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UTRECHT SUSTAINABILITY INSTITUTE

Copernicus Institute of Sustainable Development

Smart Solar Charging to support widespread deployment of photovoltaic systems and electric mobility

Wilfried van Sark

(thanks to Robin Berg, Carolien van Hemel, and the SSC consortium)

International Conference on Renewable Energy and Resources
Vancouver, 25 July 2017

Hier wordt geïnvesteerd in uw toekomst. Dit project wordt mede mogelijk gemaakt door het Europees Fonds voor Regionale Ontwikkeling.

smart solar charging Regio Utrecht

Motivation

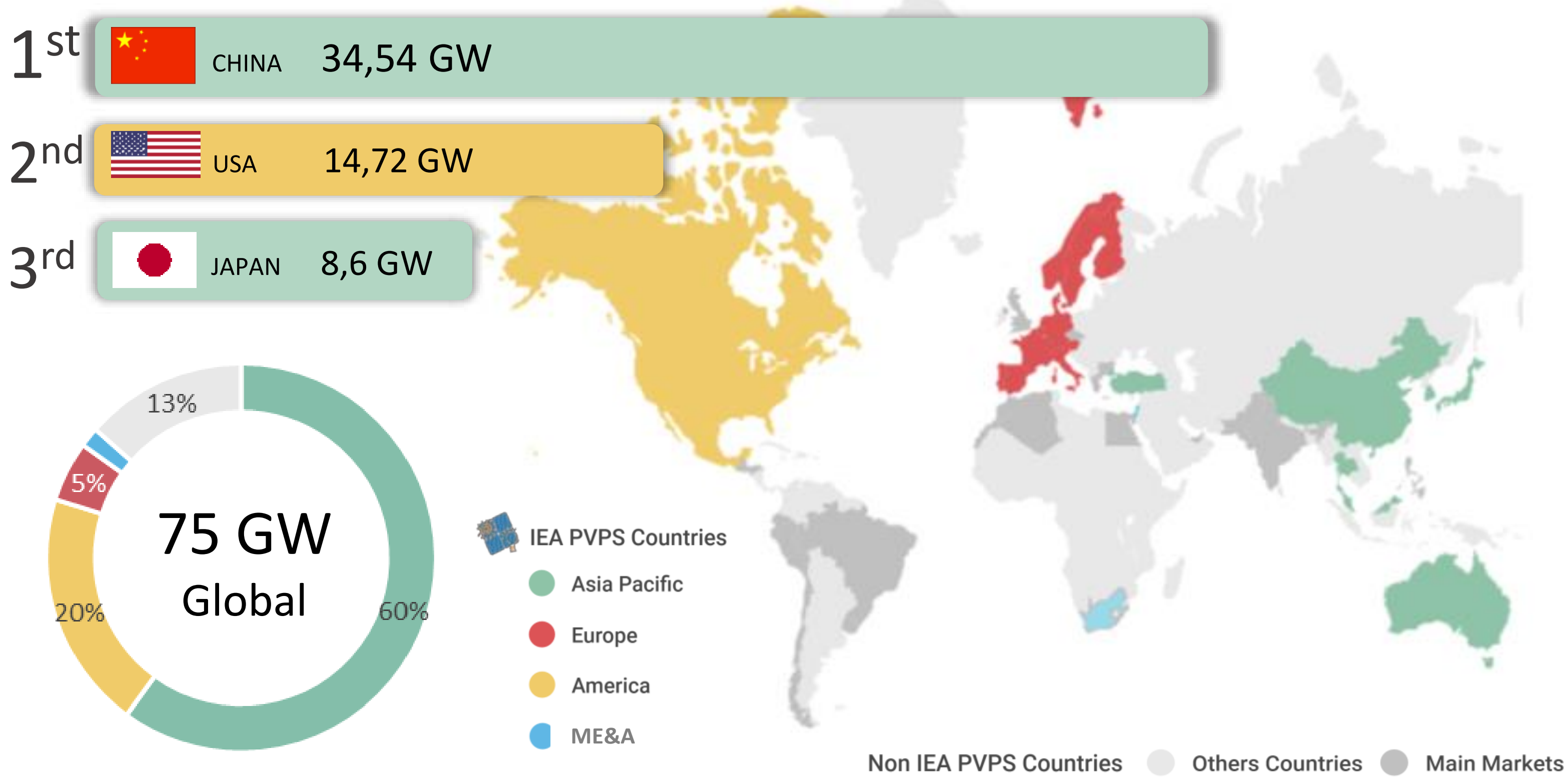
- Fast increasing amount of photovoltaic solar energy installations due to decreasing prices

  now 303 GWp (~1.3 billion solar panels)

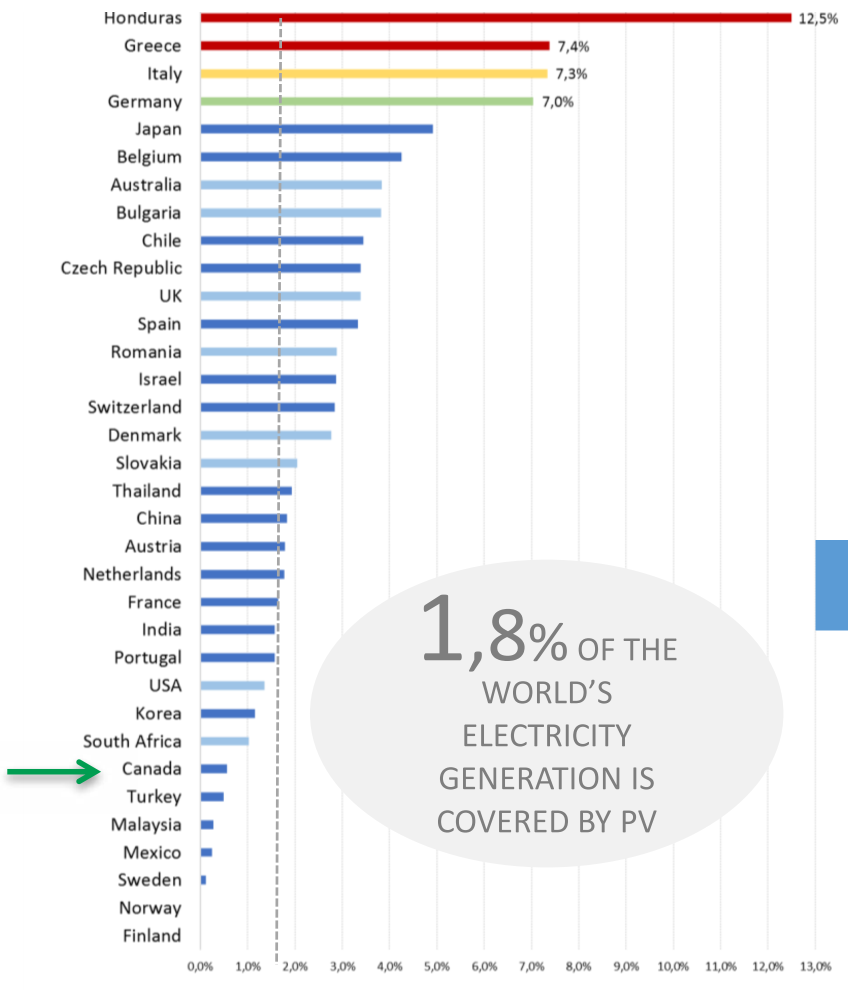
- Consumers: grid parity
- Commercial: feasible only with subsidy (>15 kWp, SDE+, NL)
- However, multi-MW:
  PPC of 3-4 c$/kWh in Chile, Abu Dhabi

