SolaRoad

The road that generates electricity for our mobility and pays for itself

Sten de Wit (TNO)
Mark Bolech (TNO)

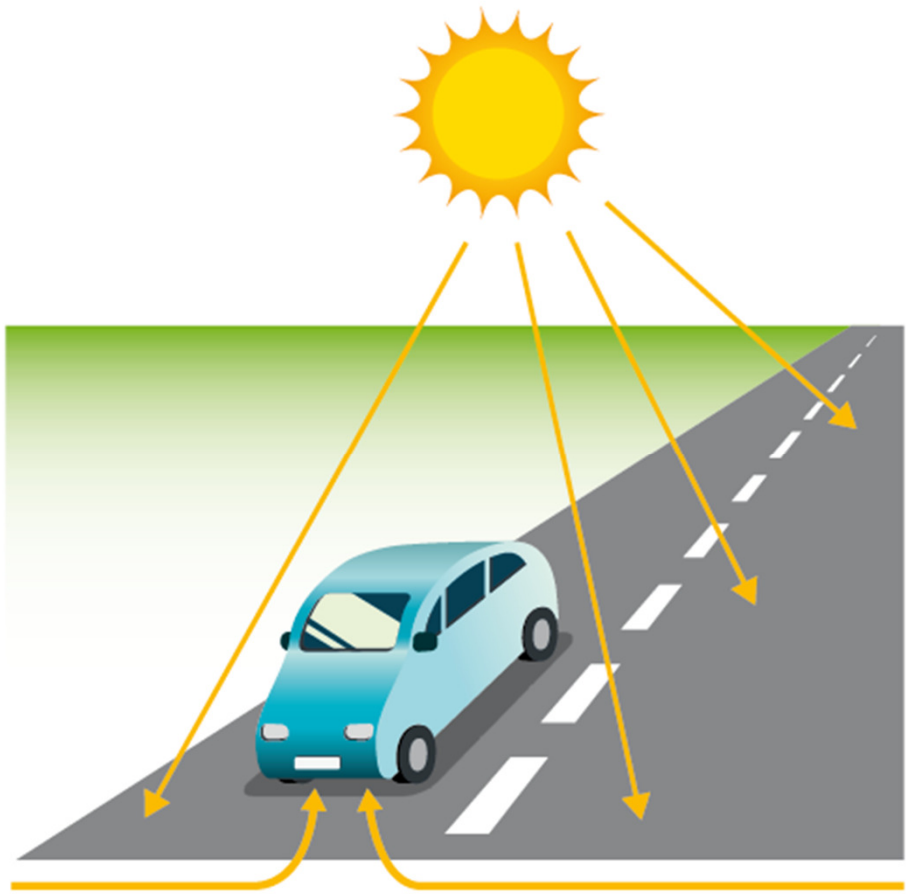
TNO

Provincie Noord-Holland

Ooms Civiel

Imtech

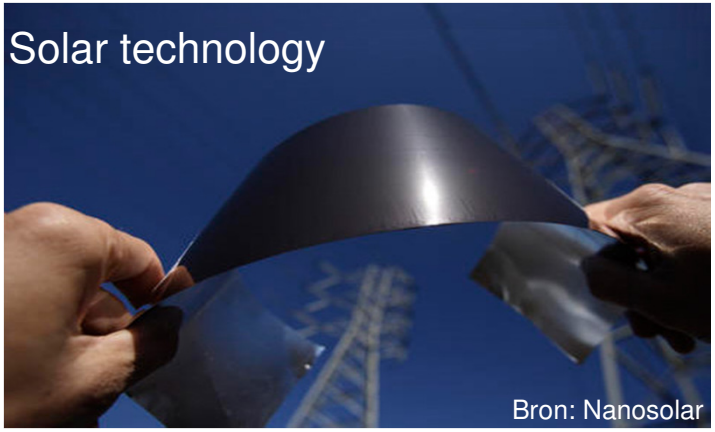
Future outlook



- Sustainable
- Zero net energy
- Profitable

Trends

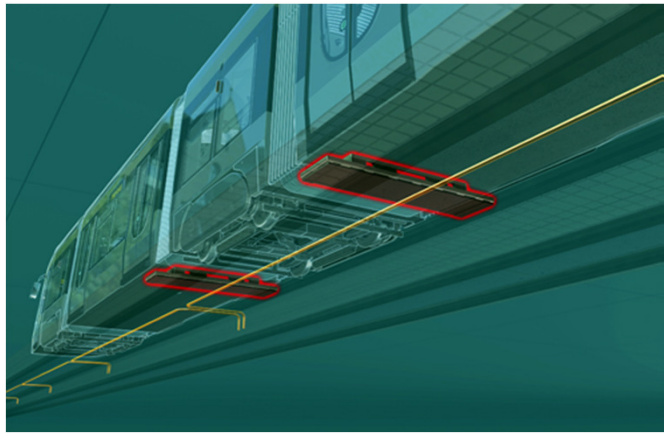
Solar technology



Electric vehicles

Road construction

Charging systems



Outline

