DC-GRIDS FOR ENABLING SMART GRIDS WITH DISTRIBUTED RESOURCES, DEMAND RESPONSE AND STORAGE FOR ELECTRICITY

Contribution to DUE (Domestic Use of Energy) conference,
Capetown, April 1th 2015.

Harry Stokman, DC Foundation and René Kamphuis, TNO and TU/Eindhoven

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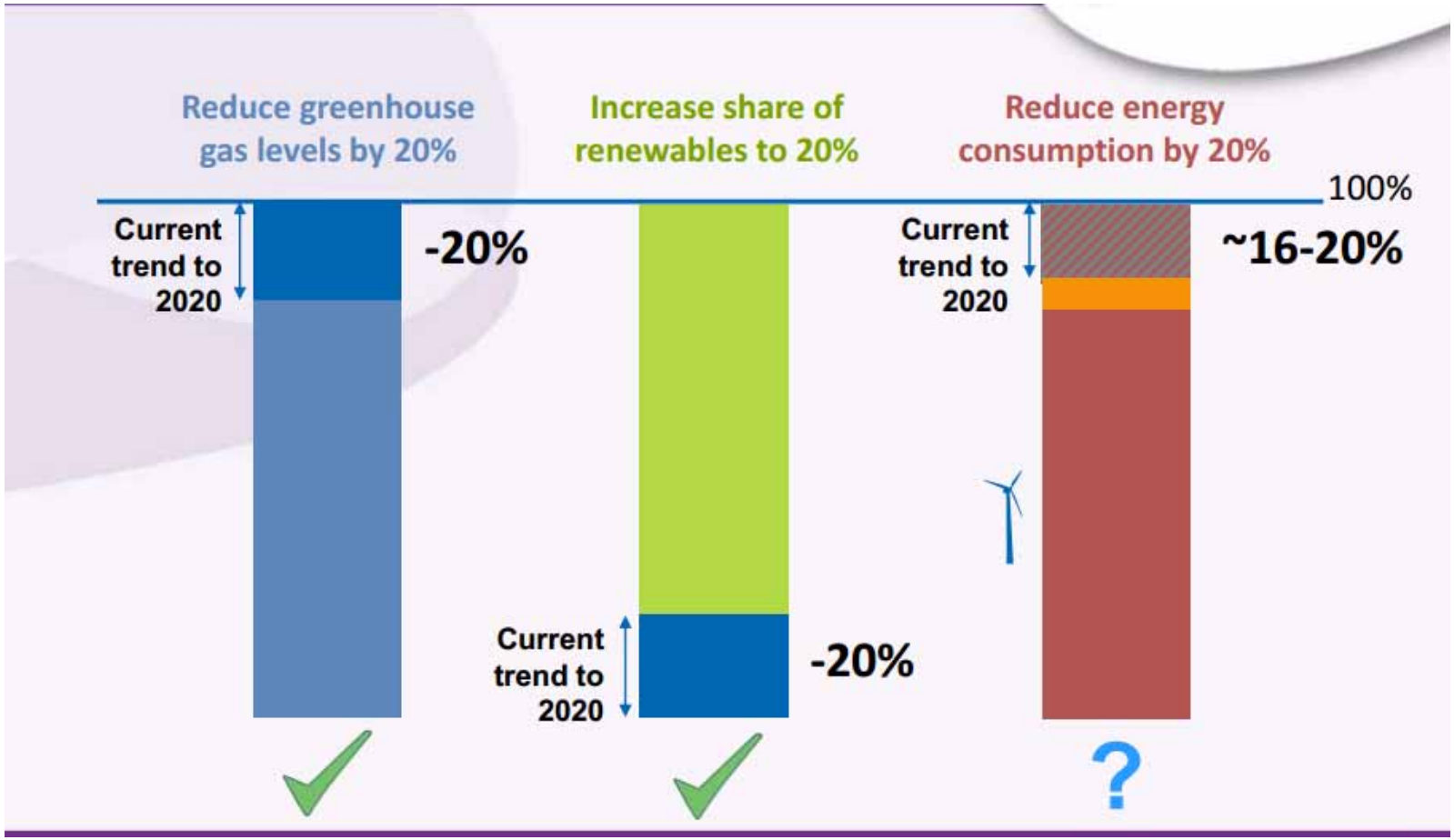
Policy issues European Union



Electricity grids have to deliver the biggest proportion

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Power flows in electricity grids

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Evolution of electricity grids

- New types of generation
- Electrification
- Simultaneous/ bidirectional
- Synergy electr./gas/heat/cold

Large generators

Combined heat/power, wind

HV/MV Transmission

Industry

μ CCHP

Solar cells

EVs

Heatpumps,Air

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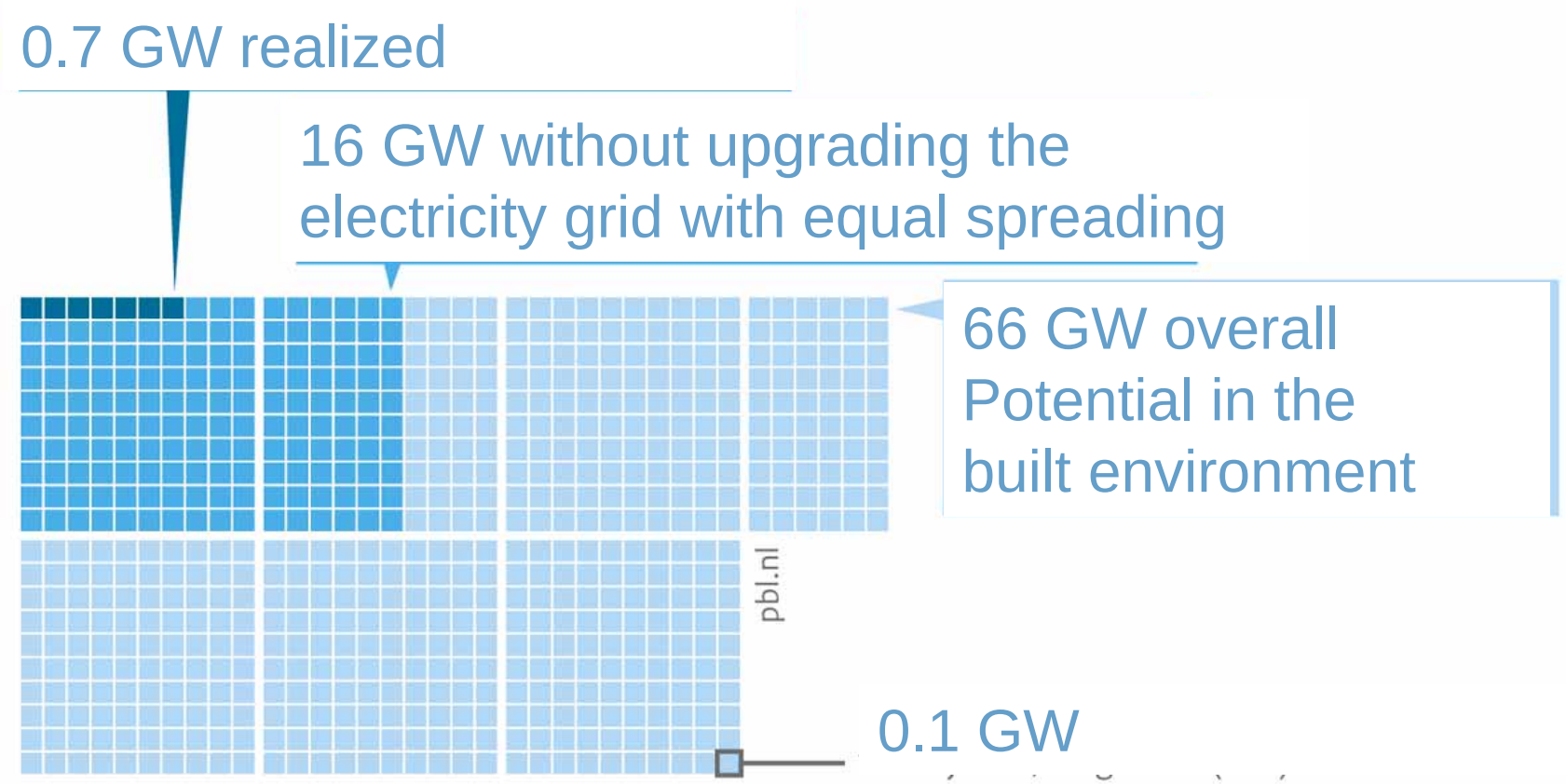
Are the potentials realizable (NL study 2014) ??