Global PV Market 2016

TOP PV MARKETS 2016



2016 THEORETICAL PV PRODUCTION



©Snapshot of Global PV Markets – IEA PVPS

303GW has been installed all over the world by the end of 2016

China is the world's **1st** PV market

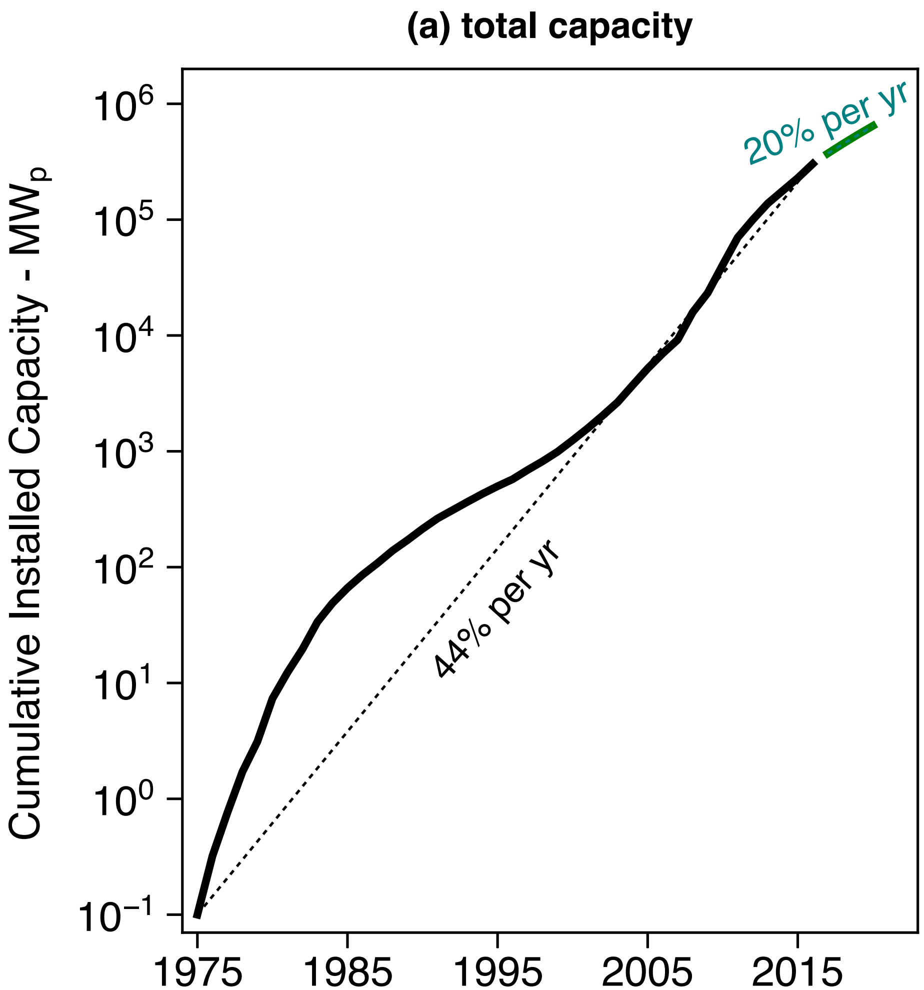
24 countries had at least **1GW** of cumulative PV capacity at the end of 2016

16 countries installed at least **500MW** each in 2016

SOLAR PV PER CAPITA 2016 Watt/capita

1st	GERMANY	511
2nd	JAPAN	336
3rd	ITALY	322

Strong growth of PV



(Louwen et al. 2016, updated)

6 orders of magnitude in 40 years

5 TWp in 2030, with 20% growth per year

(Haegel et al., Science, 2017

~30% global electricity

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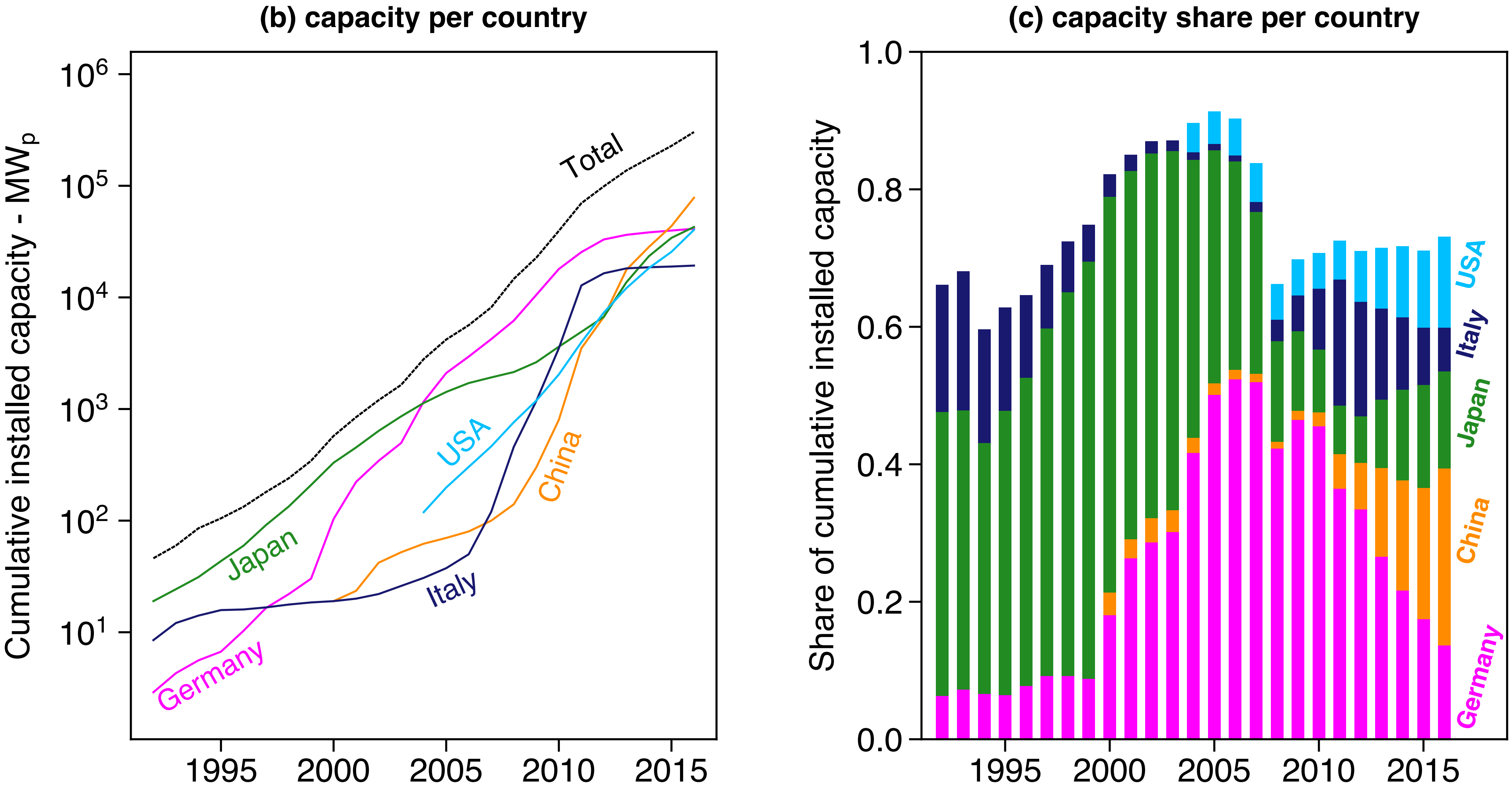
Location of PV



(Louwen et al. 2016, updated)