- Future outlook: sustainable mobility concept
- Focus today: public bus transport
  - SolaRoad
  - Solutions for electric bus transport
- SolaRoad
  - What is it
  - Roadmap and status
- Solutions for electric bus transport
  - Inventorise system solutions
  - Evaluate and rank
- Closure

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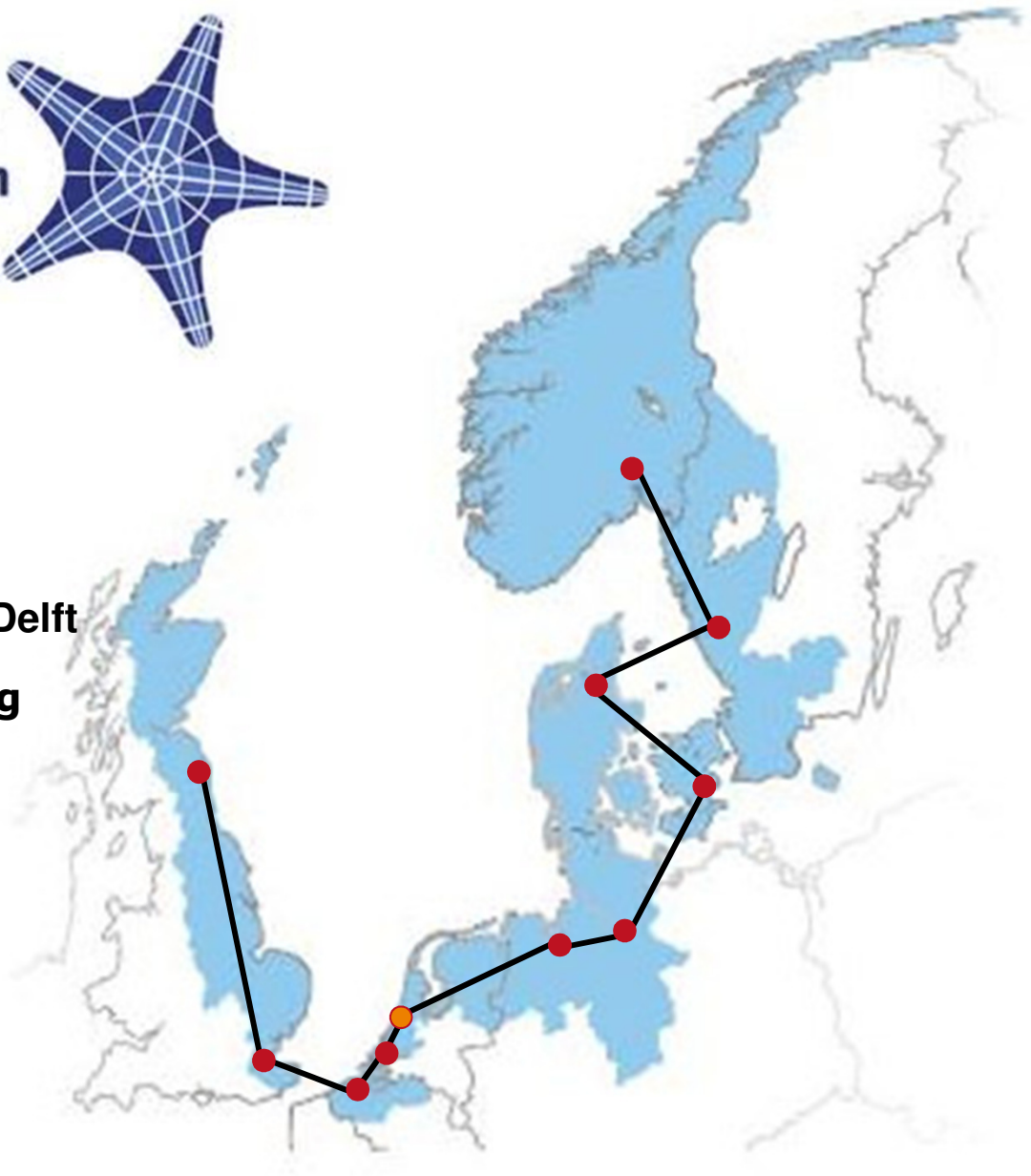
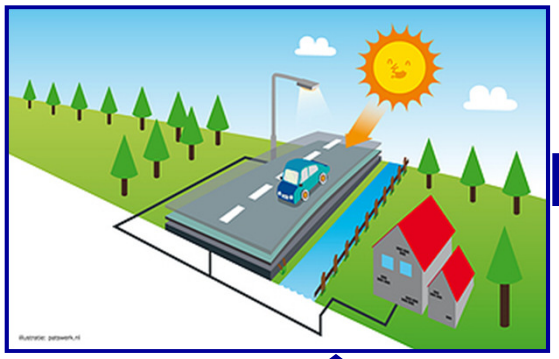
The Interreg IVB North Sea Region Programme