Realized solar power and potential for placement of PV



Bron: DNV GL/PBL 2014

USB Power Delivery

- Before connect the USB connector is standard USB Power profile 1
- Device will be powered at 5V maximum 2A
- Communication will start to negotiate for wanted power profile

USB PD will become the standard Low power device connector

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Profile	Voltage	Current	Power	Comments
1	5V	2A	10W	Startup profile
2	12V	1,5A	18W	Netbooks
3	12V	3A	36W	Utrabooks
4	20V	3A	60W	Limit for micro A/B connector
5	20V	5A	100W	Limit for standard A/B connector

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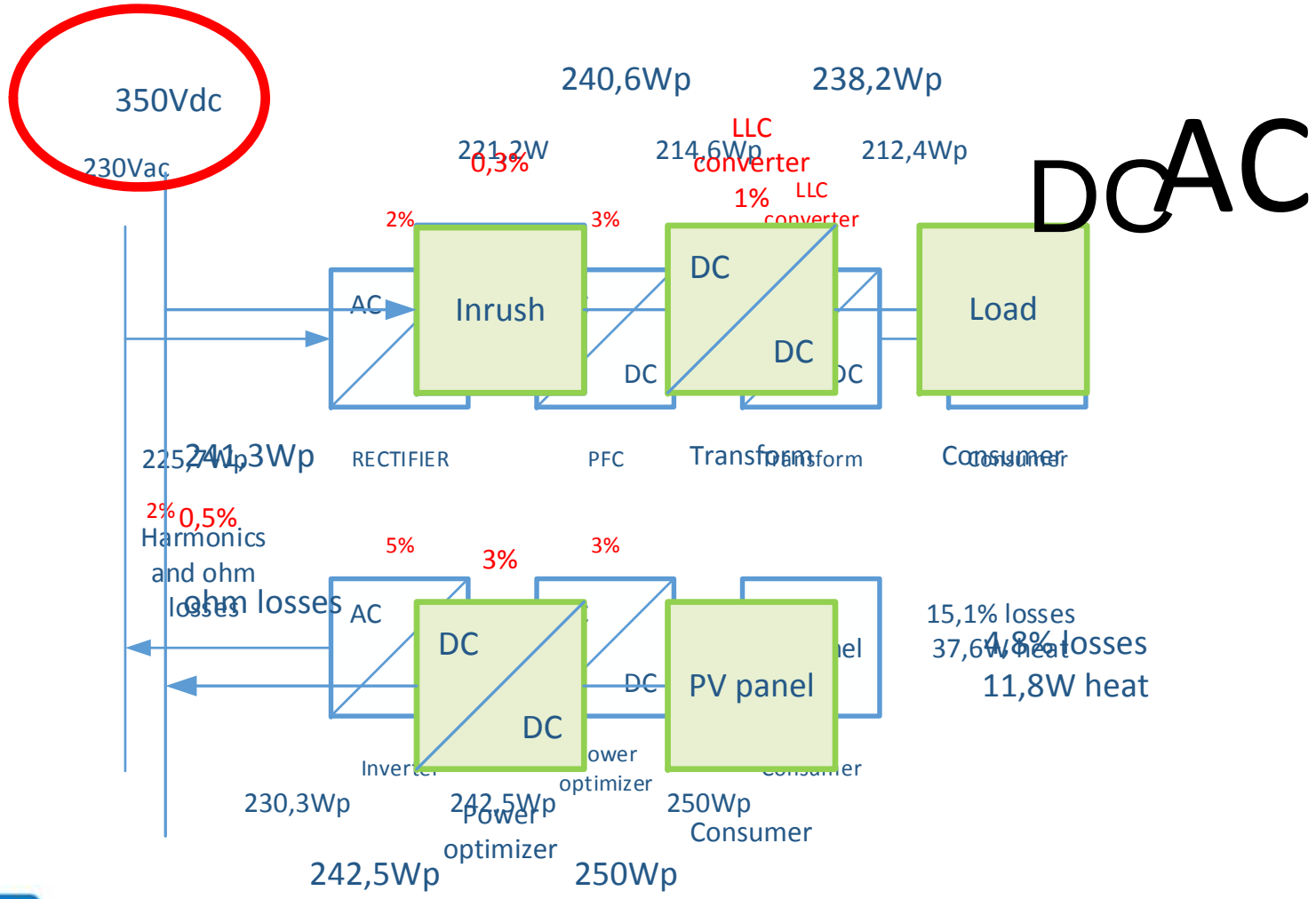
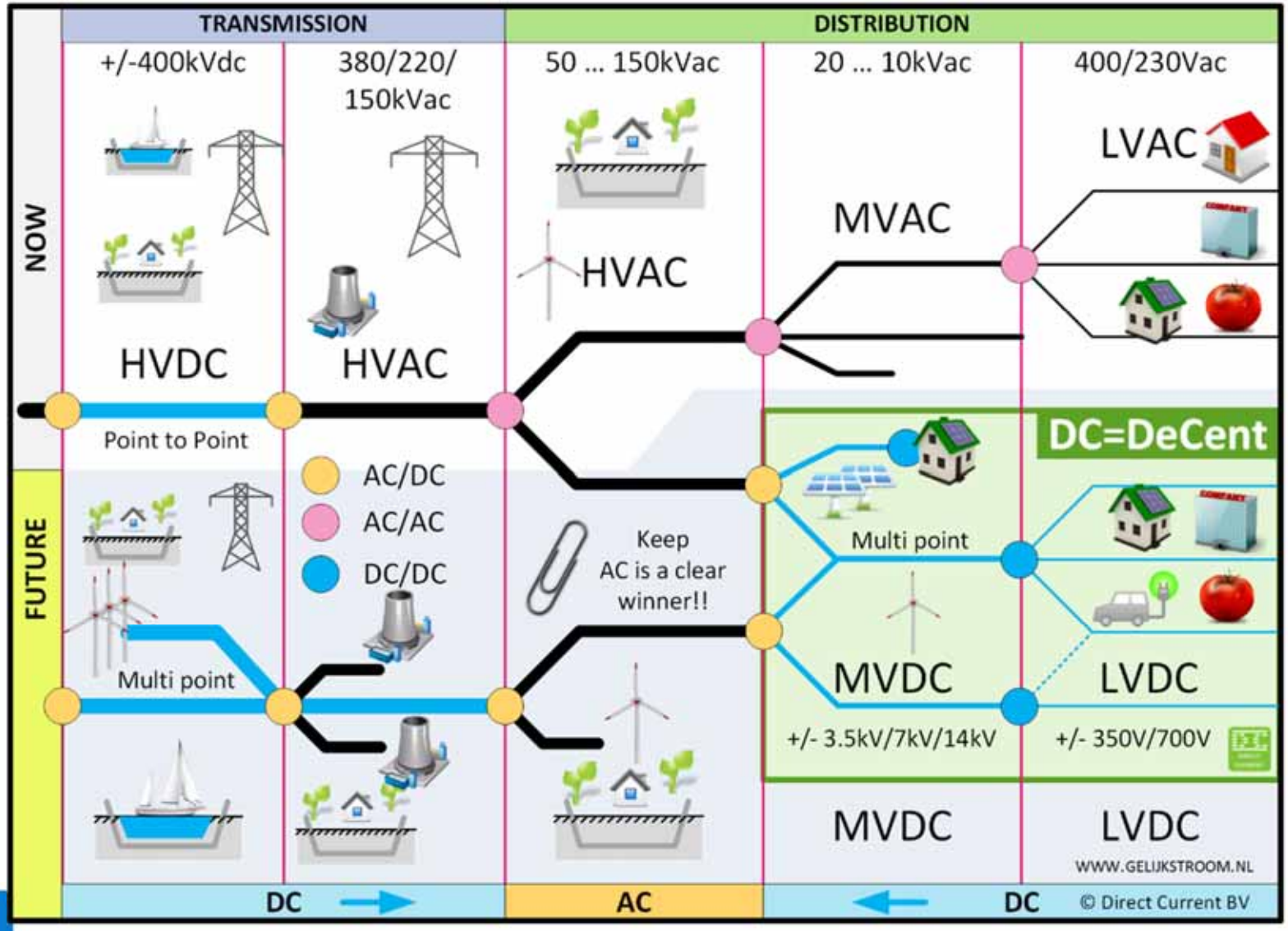


AC/DC losses (generation to load: 15.1 <> 4.8 %)