Concerns from fast growth

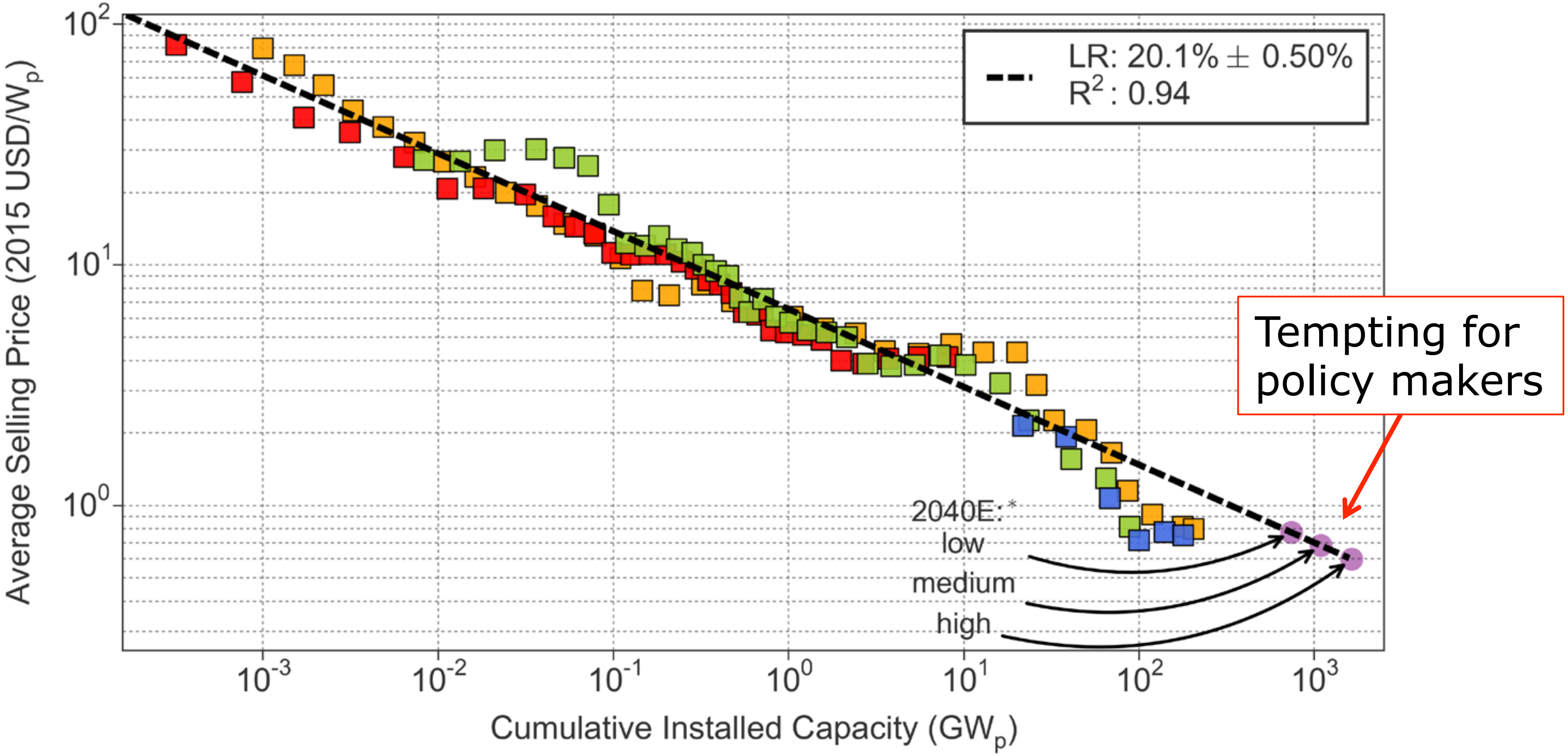
- As of 2013: for every Wp of PV capacity
  - 8-32 MJ of energy used*
  - 0.6-3 kgCO_2-eq released* → 20~80 gCO_2-eq/kWh
  - In the past this was (much) higher

- These external “costs” are paid back by generating “green” electricity
- This takes time: (energy) payback time (PBT)

- When ***PV growth > 1/PBT***
  - PV industry is net energy user
  - PV industry is net GHG emitter

*M.J. de Wild-Scholten - doi:10.1016/j.solmat.2013.08.037

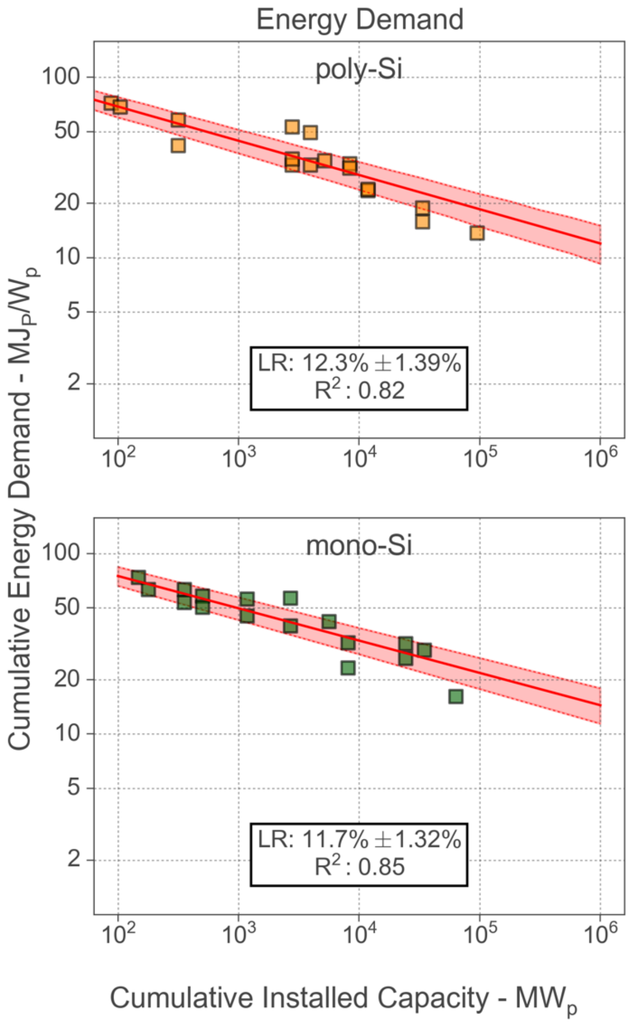
Experience curve - cost



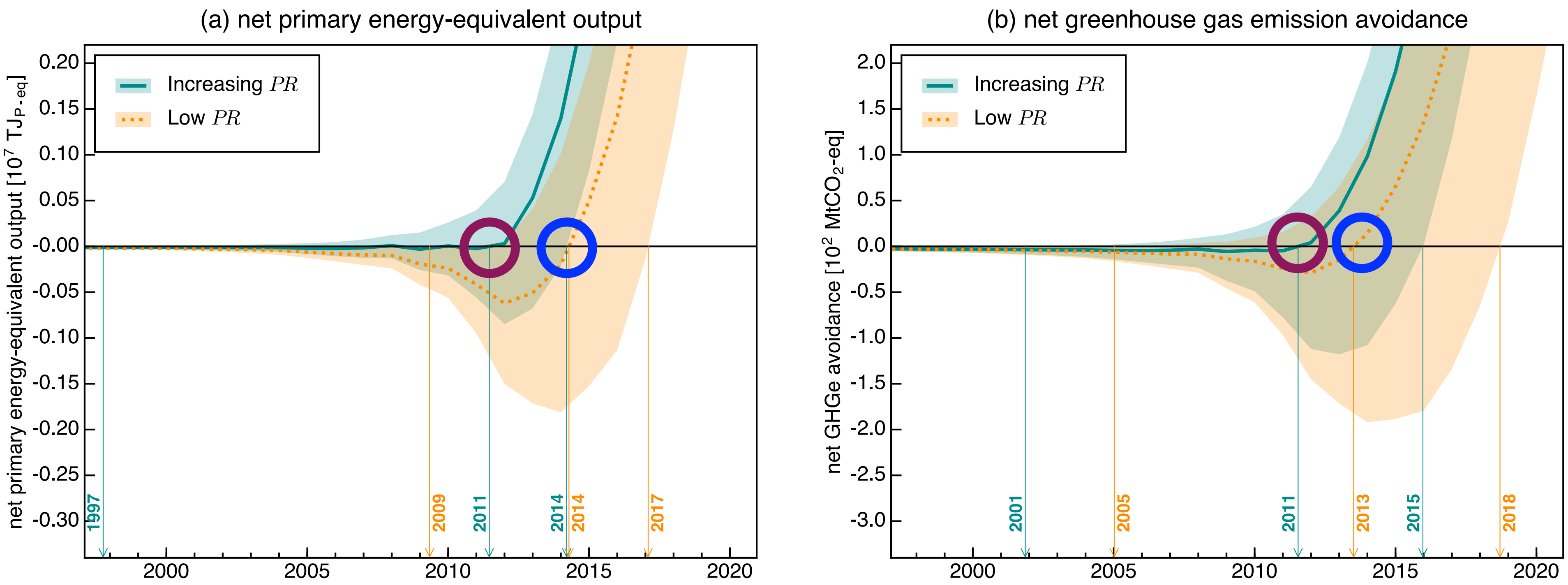
With every doubling of installed capacity cost drops with 20%

(Louwen et al. 2016)

