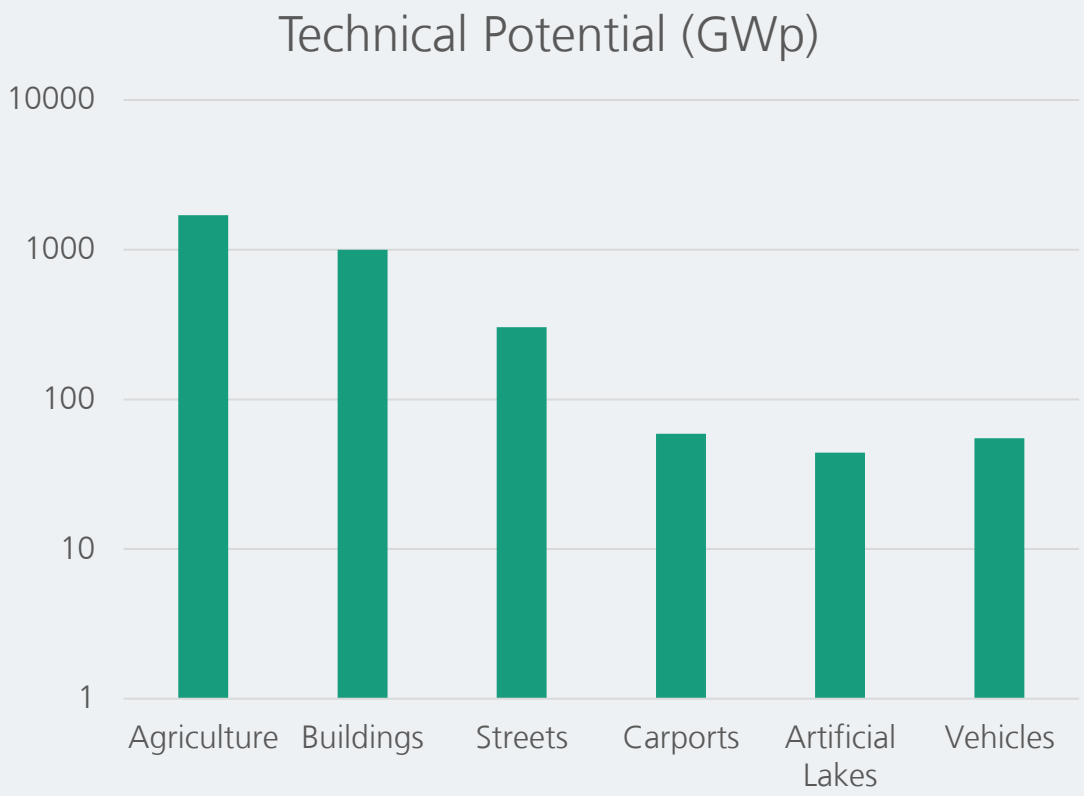
Technical Potential for Integrated PV

Estimated technical potential for integrated PV in Germany about 3.160 GWp [1]

Integrated PV opens many opportunities

- Avoiding conflicts about land use
- Reduction of material use
- Local energy production
- Local production of PV-components