Hybrid road maps for AC and DC power infrastructures

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ieadsm energy efficiency

DC	House hybrid AC/DC	House DC	Heat Pump 2/50kW	EV 10/20kW	Office 100Wp on DC	Data center >1MW	Factory >1MW	Ware house lighting	Green house >1 MW	Solar System 10kW	Solar park 2MW	Power Watt/mm2 @6A/mm2	Cu mg/W 1m @6A/mm2	Can replace	Wires no PE	Distance 1% drop @ 6A/mm2	600Vdc	1500Vdc
12V	x	x	x	x	x	x	x	x	x	x	x	72 W	247/+1817%	-	2	0,6 m	USA	
24V	x	x	x	x	x	x	x	x	x	x	x	144 W	124/+858%	-	2	1,2 m		
48V	√	x	x	x	x	x	x	x	x	x	x	288 W	61,8/+379%	-	2	2,4 m		
60V	√	x	x	x	x	x	x	x	x	x	x	360 W	49,4/+283%	-	2	2,9 m		
110V	√	x	x	x	x	x	x	x	x	x	x	660 W	27,0/+109%	-	2	5,4 m		
220V	√	√	x	x	√	x	x	x	x	x	x	1320 W	13,5/+5%	230Vac 1ph	2	10,8 m		
300V	√	√	x	x	√	x	x	x	x	√	x	1800 W	9,9/-23%	230Vac 1ph	2	14,7 m		
350V	√	√	x	x	√	√	x	√	x	√	x	2100 W	8,5/-34%	230Vac 1ph	2	17,2 m		
+/- 190V	√	√	x	x	√	√	x	√	x	√	x	2280 W	11,7/-9%	230Vac 1ph	3	18,6 m		
380V	√	√	x	x	√	√	x	√	x	√	x	2280 W	7,8/-39%	230Vac 1ph	2	18,6 m		
400V	√	√	x	x	√	√	x	√	x	√	x	2400 W	7,4/-43%	230Vac 1ph	2	19,6 m		
500V	x	x	x	x	x	√	x	x	x	√	x	3000 W	5,9/-54%	-	2	24,5 m		
+/-300V	√	√	√	√	√	x	x	√	x	√	x	3600 W	7,4/-43%	-	3	29,4 m	IEC	
600V	x	x	√	√	x	x	x	x	x	√	x	3600 W	4,9/-23%	400Vac 3ph	2	29,4 m		
+/- 350V	√	√	√	√	√	√	√	√	x	√	x	4200 W	6,4/-51%	230Vac 1ph	3	34,3 m		
700V	x	x	√	√	x	√	√	x	x	√	x	4200 W	4,2/-34%	400Vac 3ph	2	34,3 m		
+/- 380V	√	√	√	√	√	√	√	√	x	√	x	4560 W	5,9/-55%	230Vac 1ph	3	37,3 m		
760V	x	x	√	√	x	x	√	x	x	√	x	4560 W	3,9/-39%	400Vac 3ph	2	37,3 m		
[illegible]	x	x	√	√	x	x	√	x	x	x	x	5400 W	3,3/-49%	-	2	44,1 m		
1000V	x	x	x	x	x	x	√	x	x	x	x	6000 W	3,0/-54%	-	2	49,0 m		
+/- 600V	x	x	√	x	x	√	√	x	√	√	√	7200 W	3,7/-42%	400Vac 3ph	3	58,8 m		
1200V	x	x	x	x	x	x	√	x	x	x	x	7200 W	2,5/-34%	690Vac 3ph	2	58,8 m		
+/- 700V	x	x	√	x	x	√	√	x	√	√	√	8400 W	3,2/-51%	400Vac 3ph	3	68,6 m		
1400V	x	x	x	x	x	x	√	x	x	x	x	8400 W	2,1/-43%	690Vac 3ph	2	68,6 m		
	Author Harry Stokman				© 2013 by Direct Current BV internet: www.directcurrent.eu							1380 W	12,9	230Vac 1ph	2	11,3 m	Standard low voltage limits	
√	EMerge Alliance			Best range	√	Proposed standard by Direct Current BV					AC	4157 W	6,4	400Vac 3ph	3	34,0 m		
√	Possible extension				√	Possible 300V/600V grids						7171 W	3,7	690Vac 3ph	3	58,6 m		

Hybrid road maps: interfacing possibilities exist

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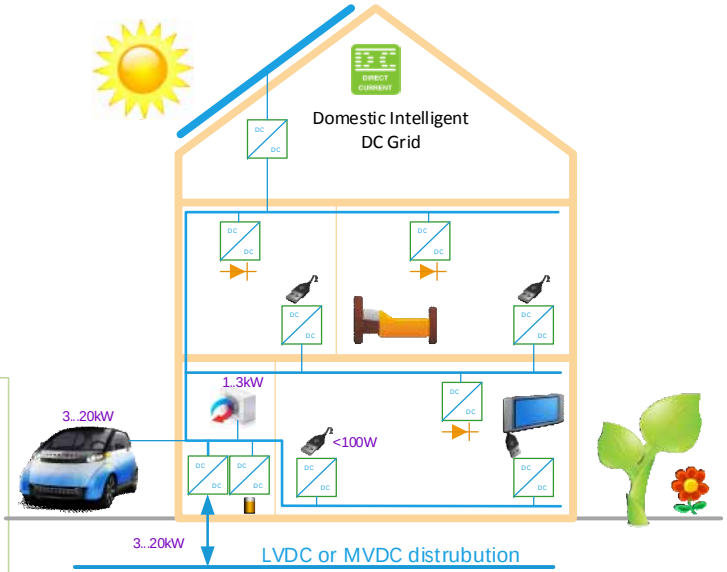
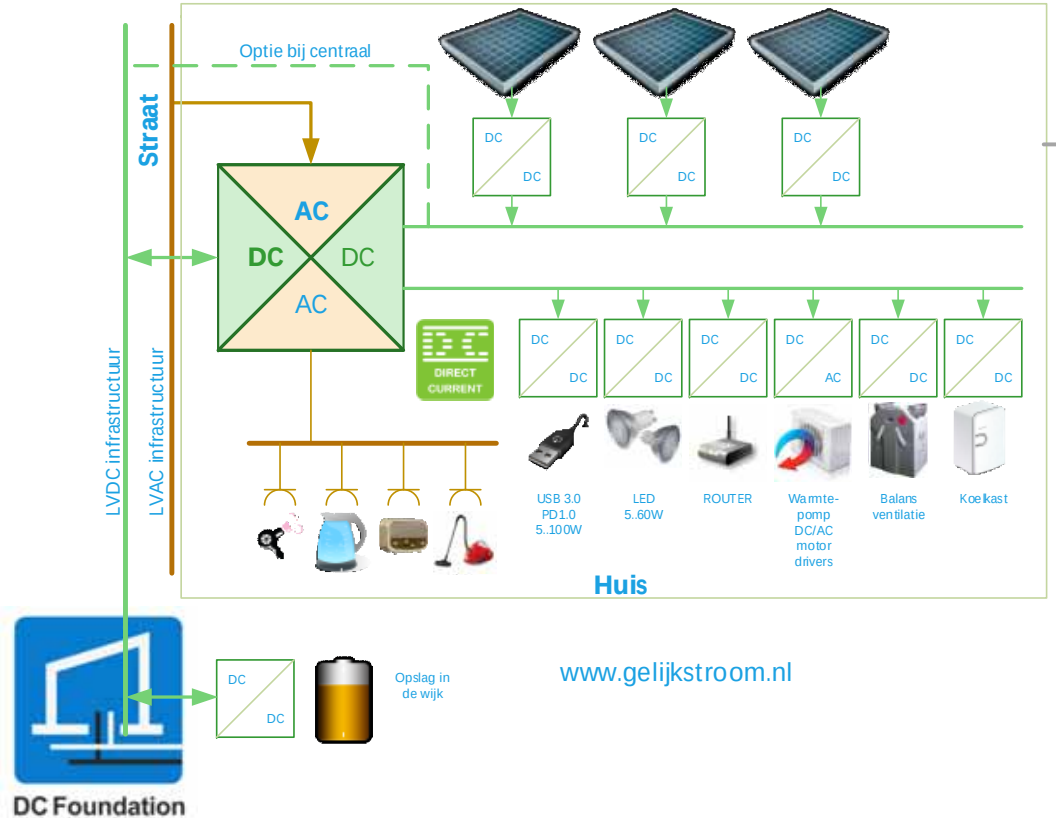
DC-grid application areas

- Residential homes

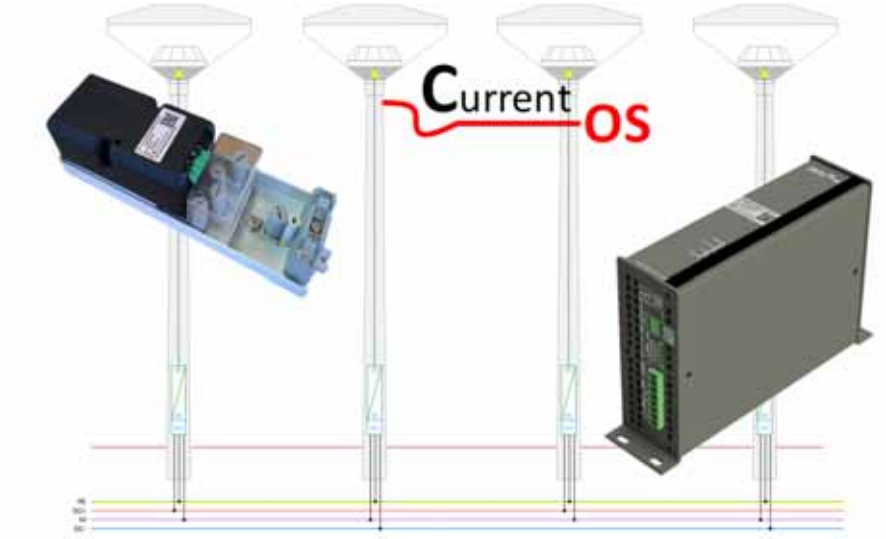




www.gelijkstroom.nl

Application areas

- Residential homes
- Public lighting



Example: 500 Public Lights of 60W in the Netherlands based on:

- ±350Vdc Grids
- Earth fault protection 1..10mA
- Cable quality and state is known
- Lighting Protection
- Arc detection
- Corrosion protection
- Fully controlled
- Smart grid (Current/OS)
- Power Line Communication G3 protocol connected to the cloud
- No Breaking Current needed for protection
- Cable length > 2km
- HVAC transmission lines area