- Newcastle
- London
- Antwerpen
- PNH/MRA + TU Delft
- Bremen-Hamburg
- Kopenhagen-Høje Taasrup
- Göteborg
- Oslo



Interreg programma: SolaRoad project



The bus lane is free of traffic

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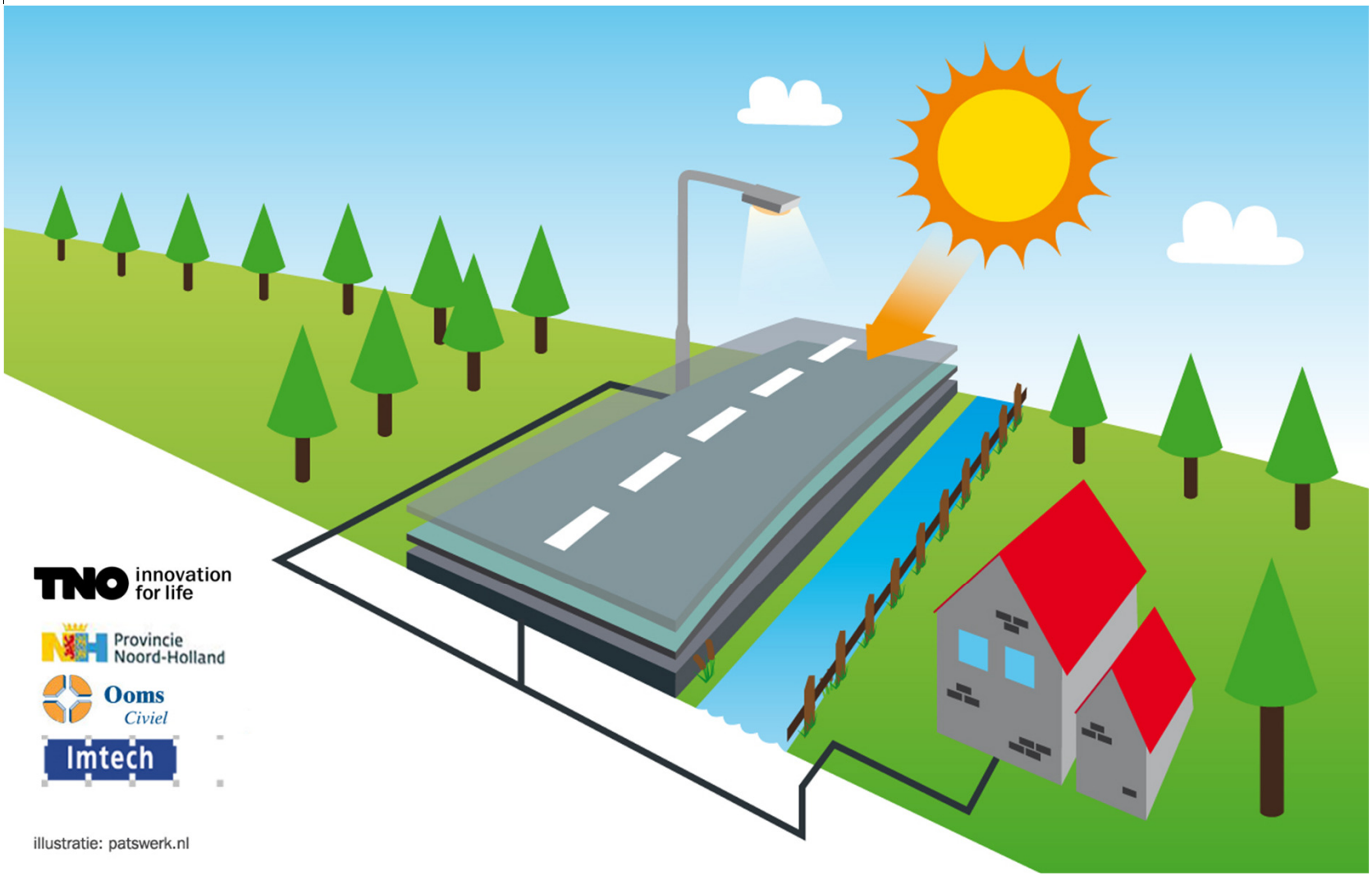
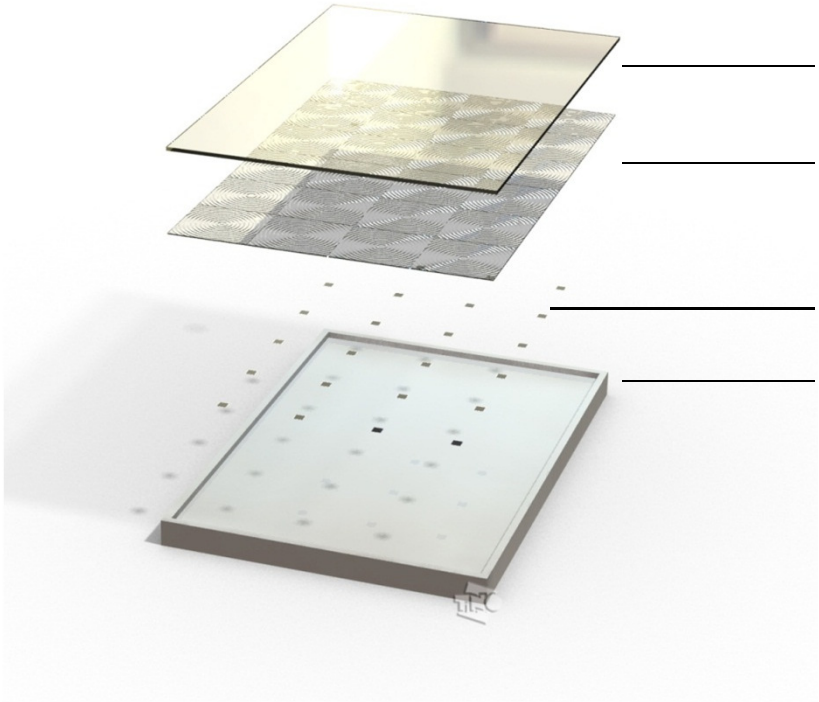
What is SolaRoad