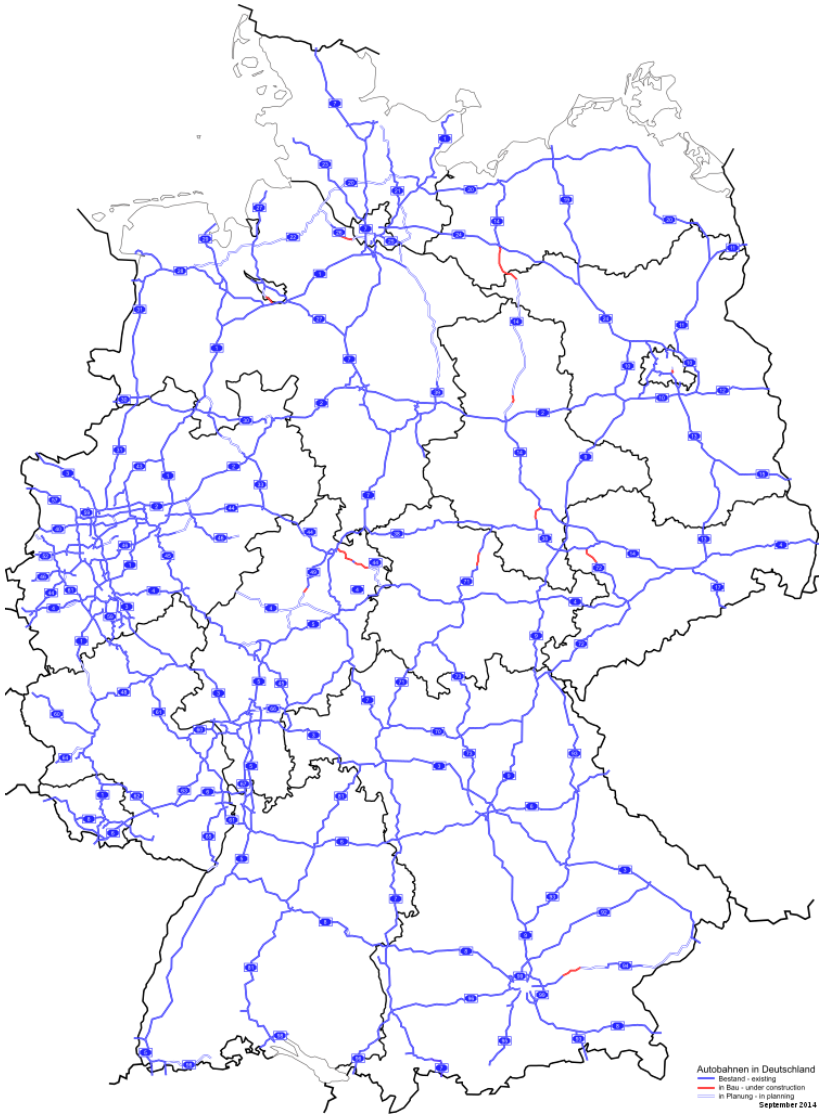
[1] Wirth *et al.*, Potenziale der Integrierten Photovoltaik in Deutschland, 36. PV Symposium, Mai 2021.

Integrated Photovoltaic

Road Integrated Photovoltaic

- Roads and Rails: 3.300 km² in total (5% of land area)

Federal highways	289 km²
Federal roads	343 km²
Rural roads	421 km²
Regional roads	409 km²
Inner city roads	1720 km²
Railways	115 km²



Federal highways in Germany © Wikimedia

https://de.wikipedia.org/w/index.php?title=Datei:Autobahnen_in_Deutschland.svg#filelinks

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Integrated PV

High Potential for RIPV

Estimation of technical potential based on current findings [1]

- Inner-city areas not considered here (shading).
- For street roofing, a high performance ratio is assumed (85 %)

Integration Type	Technical Potential		
Street Roofing	1285 km²	257 GWp	238 TWh/a
Street Integration	172 km²	34 GWp	14 TWh/a
Rail Bed Integration	50 km²	10 GWp	6 TWh/a
Noise Barriers	14 km²	3 GWp	2 TWh/a

Note

The economic-practical potential depends on general and site-specific factors.

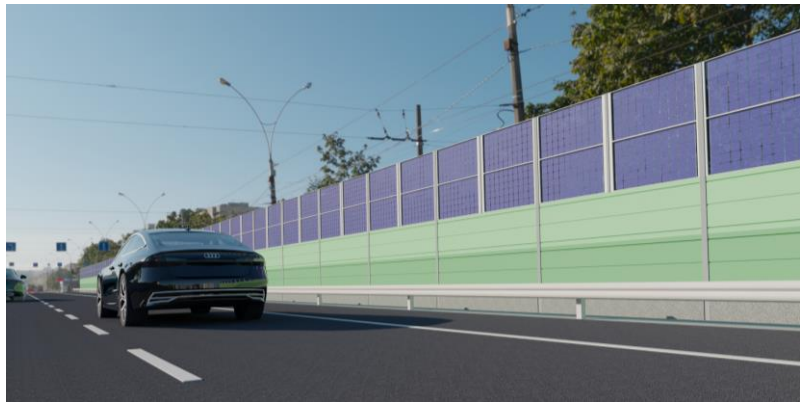
[1] Wirth *et al.*, Potenziale der Integrierten Photovoltaik in Deutschland, 36. PV Symposium, Mai 2021.