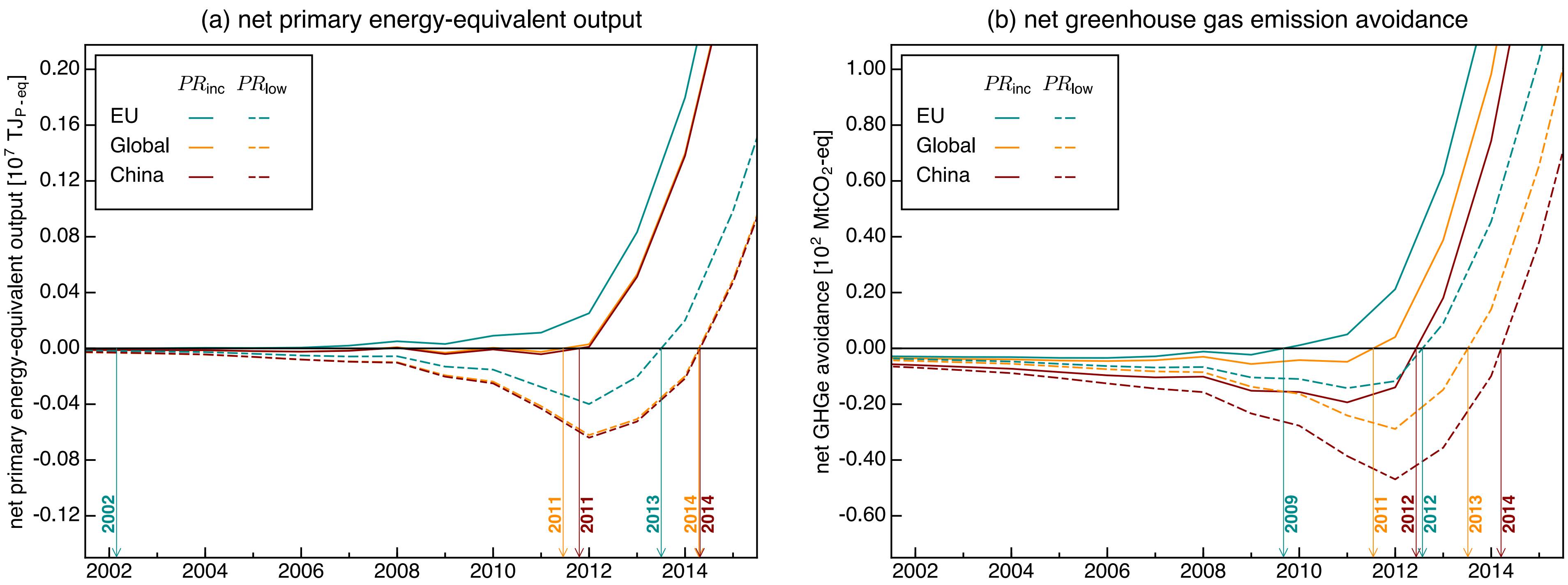
Experience curves – Environmental Impact



Results: breakeven energy and GHG



Results: breakeven energy and GHG regional differences



Motivation - 2

- More photovoltaic solar energy installations due to decreasing prices (303 GWp globally)
  - Consumers: grid parity

- Increased amount of electric mobility
- Hybrid, plug-in hybrid, full electric

Tesla Model 3, 345 km range

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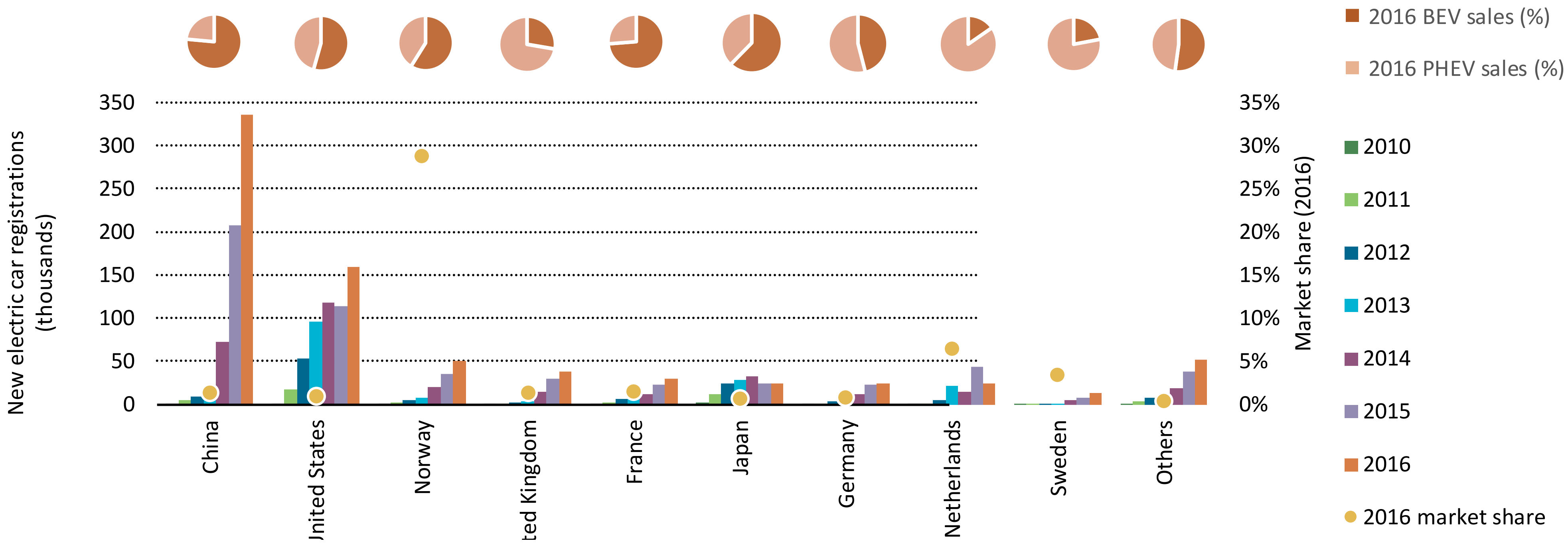
Electric vehicles market growth



China+US ~ 500,000 EVs
NL, Norway: high market share

(IEA, 2017)

Concerns EV

- Will the local grid be able to handle increased amount of EVs?
- Charging peak coincides with peak demand (6-9PM)
- Charging behaviour
  - Uncontrolled
  - Controlled (who is controlling)

Motivation - 3

- More photovoltaic solar energy installations due to decreasing prices (303 GWp globally)
  - Consumers: grid parity
- Increased amount of electric mobility
- Can we link PV and EV development?
  - Business case: charge EV with solar

    → Smart Solar Charging
  - Include vehicle-to-grid
  - Distribution grid level

Rendement smartgrid voor iedereen!

Projectpartners				Co-financiers
EBU Economic Board Utrecht	Capgemini	KEMA DNV	ECOFYS	provincie Utrecht
Eemflow Energy	HU Hogeschool Utrecht	ICA2US	LOMBOX	Gemeente Utrecht
rijksuniversiteit groningen	STEDIN	Universiteit Utrecht	Utrecht Sustainability Institute	Amersfoort

Smart Grid – Value4All 2012-2015

Creating business by developing smart energy services

Pilot Lombok: E-car4all en Storage4all

Objective

Develop and evaluate **algorithms** for a smart grid system that can **increase self-consumption** of PV-power by storing electricity in EVs in the residential sector while **meeting the demands** by the use of the **EVs**