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Application areas

- Residential homes
- Public lighting
- Horticultural 51 HPS 600W bulbs with DC

Bouvardia grower Vreeken

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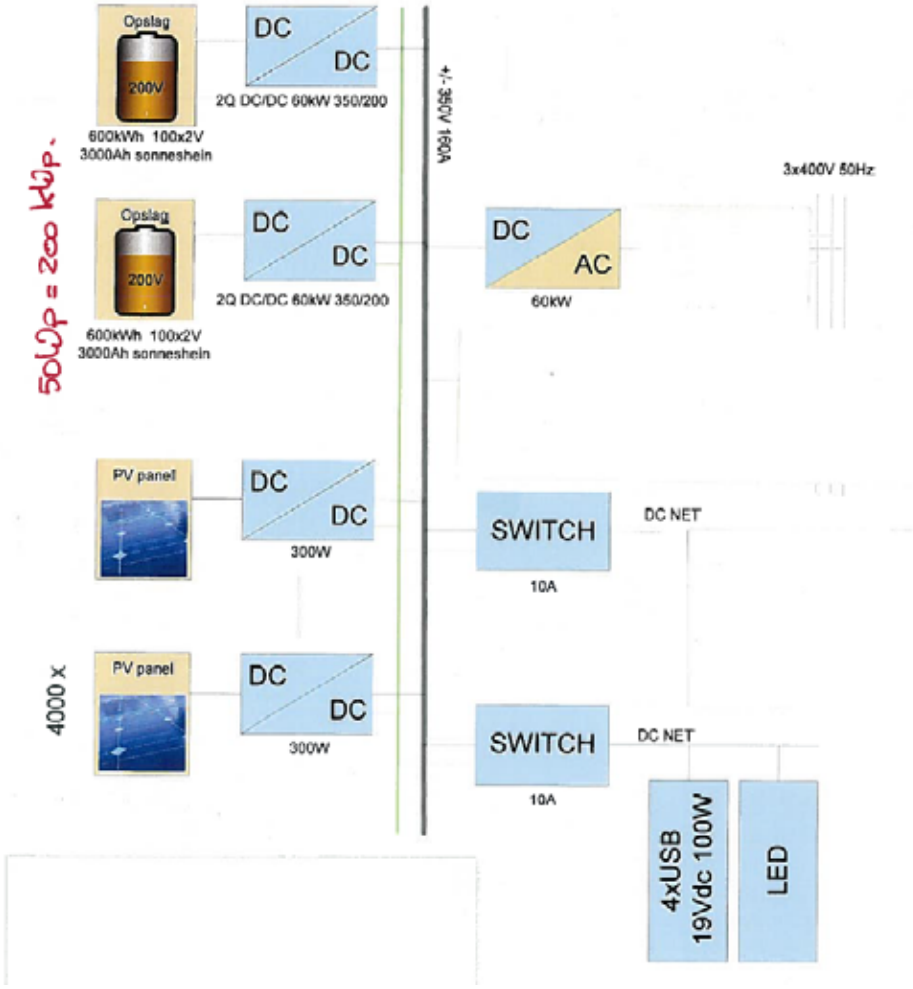
Application areas

- Residential homes
- Public lighting
- Horticultural
- Office environments



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Smart DC-grids may be linked to demand response and increase the embedding percentage of renewables

- (Pro-)Active distribution grids (nano-grids)
- Support of congested electricity infrastructure; microgrids
- Heat/cold storage (cheap buffering of energy)

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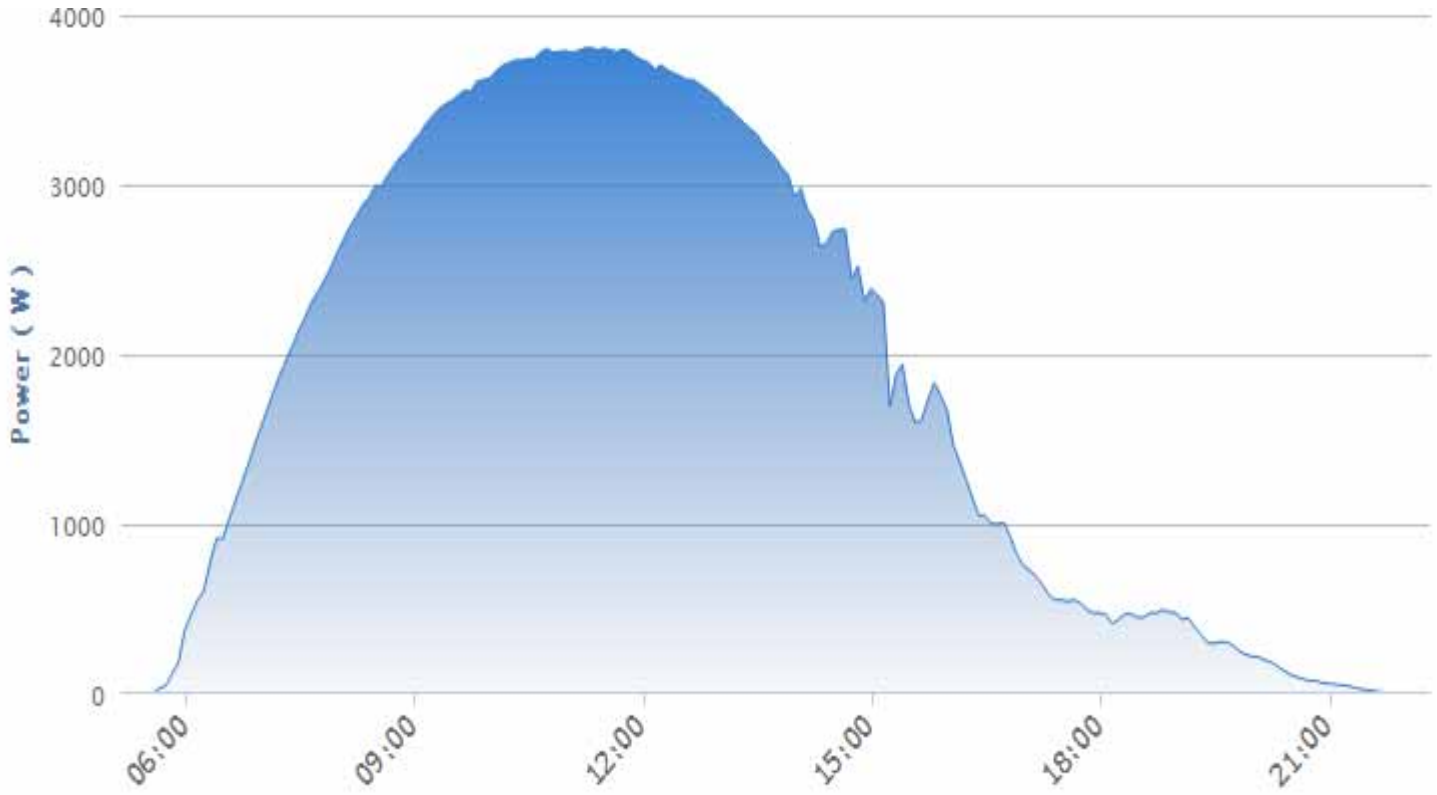
DG-RES Impact on electricity grids (PV Solar)



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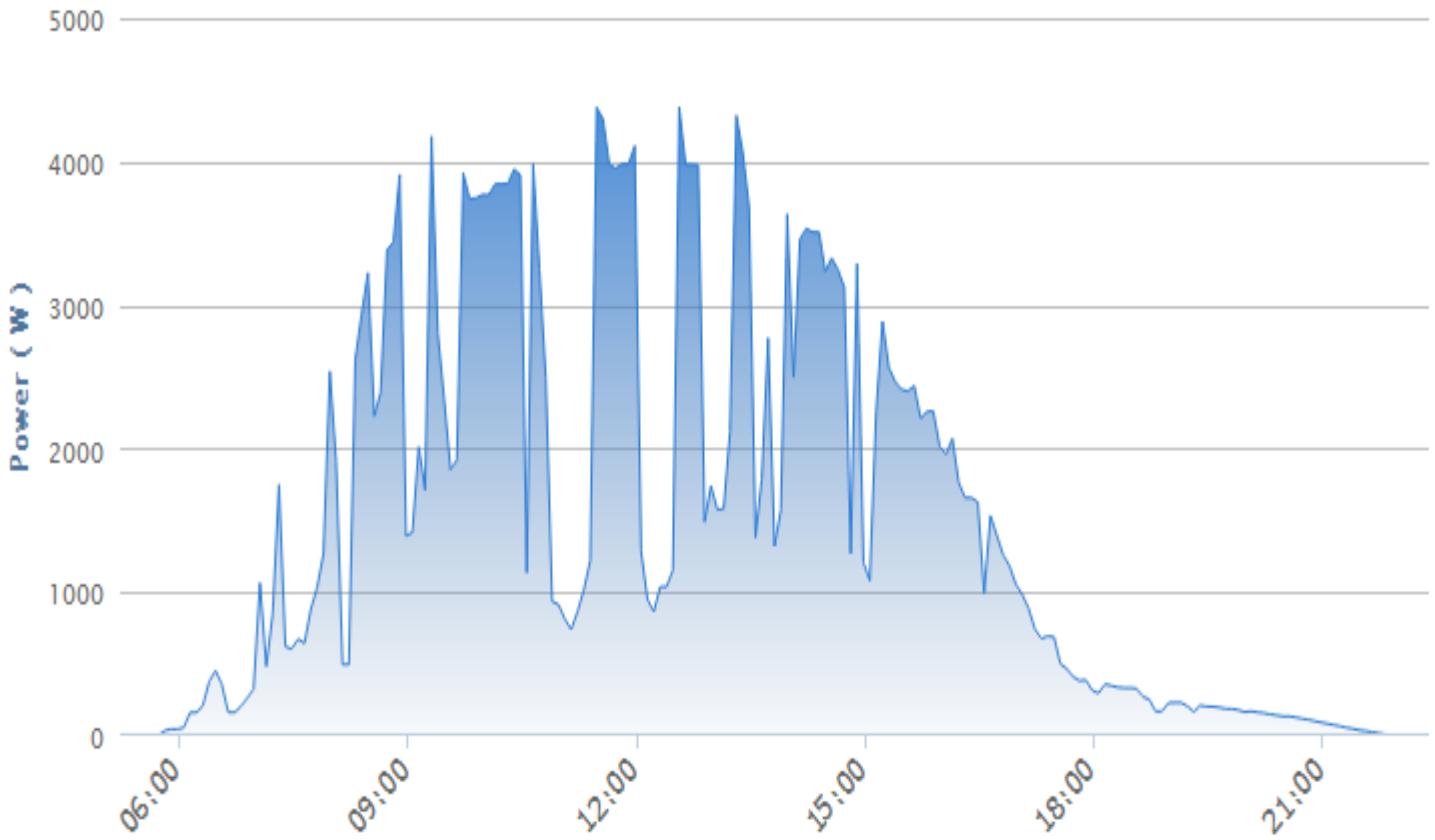
DG-RES impact on grid (PV solar; cloudy)