Integrated Photovoltaic

Road Integrated Photovoltaic

Possibilities to integrate PV

- Next to the road:
  - As a path border and for noise protection → **Project PVwins**
- Above various surfaces:
  - As roofing → **Project PV Süd**
- In the traffic area:
  - Walkable and drivable road surface, in verges or track beds



RIPV Implementation Options

PV integration *next* to the road

Potentials

- No additional construction necessary for the PV components
- Very low land consumption
- Close proximity to potential consumers e.g. EV charging stations
- Paying off cost of infrastructure over time

Challenges

- Non-ideal alignment depending on structure function (especially vertical boundaries and noise barriers)
- Risk of vandalism and safety in case of accidents
- Noise control functions or impact protection not compatible with conventional PV module concepts

PVwins

PV integration *next* to the road

Project timeframe: 01.04.20 – 31.03.23

Joining different competences

Fraunhofer ISE:
Project lead, Integrated PV and new solar products

R. Kohlhauer GmbH:
Innovative noise barrier concepts

Igrapower GmbH:
PV system planning and operation

Megasol:
Individual PV-module production

1 **Product design**
Retrofit and Replacement
Construction of new noise barriers

2 **Product Development**
Technical feasibility
Economics, Life Cycle Inventory

3 **Business Model Development**
Yield estimation and optimization
LCOE calculation