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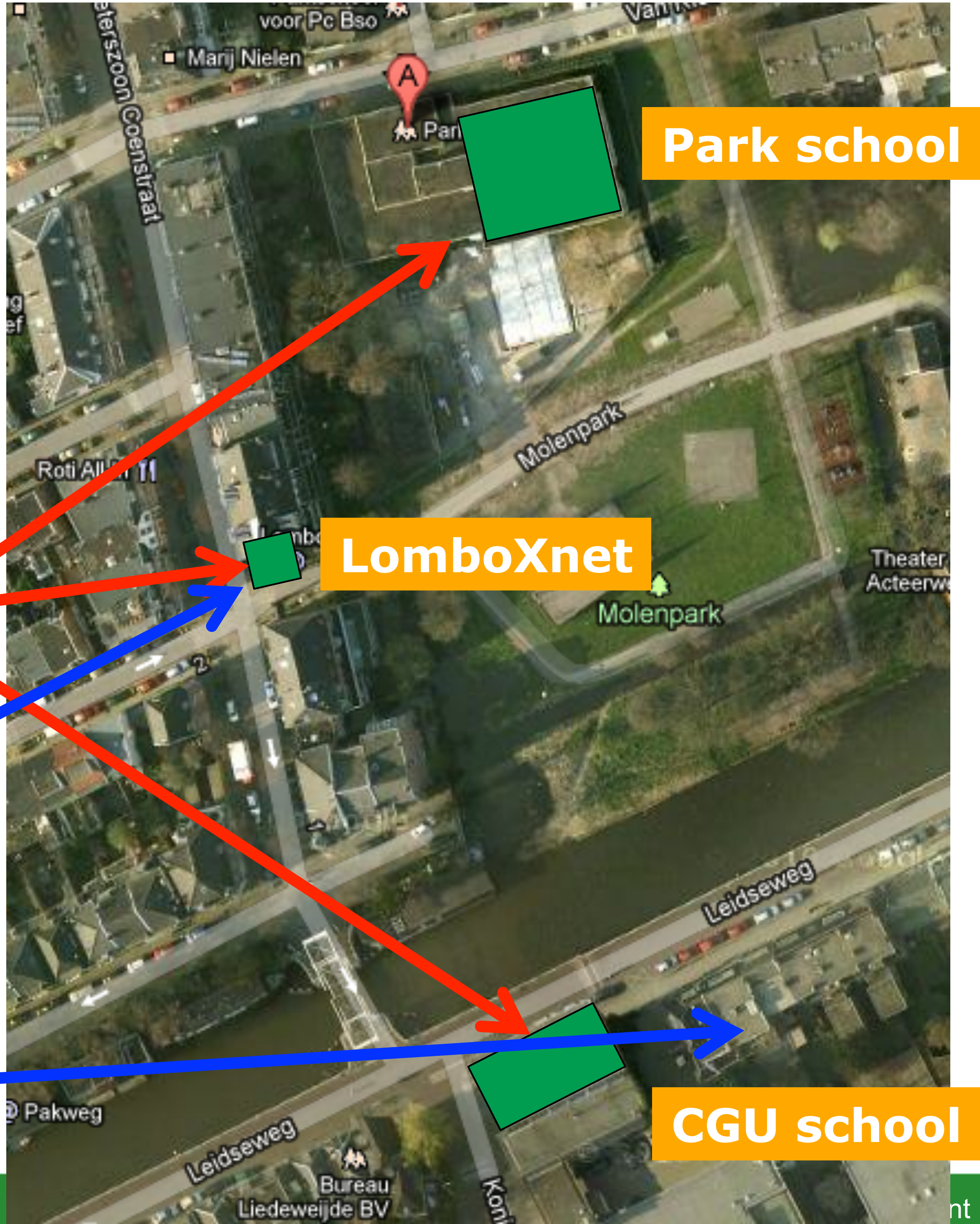
PV panels

E-car charger

E-car charger



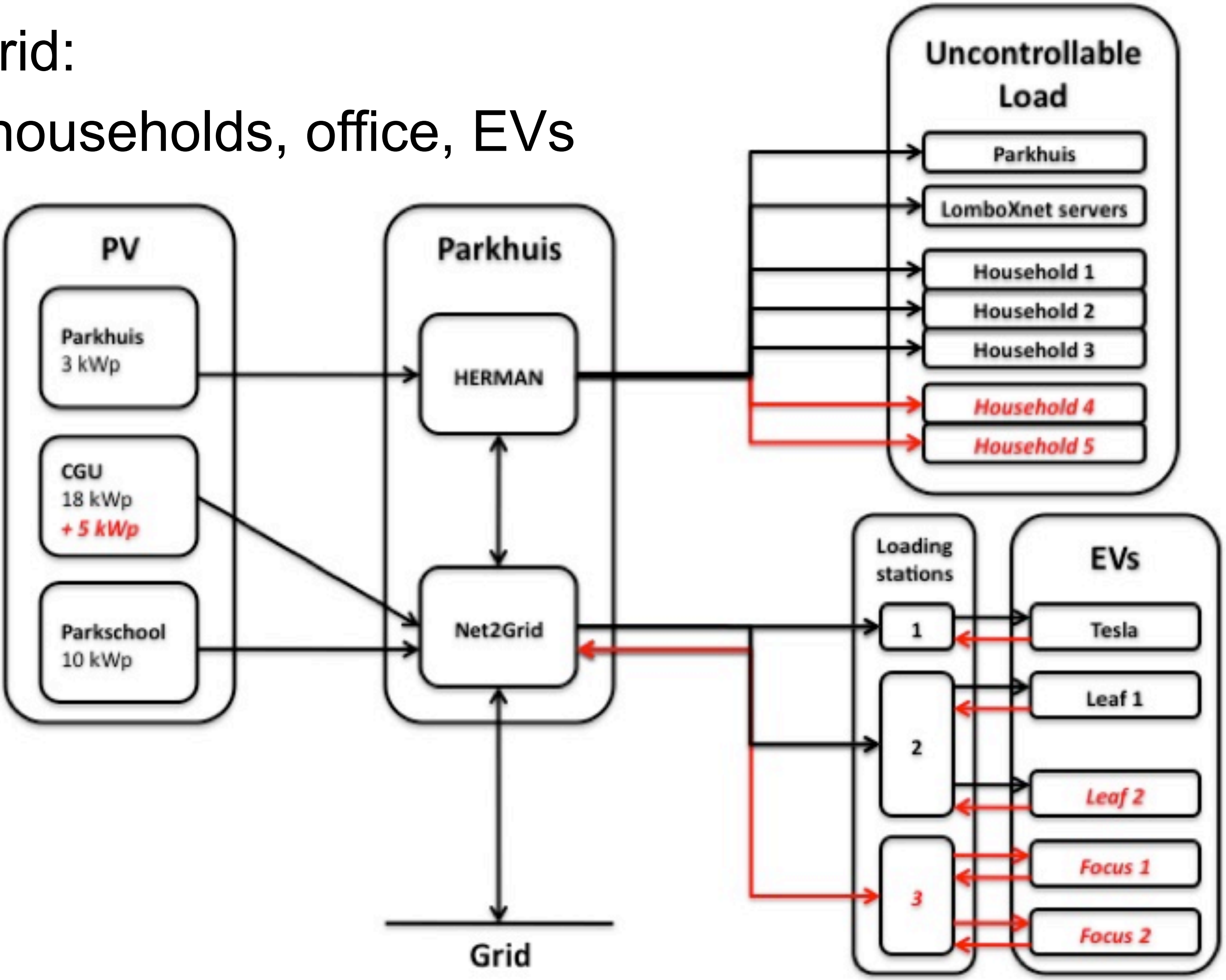

LomboXnet
Park school
CGU school

Utrecht Lombok

Model development

Microgrid:

- PV, households, office, EVs

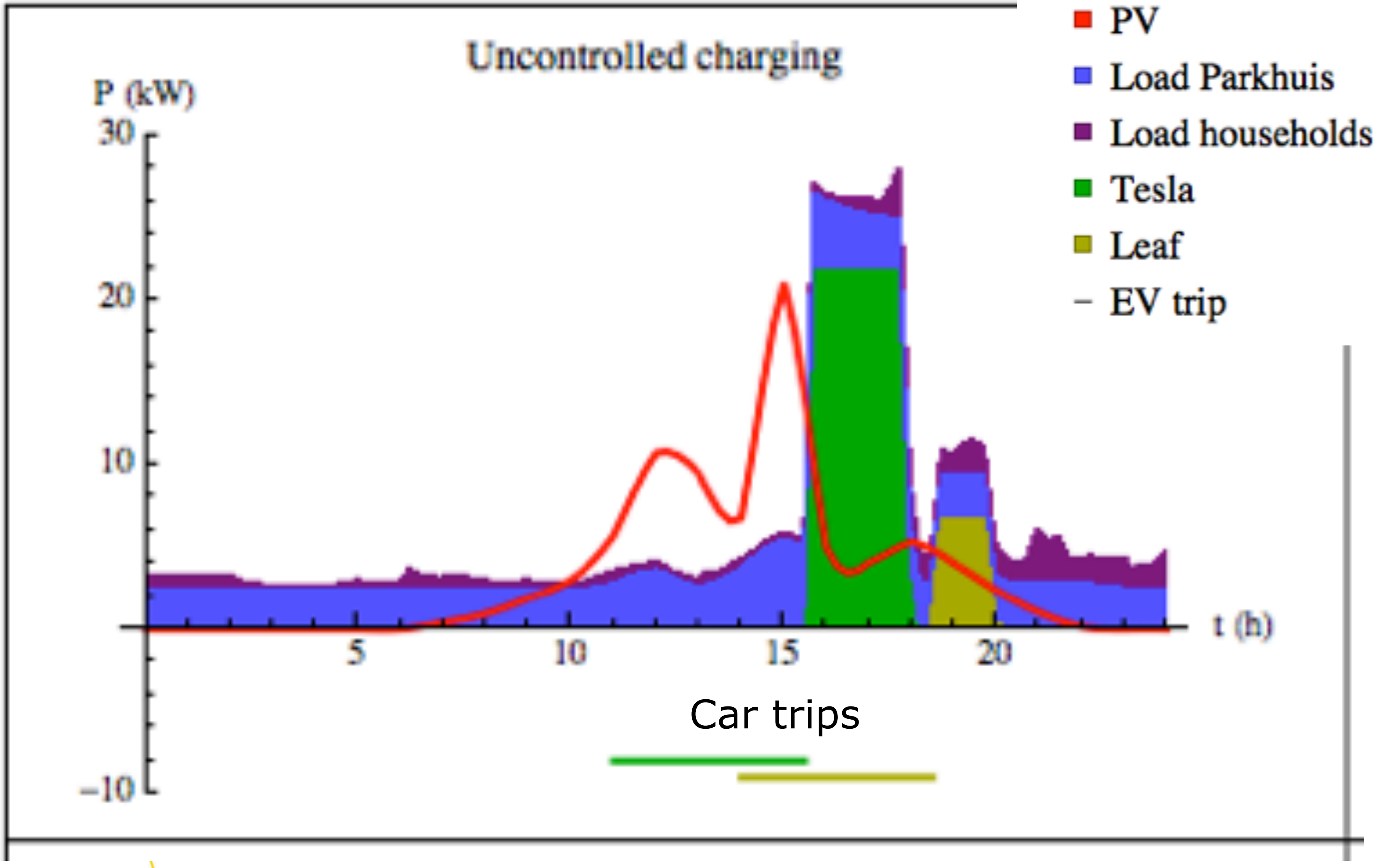


Van der Kam, 2015

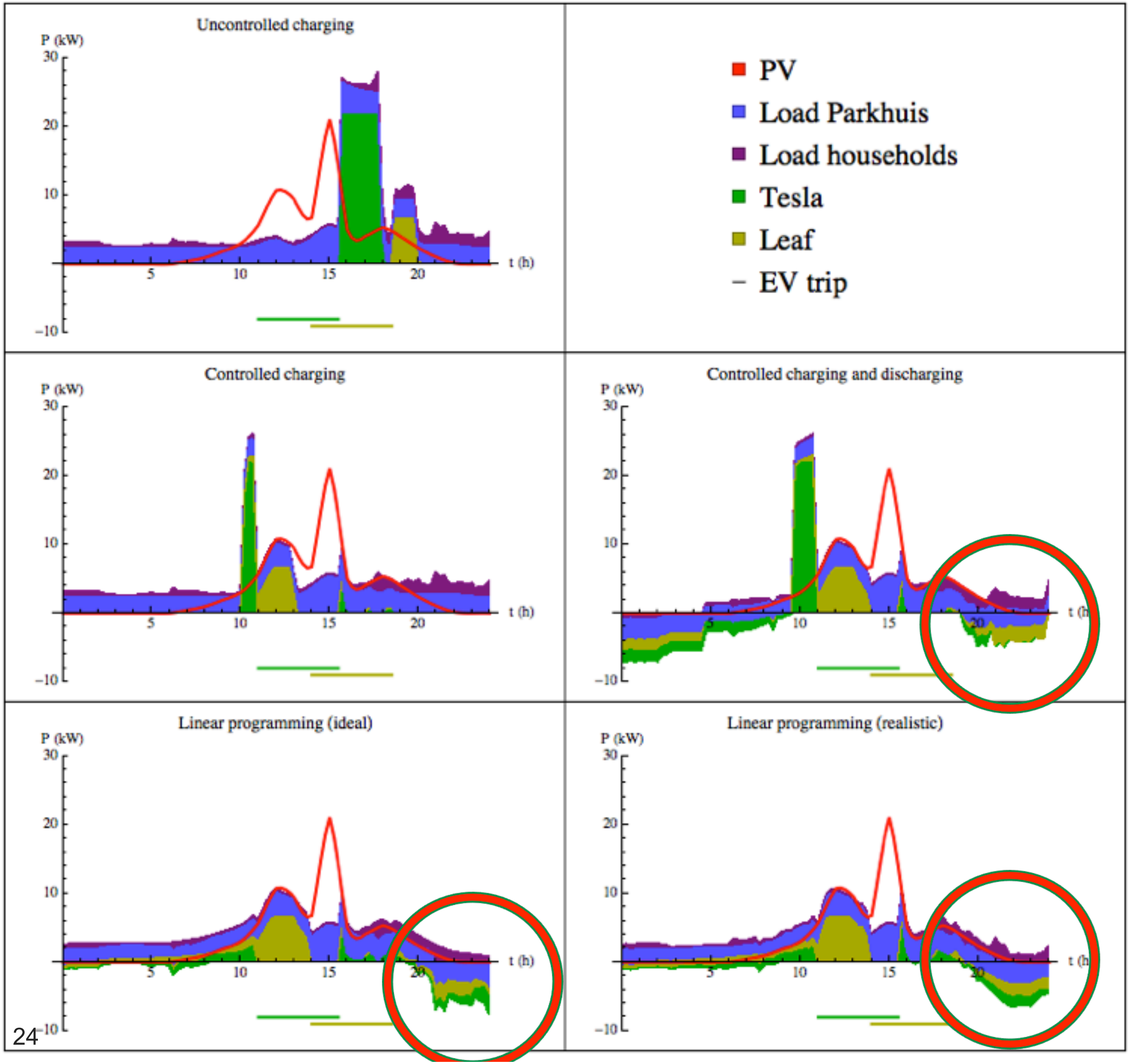
Strategies EV-charging

- Uncontrolled charging: “plug&charge”
- Controlled charging
- Controlled charging and discharging
- Linear optimization
  - (Dis-)charging profile established through mathematical optimisation
  - Good predictions for PV and demand necessary
  - Evaluation with and without perfect information (ideal vs. realistic)