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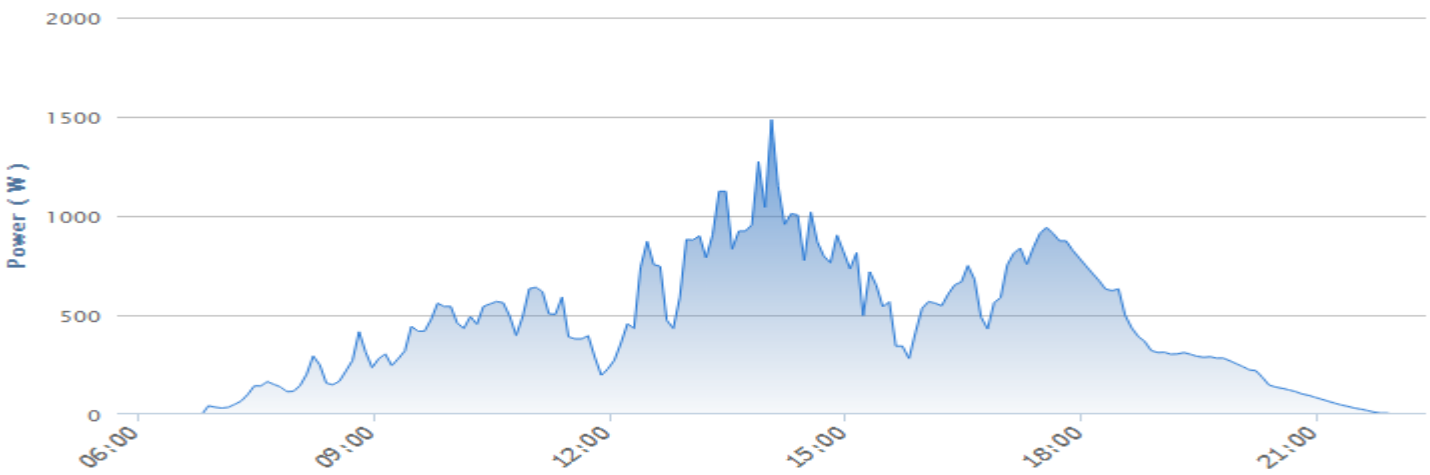
DG-RES penetration (PV solar; diffuse)



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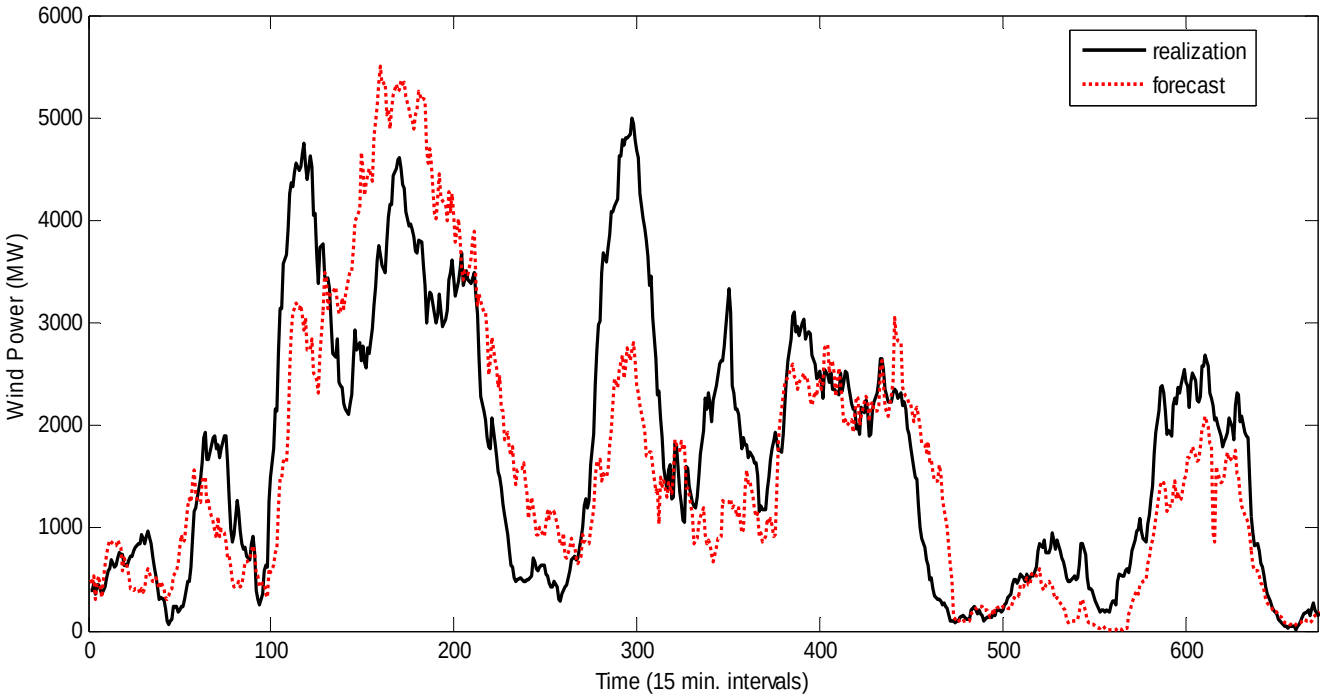
DG-RES penetration (Wind)



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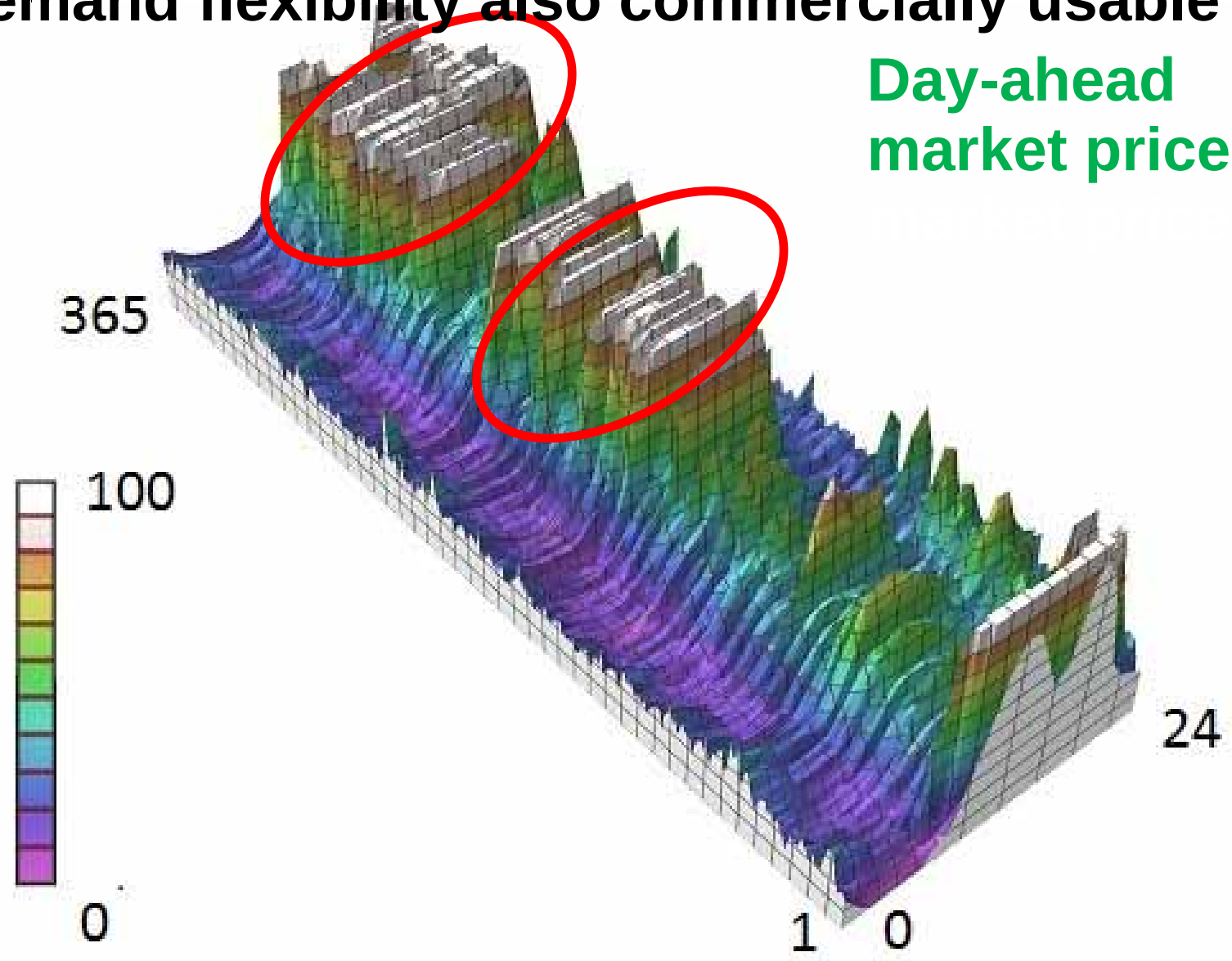
Demand flexibility also commercially usable