4 **Demonstrator Objects**
Tests on pilot objects

Project partners

KOHLHAUER Lärmschutzsysteme

IGRA Power Integrated Power Systems

megasol

Advising institutions

eGIS EnergieGenossenschaft Inn-Salzach eG
Energie aus Bürgerhand

Deutsches Zentrum für Schienenverkehrsforschung beim Eisenbahn-Bundesamt

bast Bundesanstalt für Straßenwesen

RIPV Implementation Options

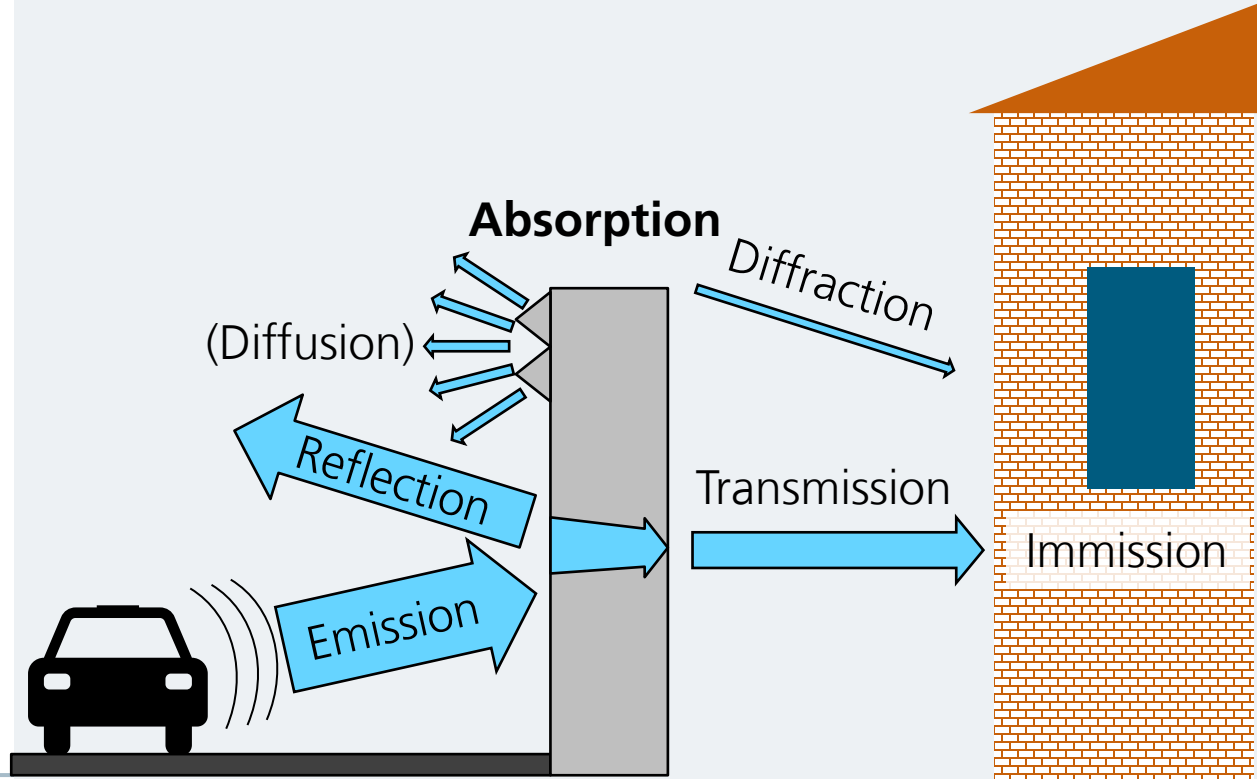
PV Noise Barriers

Acoustic properties of noise barriers

Absorption Requirement Levels according to ZTV LSW 2.2/ DIN EN 1793-1		
Group	Schallabsorption DLa [dB]	Description
A1	< 4	**not absorbing, reflecting**
A2	4 - 7	**absorbing**
A3	8 - 11	**highly absorbing**
A4	> 11	

Absorption:
Ability to absorb sound energy

Noise Insulation:
Emission – Immission > 24 dB(A)



RIPV Implementation Options

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- Good example for Integrated Photovoltaic: Incorporating both acoustic functions of absorption and noise insulation and PV power production

Group A1:
Sound reflecting PV elements on large area

Group A2:
Fractional use of PV modules combined with acoustic absorber elements

Group A3:
Sound absorber elements on large area, PV only as top mount

RIPV Implementation Options

PV integration *above* the traffic area: Roofing

Potentials

- Weather protection for traffic areas and road users
- Additional requirements primarily for substructure (integration of high-quality glass-glass PV modules)
- Sound insulation functions when combined with side walls
- Very large surface potentials due to roads, cycle paths, footpaths and parking areas
- Solar yield almost independent of road layout, bifacial modules and high performance ratio through rear ventilation

Challenges

- Need for the most cost-effective and durable substructure possible
- Dynamic loads from underlying traffic and wind and static loads from snow
- Safety of overhead installation and fall protection of PV modules

PV Süd

PV integration *above* the traffic area

Project timeframe: 03/2020 - 02/2023

Austrian Institute of Technology GmbH (AIT):
Project lead, Effect on street, concept for supporting structure

Fraunhofer ISE:
PV-module technology development and optimization, tests and prototypes

Forster Industrietechnik GmbH:
Support in concept development, demonstrator implementation, requirements

Project partners

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

FORSTER FF

Advising institutions

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Strassen ASTRA

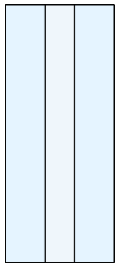
FFG Forschung wirkt.

Bundesministerium für Verkehr und digitale Infrastruktur

Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie

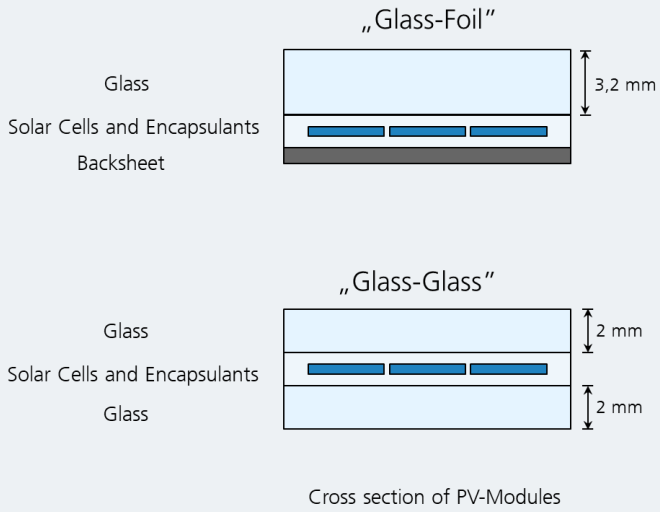
PV Süd

Overhead certified PV modules



Glass Glass
PVB

- Mechanical requirements: FEM simulations and mechanical load tests (IEC 61215)



Cross section of PV-Modules

- Industrial glass/glass PV modules with overhead certification are commercially available

Berlin Main Station © Deutsche Bahn AG / Volker Emersleben

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More Information

https://www.ise.fraunhofer.de/content/dam/ise/de/documents/infomaterial/brochures/21_en_ISE_RIPV.pdf