Prototype



transparant top layer

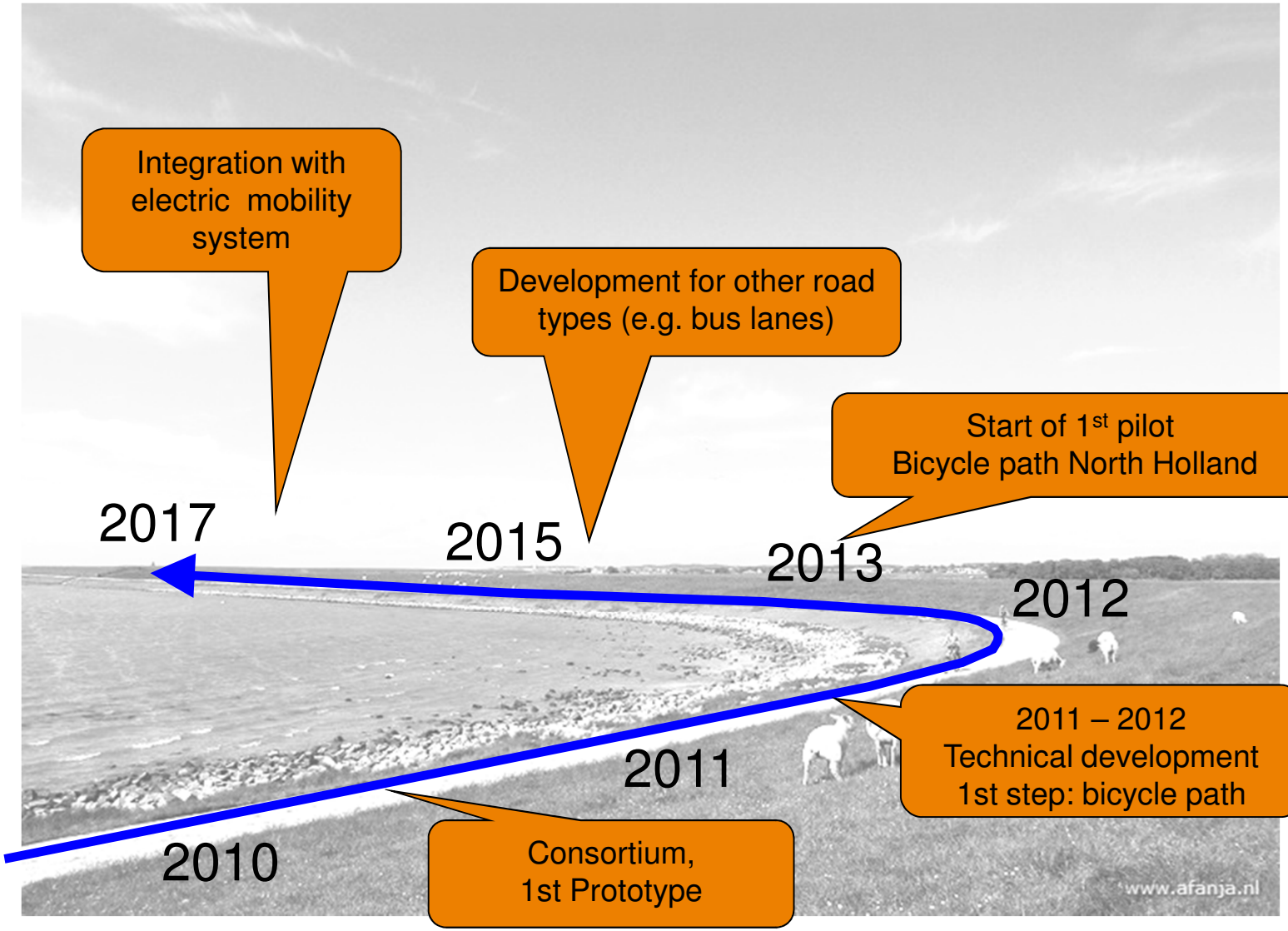
optical layer

solar cells

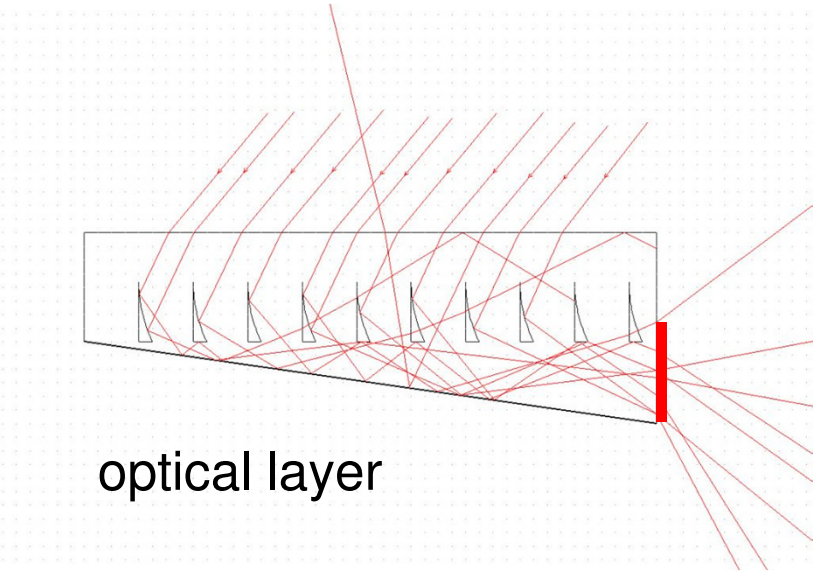
concrete casing

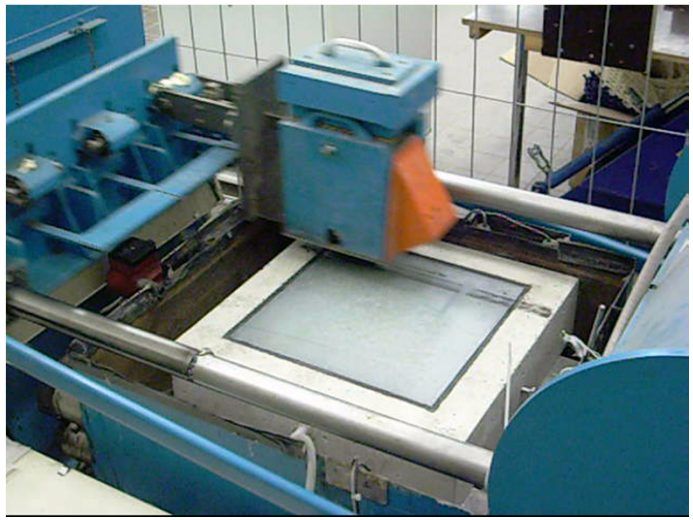
prefab elements

Roadmap

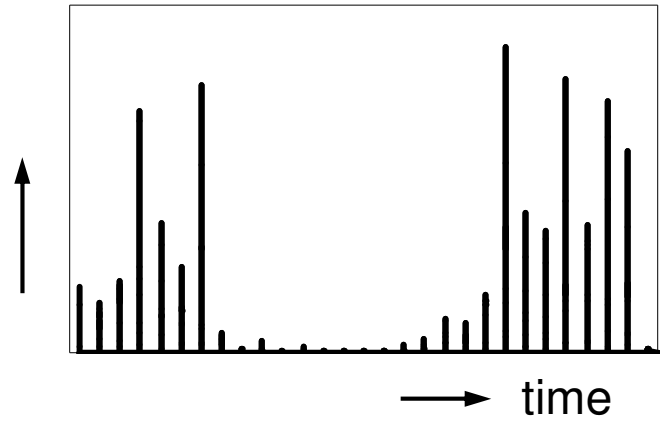

Integration with electric mobility system
Development for other road types (e.g. bus lanes)
Start of 1st pilot Bicycle path North Holland
2017
2015
2013
2012
2011 – 2012 Technical development 1st step: bicycle path
2011
2010
Consortium, 1st Prototype
www.afanja.nl

Technical development





Top layer



Pilot bicycle path

- Opening planned in 2013
- Length: ca. 100 m
- Location in North Holland
- Duration of pilot: 5 years
- Functional and safe, but experimental

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Research goal

- What combination of vehicles, energy transfer infrastructure, road infrastructure and energy supply are the most favourable* in combination with SolaRoad?
- In what way can SolaRoad be incorporated into this system in order to create maximum added value*?