Day-ahead market prices



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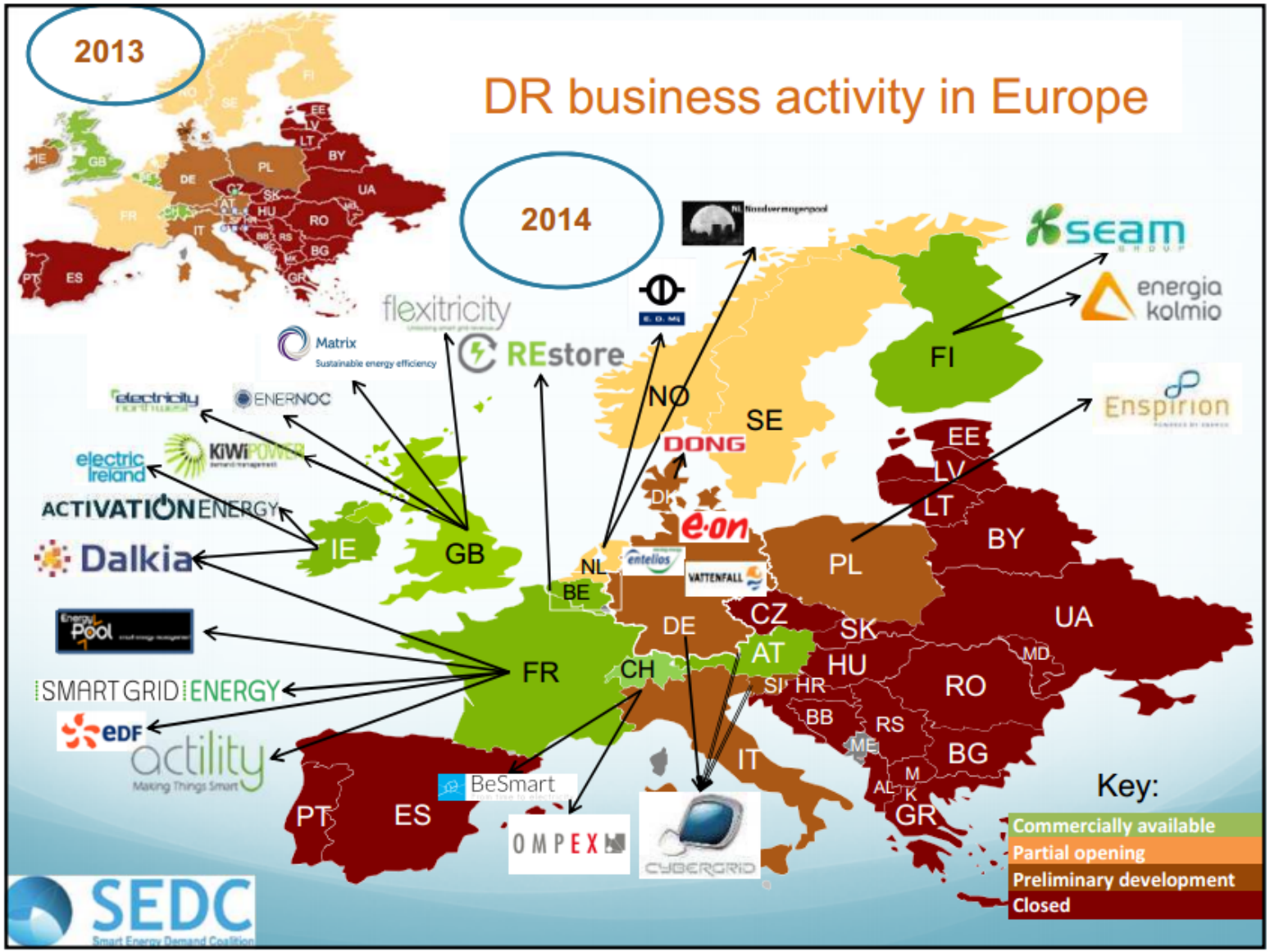
Flexibility is needed SEDC: Smart Energy Demand Coalition



SEDC Smart Energy Demand Coalition

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High DG-RES percentages require flexible demand

- New roles (1/2)
  - Aggregator
    - Provides access to the network/markets for small size resources
    - Directive EE
      - Aggregator : *"a demand service provider that combines multiple short-duration consumer loads for sale or auction in organized energy markets"*
    - Necessity to extend this definition to include small sized generation…
    - …while defining rules to avoid discrimination between generation side and demand side resources

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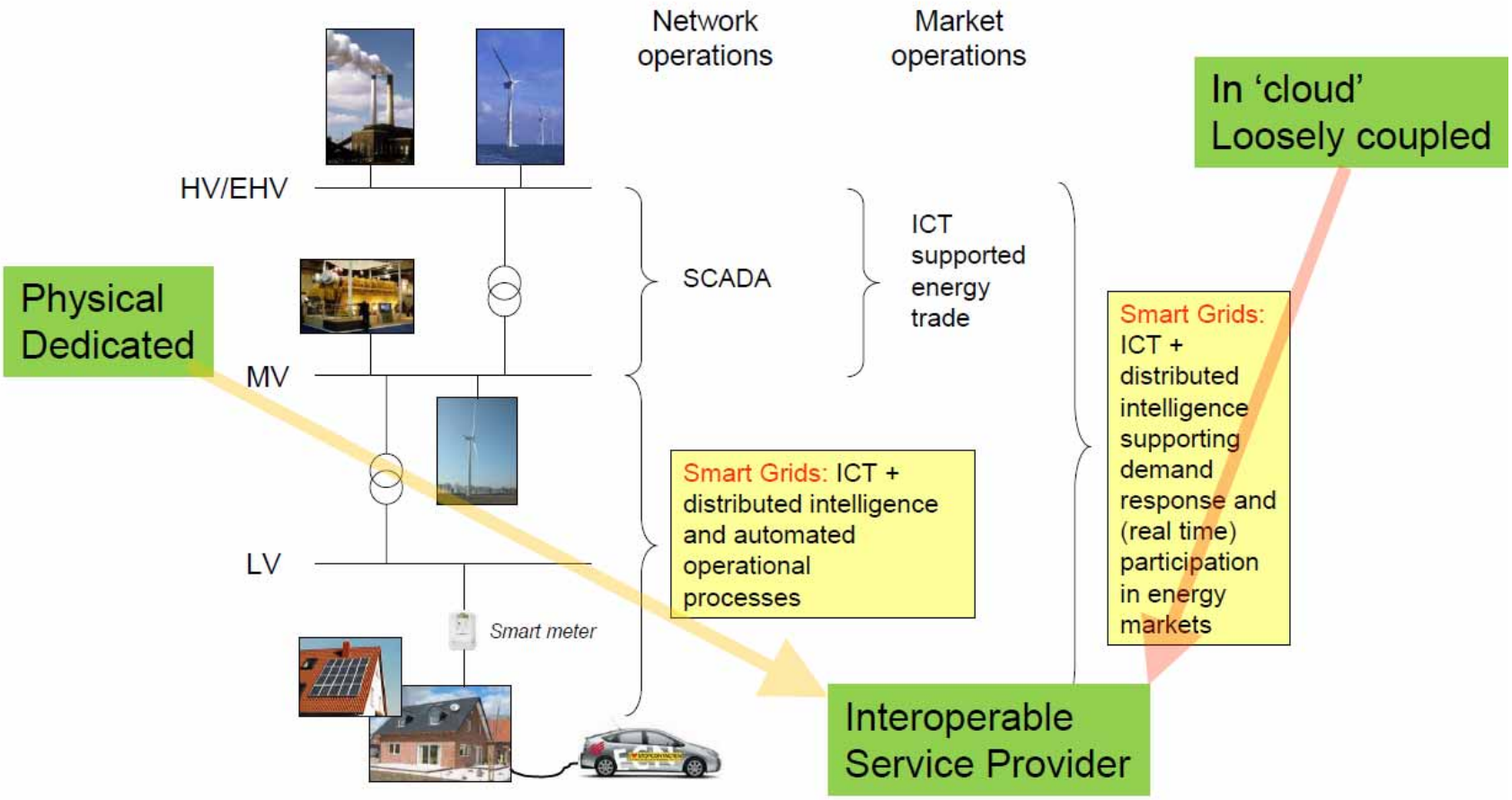
New roles need to be enabled

- New roles (2/2)
  - FSP: Flexibility Service Provider
    - Because
      - Other services than the ones directly linked to the balance of the system
      - To other market parties than the TSO
    - Firstly, need for a definition of flexibility
      - Does it include energy?
      - Does it include power able to be activated?
    - Definition should include all resources
      - Regardless the connection grid (TSO / DSO)
      - Aggregated or not aggregated