Results: uncontrolled charging



Van der Kam, Van Sark, 2015



Van der Kam, Van Sark, 2015

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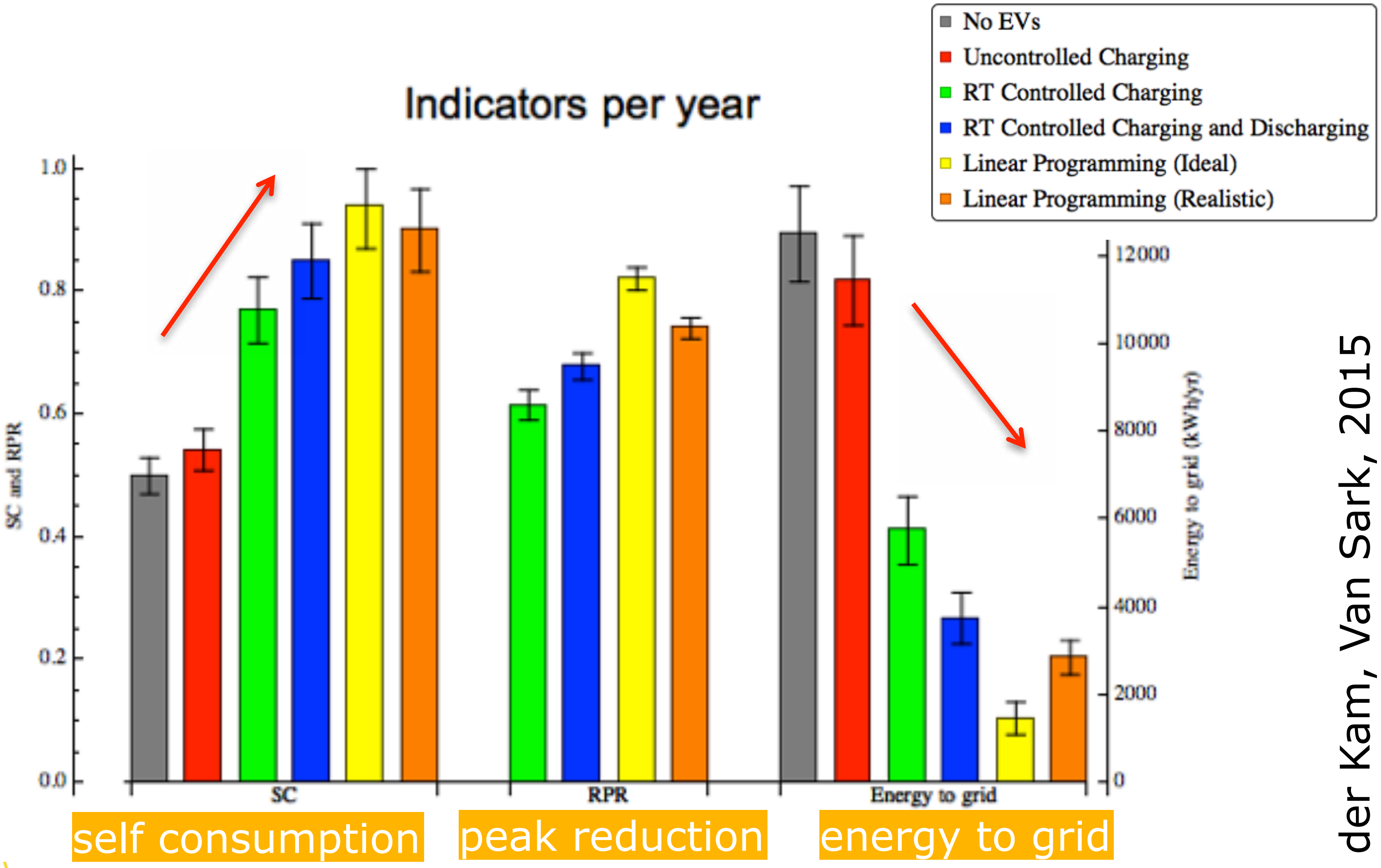
Results: self consumption, peak reduction, energy to grid



Van der Kam, Van Sark, 2015

Summary results

- Smart grid control algorithms for managing the (dis)charging profile of multiple EVs, either in real-time or using linear optimization with predictions for PV-power and electricity demand

- Results show that smart storage of (solar) electricity in EVs can increase self-consumption with 23% to 38%, reduce energy sent to the main grid with 3 to 9 MWh per year and reduce peaks with 27% to 67%

  (in this case study)

First bidirectional charging station in Europe

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June 9th 2015:

First solar-controlled, V2G public AC charging station in the world

44 kW grid connection

Gemeente Utrecht

vidyn
an allinq company

LomboXnet

EBU
ECONOMIC BOARD UTRECHT

last mile solutions

STEDIN

June 9th 2015: live demonstration during international V2G-meeting Nissan

Summary

NOW: time for experimental data (bidirectional chargers)

→ smart solar charging Regio Utrecht

- Scale-up
- Other districts, with different population (office area, university campus)
- Company: WE DRIVE SOLAR

WE DRIVE SOLAR

MOBILITY HEROES

ENERGIE U

Veronica Verkeersschool

NEWSOLAR ENERGY SOLUTIONS

MRA elektrisch

natuur en milieu federatie utrecht

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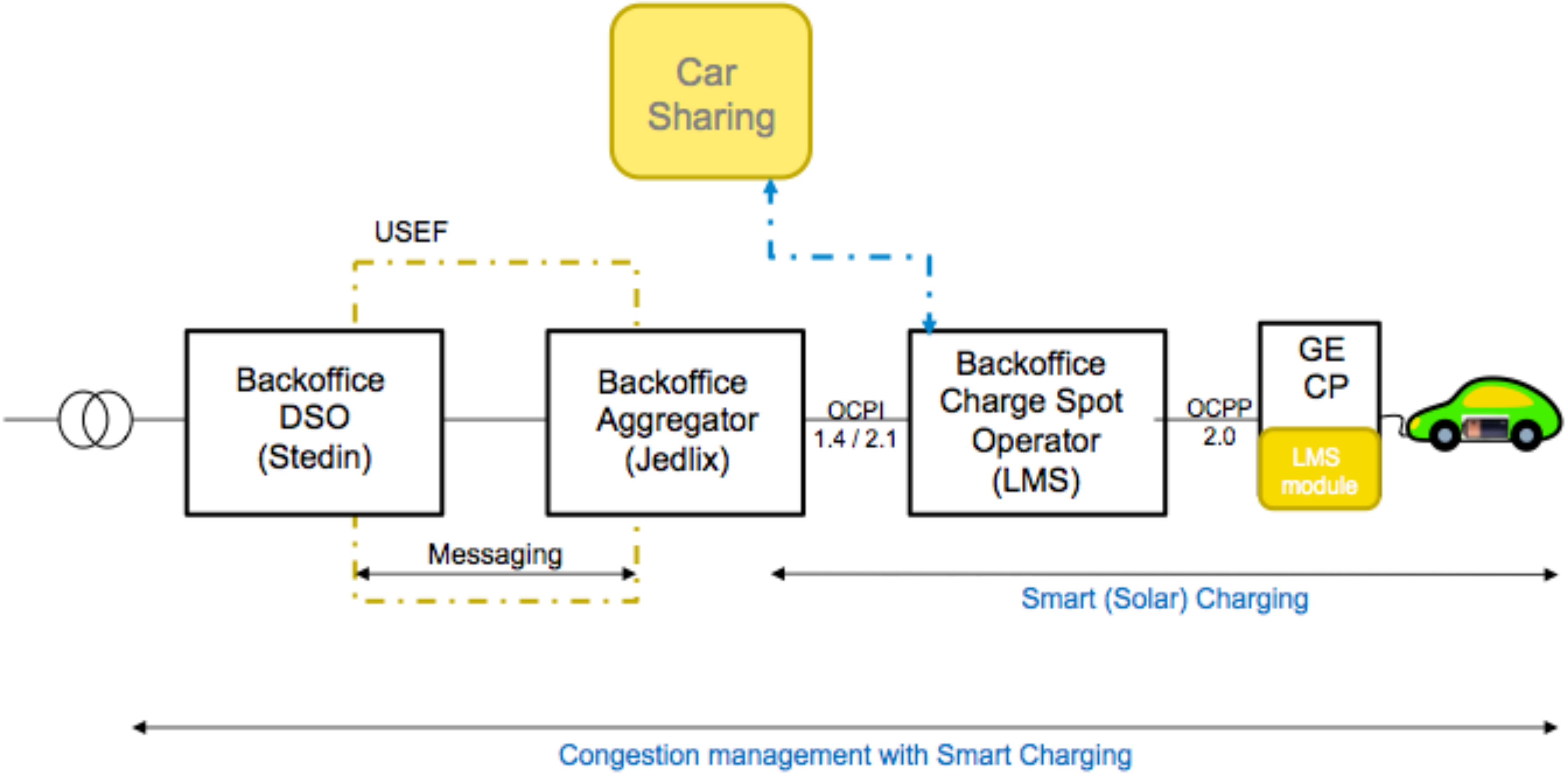
Living Lab Lombok:

- 22 Smart Solar Charging stations
- 100 kW new solar

Organize the business case



Paris March 11 2016, Dutch royal visit to France
150 Renault ZOE's, 300 km range, bidirectional

22 kW AC bidirectional charging

Standards together with Elaad


300 km range
WE DRIVE SOLAR
Entry price € 99,-/month [CAR SHARING]
Includes km and insurance
Licence plate based parking lot with Smart Solar Charging
App for reservation and opening
Support Province of Utrecht