Approach of investigation

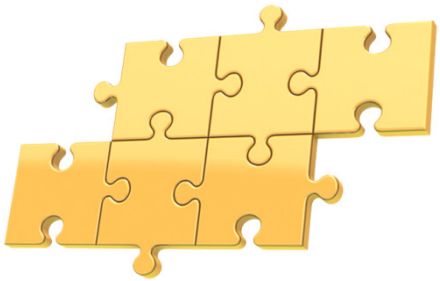
- **Phase 1:** make inventory, and evaluation/ranking of various bus systems for electric public transport.
- **Phase 2:** selection and more detailed analysis of the most promising systems.

- Please note: project has entered phase two. Therefore this is a presentation of work in progress and by no means a definitive ‘judgement’ on certain electric bus system-solotions

Morphologic Analysis

1. Generate a broad range of possible technological solutions for the various tasks the system should do

2. Generating system solutions by combining the individual technical solutions.



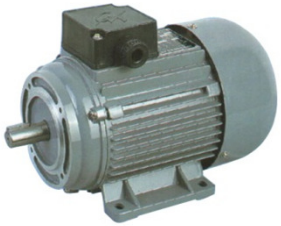
3. Ranking of the system-solutions based on relevant criteria

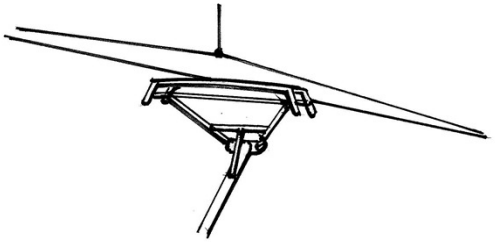
Morphological Map

	SUB SYSTEMS							
	Energy generation	Grid	SolaRoad	Wind	Power rating?			
	Energy Storage (stationary)	Fly wheels	Redox batteries	Pumped hydro-electric	Re-used batteries	Hydrogen generated or Metal (Norwegian highway)	Compressed air	
Cond. - inductive continuous - discont.	**Transfer**	Conductive	Continuous conductive power transfer	Discontinuous conductive power transfer	Magnetic resonance coupling (MRC)	Hot-swap Energy storage		
		Inductive	Continuous inductive power transfer	Charging inductive power transfer				
	Energy Storage (mobile)	Super cops	Batteries li-ion	Compressed air	Fly wheel	Hydrogen storage	Ultra batteries	
	Braking / Driving	Propulsion	Electric drive train in wheel	Electric drive train (EVT)	Positive displacement machine	Single electric + Gearing		
Passenger Comfort (heating, cooling, lightening, …)	**Vehicles**	Personalized bus	Single	Double (articulated)	Triple (double articulated)	Driver-less	City bus	Regional (street) bus
	ICT	Control system	Energy management	Route planning	Green driving support	Range estimation	Lifetime management	Brake management

From building blocks to system

- Specialists combined sub-system to operational bus-concept





- In short a **Trolley-bus** concept
- Collective ranking / evaluation → most interesting concepts