Tools for flexibility providers via ICT layers in smarter grids

ICT Functions for market and network operations



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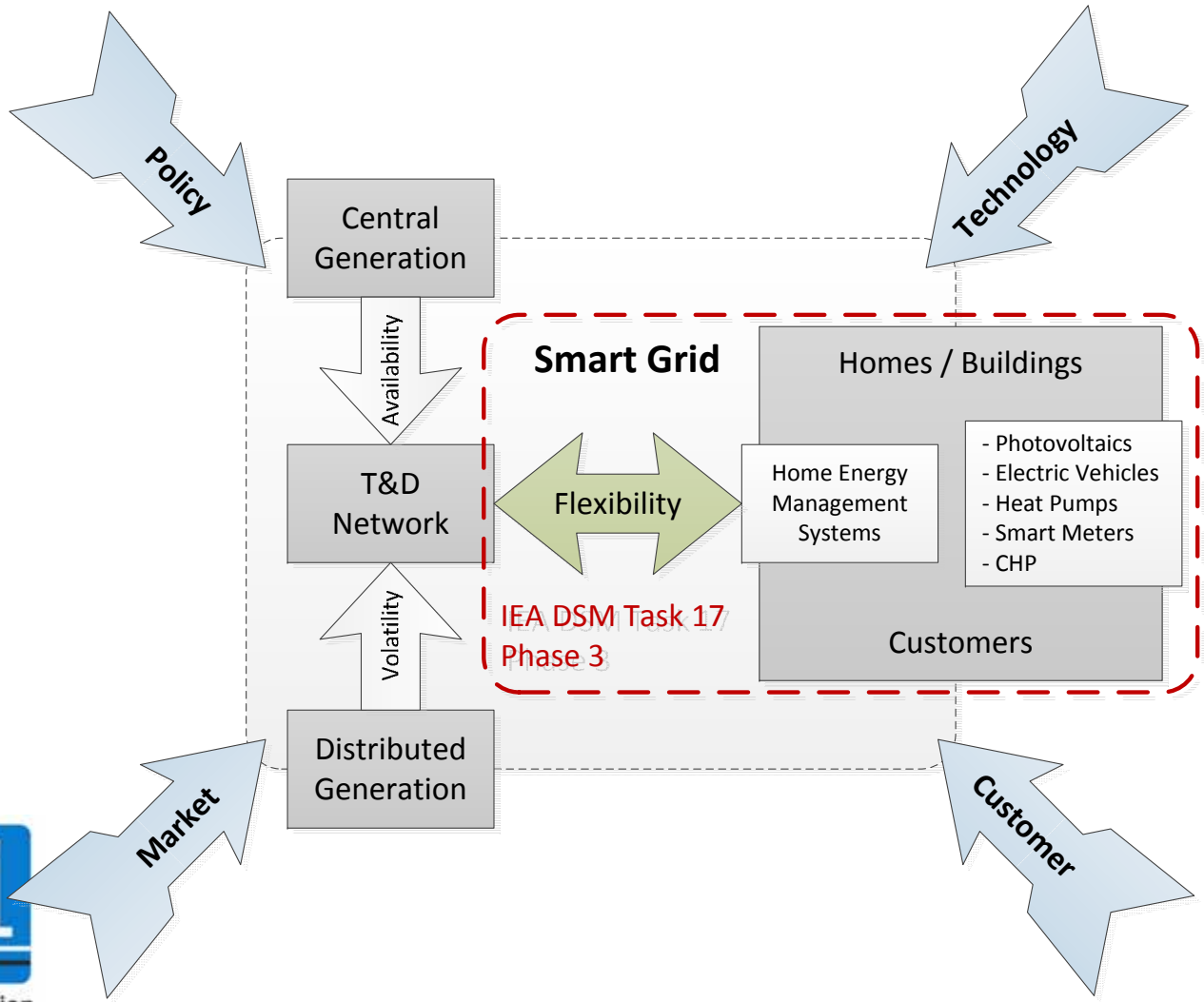
Subtask of Phase 3 - Philosophy

Systems view on enabling flexibility in the smart grid



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Phase 3: Look and analyze this theme from system view

Task-17
Phase 3
(2014+)

10: Role and potentials of flexible households and buildings
11: Changes and impact on the grid and market operation
12: Sharing experiences and finding best practices
13: Conclusions and recommendations

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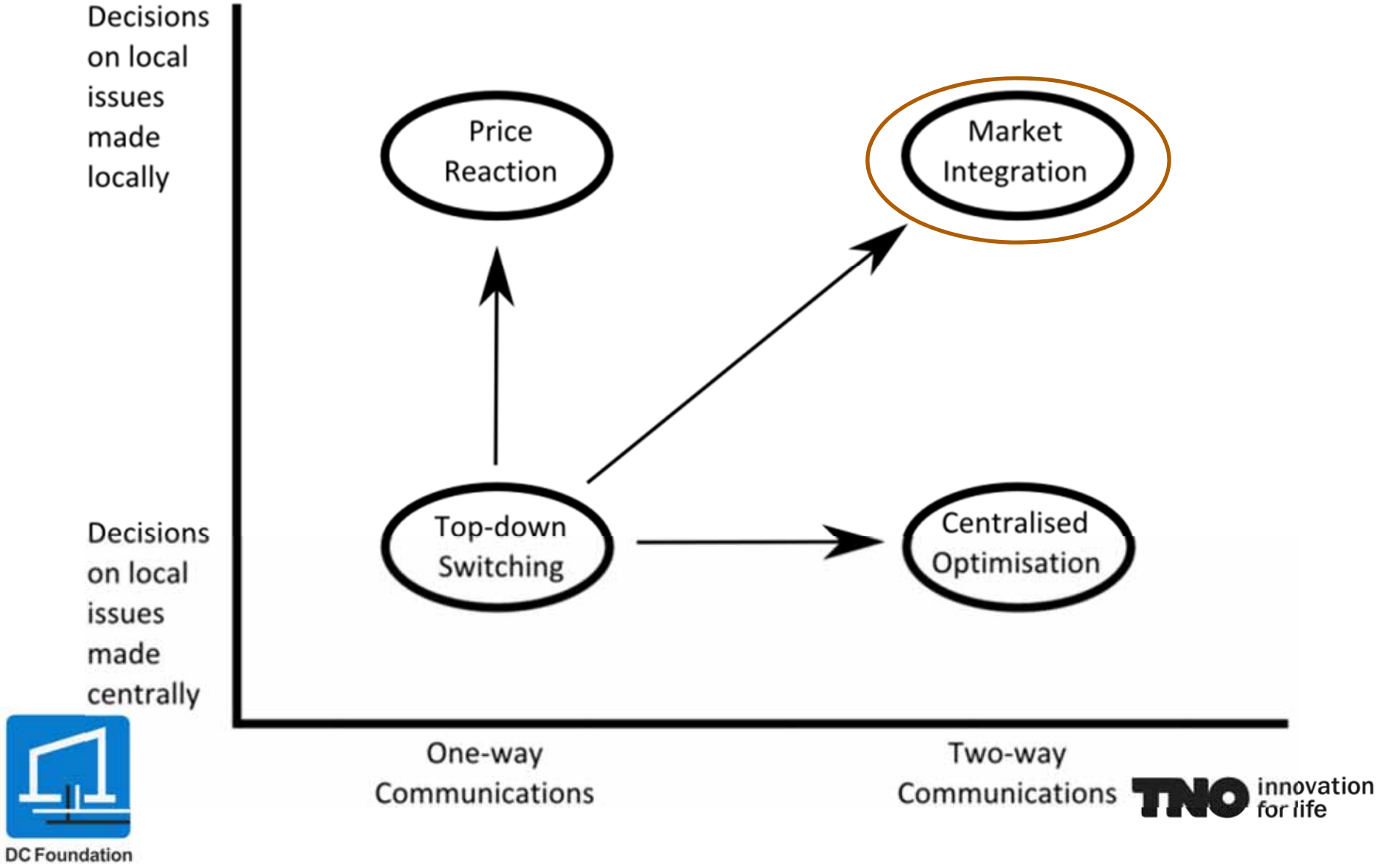
ICT and coordination; example project



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Building VPPs with PowerMatcher AGENTS







