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

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Policy issues European Union

Electricity grids have to deliver the biggest proportion

Reduce greenhouse gas levels by 20%
Increase share of renewables to 20%
Reduce energy consumption by 20%

Current trend to 2020 -20% Current trend to 2020 -20% Current trend to 2020 ~16-20%
Power flows in electricity grids

- Large generation
- CHP, Wind
- HV/MV Transmission
- Industry
- LV/MV Distribution
Evolution of electricity grids

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

HV/MV Transmission

Large generators

Combined heat/power, wind

Industry

μ CCHP

Solar cells

EVs

Heatpumps, Air
Are the potentials realizable (NL study 2014)?

Realized solar power and potential for placement of PV

0.7 GW realized

16 GW without upgrading the electricity grid with equal spreading

66 GW overall Potential in the built environment

0.1 GW

Bron: DNV GL/PBL 2014

www.pbl.nl

TNO innovation for life
Before connecting the USB connector, it is standard USB Power profile 1.

- Device will be powered at 5V, maximum 2A.
- Communication will start to negotiate for wanted power profile.

**USB Power Delivery**

- **Connect**

**USB PD** will become the standard Low power device connector.

<table>
<thead>
<tr>
<th>Profile</th>
<th>Voltage</th>
<th>Current</th>
<th>Power</th>
<th>Comments</th>
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<tbody>
<tr>
<td>1</td>
<td>5V</td>
<td>2A</td>
<td>10W</td>
<td>Startup profile</td>
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<tr>
<td>2</td>
<td>12V</td>
<td>1.5A</td>
<td>18W</td>
<td>Netbooks</td>
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<td>12V</td>
<td>3A</td>
<td>36W</td>
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<tr>
<td>4</td>
<td>20V</td>
<td>3A</td>
<td>60W</td>
<td>Limit for micro A/B connector</td>
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<tr>
<td>5</td>
<td>20V</td>
<td>5A</td>
<td>100W</td>
<td>Limit for standard A/B connector</td>
</tr>
</tbody>
</table>
AC/DC losses (generation to load: 15.1 <> 4.8 %)
Hybrid road maps for AC and DC power infrastructures
Hybrid road maps: interfacing possibilities exist
**DC-grid application areas**

- Residential homes
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
Application areas

- Residential homes
- Public lighting
- Horticultural

51 HPS 600W bulbs with DC Bouvardia grower Vreeken
Application areas

- Residential homes
- Public lighting
- Horticultural
- Office environments
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)
DG-RES Impact on electricity grids (PV Solar)
DG-RES impact on grid (PV solar; cloudy)
DG-RES penetration (PV solar; diffuse)
DG-RES penetration (Wind)

![Graph showing DG-RES penetration over time with realizations and forecasts.](image-url)
Demand flexibility also commercially usable

Day-ahead market prices
Flexibility is needed SEDC: Smart Energy Demand Coalition

DR business activity in Europe
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
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

Physical Dedicated

HV/EHV

MV

LV

Network operations

Market operations

ICT supported energy trade

Smart Grids: ICT + distributed intelligence and automated operational processes

Interoperable Service Provider

In ‘cloud’ Loosely coupled

Smart Grids: ICT + distributed intelligence supporting demand response and (real time) participation in energy markets

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Subtask of Phase 3 - Philosophy
Systems view on enabling flexibility in the smart grid
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
ICT and coordination; example project
Building VPPs with PowerMatcher AGENTS
Congestion management with heat pumps (7 days)

Realisations (normal: green/congested: red)
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
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
Questions ??

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