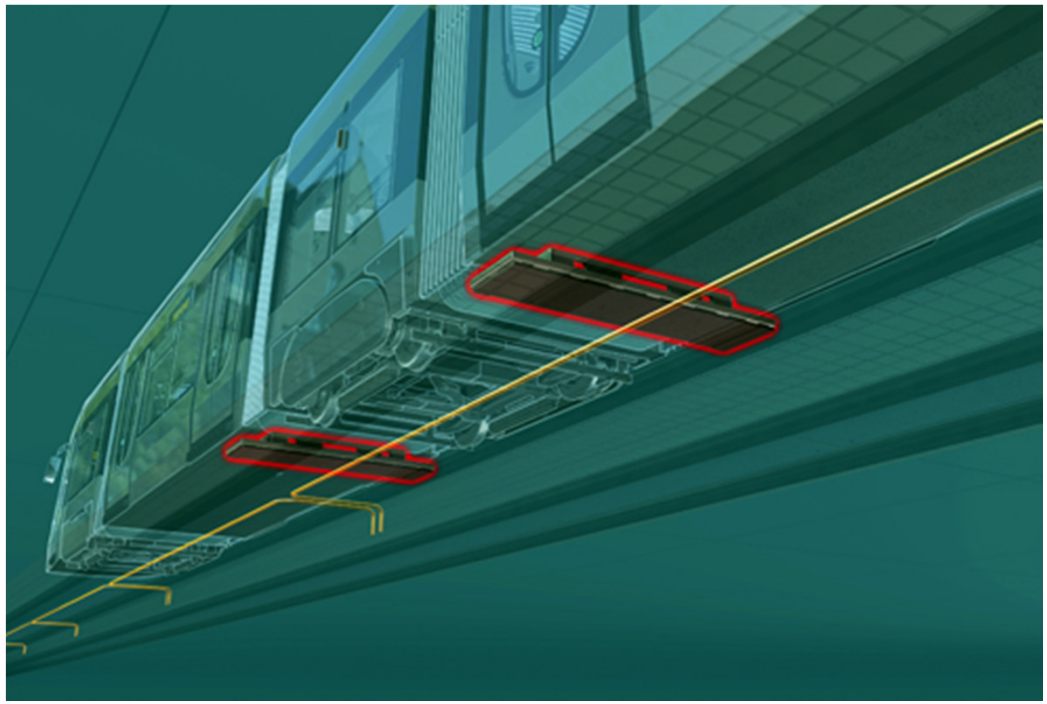
Attractive system solutions

- *Trolleybus*

+ Reliable
+ Light-weight.
− Overhead wires.
? High speed capacity

Attractive system solutions (2)

› *Bus with inductive energy supply*



+ Innovative
+ Lightweight
+ Low wear
+ Like trolley without OCS
+ Supercaps
− Integration in pavement.
− Transfer losses.
? TCO

Attractive system solutions(3)

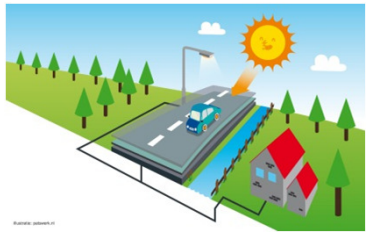
- *Battery swap concept*

+ Fastest energy transfer
+ Optimised charging
+ One ‘recharging’ station
− Large batteries
− Weight
− Costs (more batteries)
− Mechanical wear
? Battery size
? Longevity of battery

		Total Cost of Ownership	Feasibility	Innovative	Environmental benefits	Remarks
regional bus	Trolley bus	**++?**	**0**	**0**	**++**	Could be very light-weight!
	Fuel cell as range-extender	**+**	**+**	**++**	**--/0/+**	Fuel: fossil--, methanol 0, H_2 0, metal +
	(semi)continuos inductive energysupply	**0/+/++?**	**+**	**+**	**+**	Like a trolley, light, without wires! Transfer losses + costs inductive system.
	Electric hybride (batteries + supercaps)	**0**	**+**	**++**	**+**	Regeneration of braking energy. Added complexity and costs.
	Battery swap	**-/0?**	**+**	**0**	**+**	Energy supply on one single location
city bus	Inductive fast charging	**-**	**+**	**+**	**0**	Limited battery-size. Charging losses
	Li-ion + supercaps	**+**	**+**	**++**	**+**	Electrically complex
	Capa bus	**++?**	**+**	**+**	**+**	Fast charging very often
	Fly bus	**+?**	**0**	**+**	**+**	Complex system (mechanically)
	Battery swap	**0**	**+**	**0**	**+**	Energy supply on one single location
	Oportunity charging	only charging on some stops / trajectories.				
	Continous energy transfer	Light weight, but costly infra / km				
	Lightweight concept	applicable to all systems and attractive				
	Oversized articulated bus	Very attractive for busy regional bus				
	Total Cost of Ownership	Many unknowns (monetize all aspects)				

Closure

- SolaRoad: inspiring vision on sustainable infrastructure
  - Sustainable
  - Energy neutral
  - Profitable



- Combination with public bus transport is promising
- Joint development of the ‘building blocks’
  - Pilot SolaRoad bicycle path in North Holland
  - Investigation of matching electric bus concept