Agent

Capacity Management

Generic Protocol

Generic Protocol

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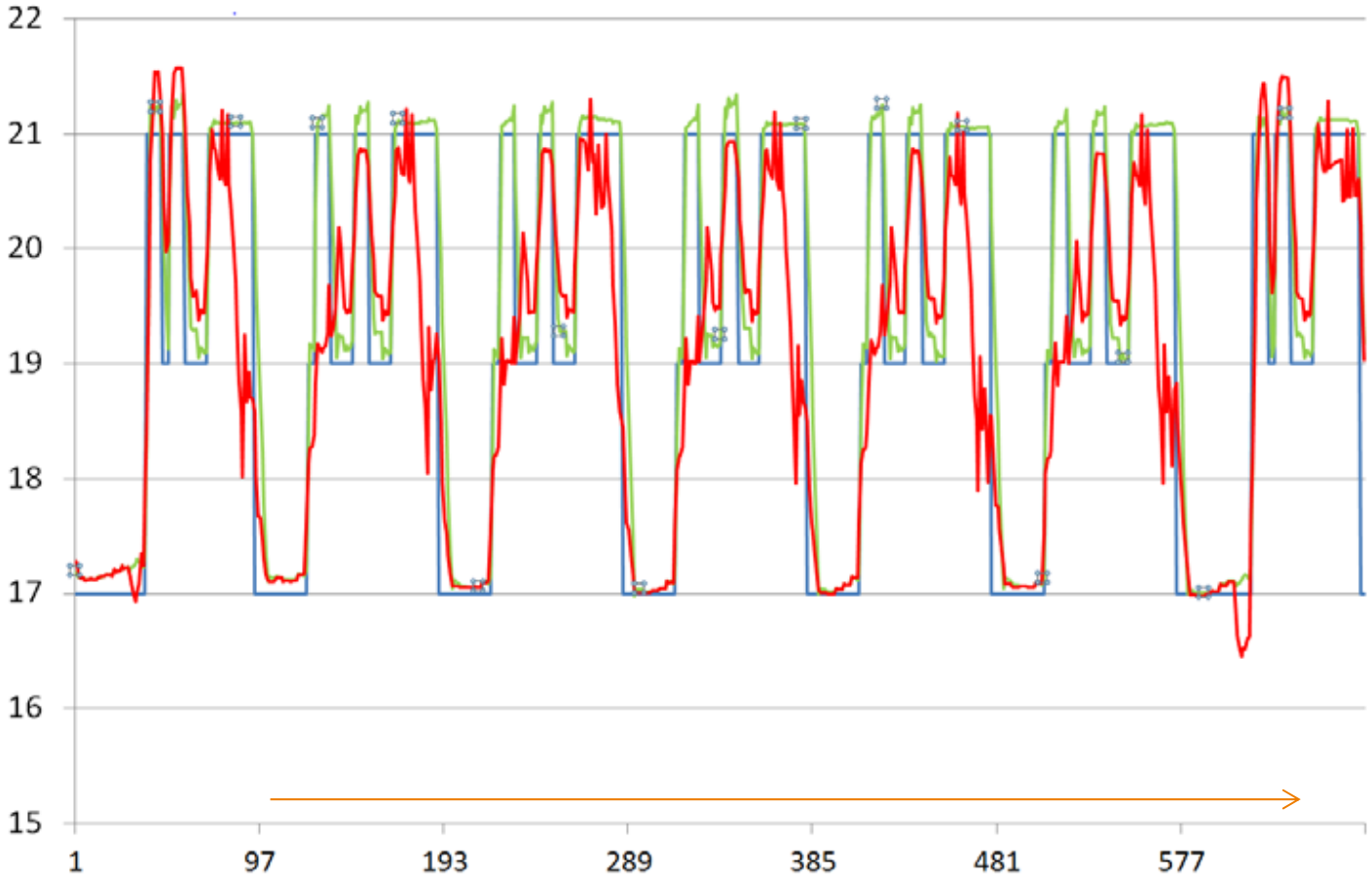
Congestion management with heat pumps (7 days)

Realisations (normal: green/congested: red)



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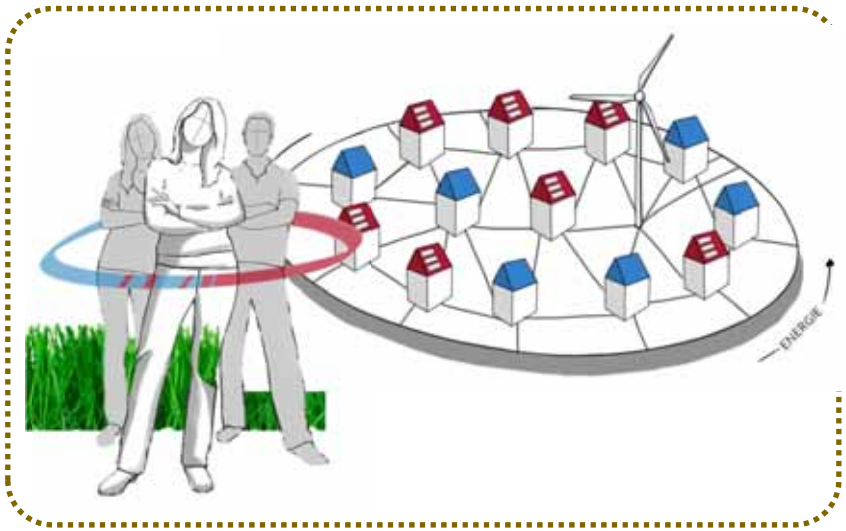
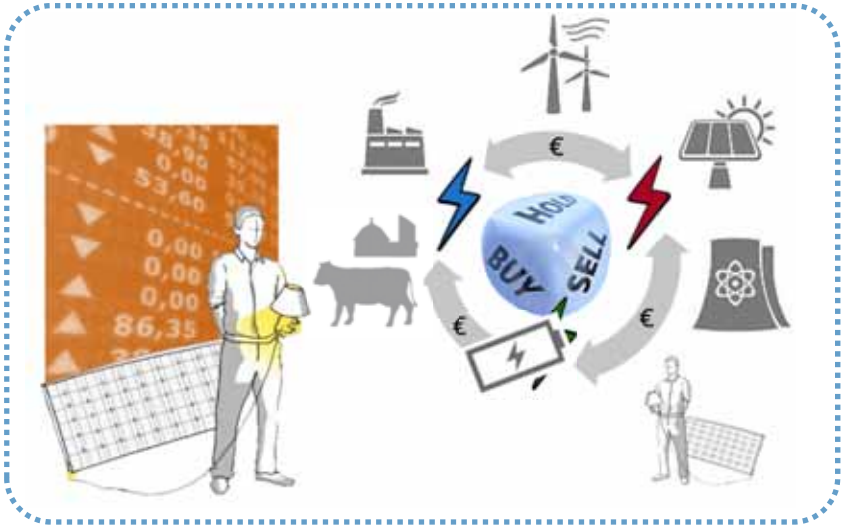
Hoogkerk fieldtest: 45 household living lab

Propositions have to be based on driving forces of customers

Renewable



Smart cost saving



Scope: **PV, µ-CHP , heat pump, washing machine, dish washer**

- **Utilize renewables**
- **Independent**
- **Comfort**

- **Together Minimize cost**
- **Lowest price**
- **Retain comfort**

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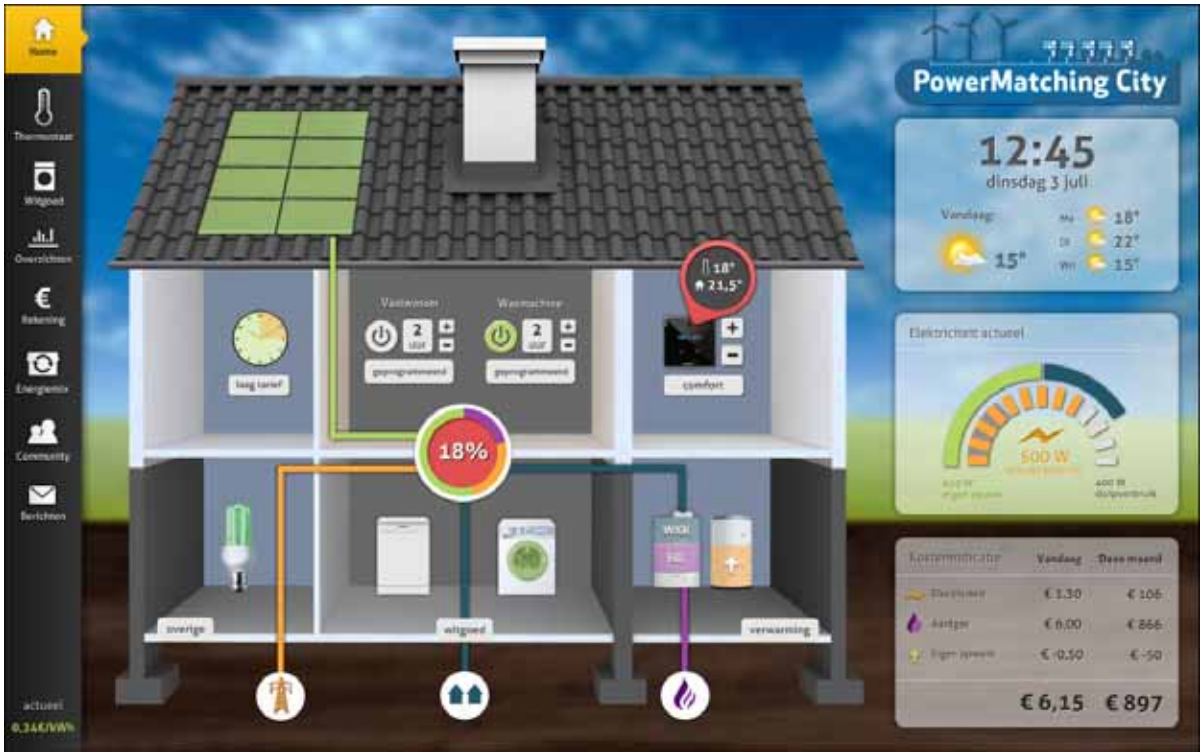
PowerMatching City



ICT-context: Energy dashboard information

- Variable price for energy (real-time, history)
- kWh vs price
- Feedback on cost-effective operation of devices
- Monthly cost-saving
- Usage at several tariff zones

- Home balance: kW, kWh (real-time , history)
- Community balance: kWh (in real-time , history)
- Monthly usage per energy carrier

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Questions ??

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