The team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smart solar charging
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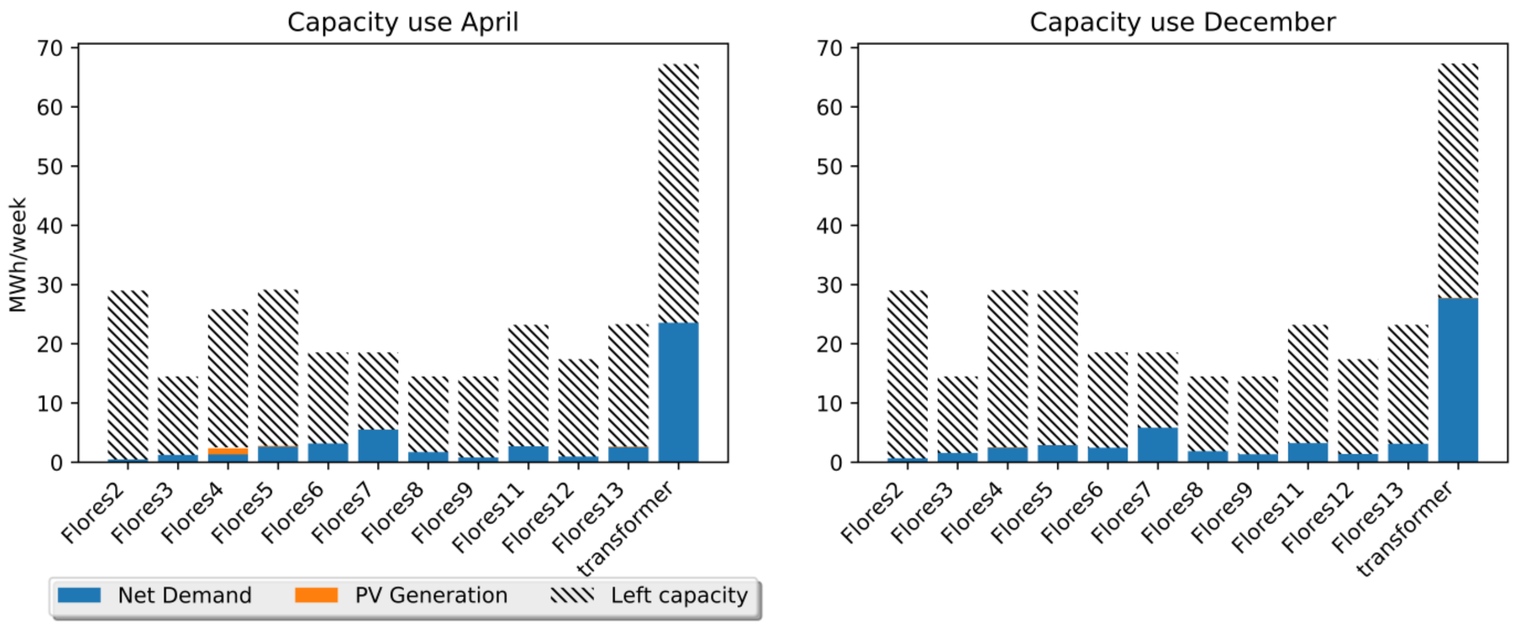
Preliminary results

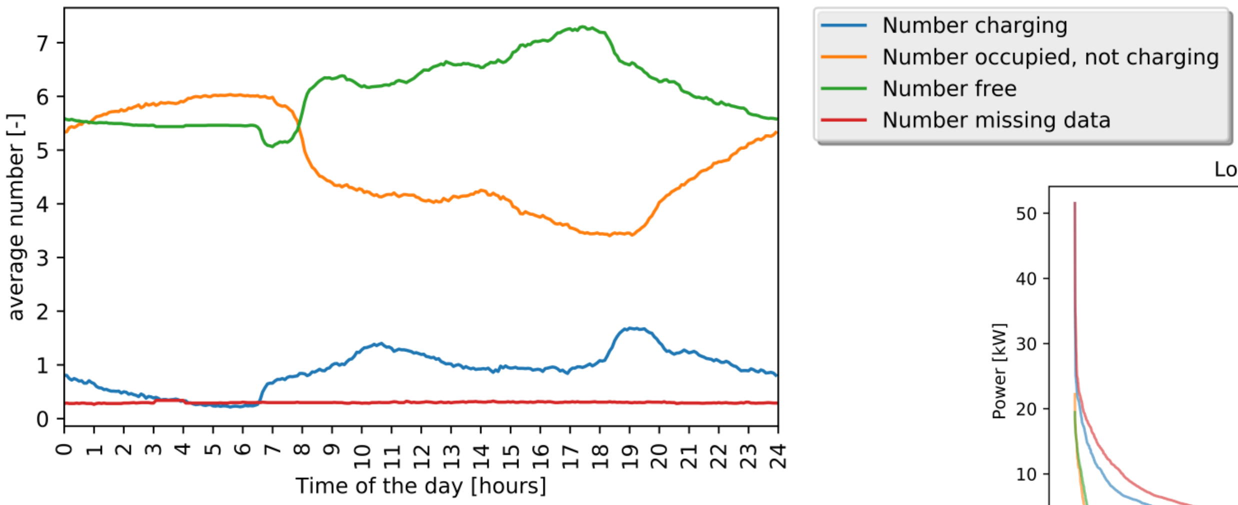
- Analysis of power flows
  - Cable capacity is high
  - Transformer capacity (400 kVA) may become issue

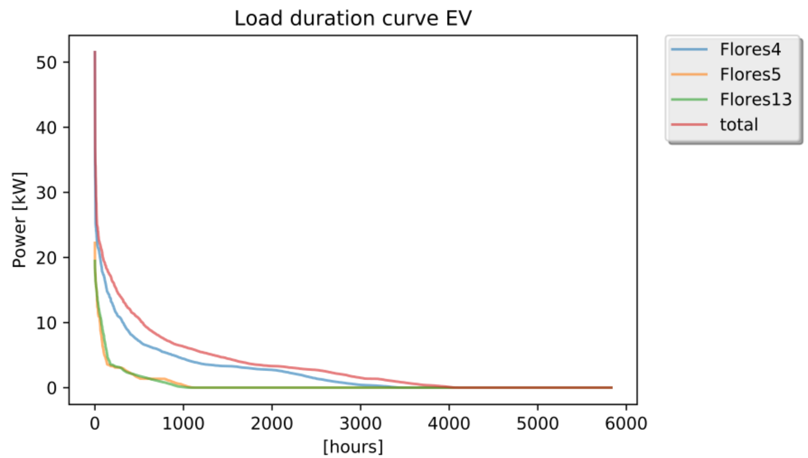


[Gerritsma, unpublished]

Charging behaviour

- With present amount (12) of 22 kW charging stations:
- On average 10% occupied and charging; 50% occupied and NOT charging!
- More EVs can be added easily





[Geritsma, unpublished]

Future work

- Organize groups of 3-6 drivers (families) per car
  - Based on typical driving behaviour

OR

- Organize pool of drivers for a fleet (5-10) of cars

- Study car sharing behaviour in relation to power flows → attempt to forecast charging needs
- Link to local, short-term solar forecast

- Determine optimal self-sufficiency level

Ambition Utrecht Region 2018/2019

1.000 solar chargers, 1.000 shared EV's, 10.000 new solar panels, 100.000 users

First region in Europe with clean energy- and mobility system based on solar

Summary

- Photovoltaics and electric mobility are increasing simultaneously
- At district level, PV+EV can be combined using "Smart Solar Charging" concept
  - Smart grid energy management
  - Defer grid investments
  - Business case car sharing
  - Potential benefit from balancing

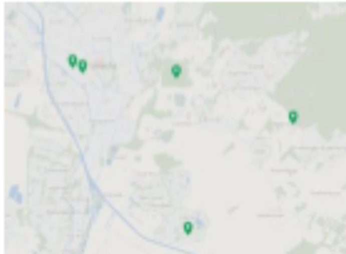
- Ingredient for Smart Sustainable Cities

Smart Solar Charging

Home | Smart Solar Charging ▾ | Five linked pilot areas | News & media ▾ | Contact | NL

THANK YOU FOR YOUR ATTENTION

smart solar charging Regio Utrecht



Smart Solar Charging

A sustainable energy system at district level. Locally produced solar energy is stored in (pool) cars. This energy can be released to the district at a later time, via a smart charging station.

Read more

The project

The experiences in Lombok will be developed further and tested over the next four years in five linked pilot areas in the Utrecht region. This will result in marketable product-service combinations for various types of areas.

Read more

Five pilot areas in the Utrecht region

All areas combine the production of renewable energy with Vehicle2Grid-charging points and car sharing systems. Each pilot area has its own user profile, type of customer and specific market.

Read more