The Customer - the forgotten one

- or the Impact of full Decarbonisation on Utilities, their Customers and the CoNDyNet Project

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More and more citizens/companies want to do something for climate protection themselves and are already doing something about it...

...and they no longer wait for political decisions!
The CoNDyNet project

Verbundprojekt CoNDyNet - Kollektive Nichtlineare Dynamik Komplexer Stromnetze

Great questions, but do they also sufficiently take into account the actual developments?

Source: http://www.condynet.de/projekt.html
part 1: the meta-level
Full decarbonisation means...

..nothing else than:

\[ \text{CO}_2 \text{ in 2050} \]

or actually a \( \text{CO}_2 \) reduction from 2040!!
The starting and finishing point:
The Paris Climate Change Conference November 2015

From the energy transition ... to the de-carbonisation of all sectors

More or less complete de-carbonisation

› Electricity
› Heating
› Transportation
› Products (internal CO₂ footprint)
› Food
› ...
Primary energy balance of Germany

The German energy balance
› Over 70 percent covered by imports
› About 98% import dependency on mineral oil
› About 93% import dependency on gas and hard coal

Is the German energy balance sustainable, resilient or CO₂-free?

Import dependence of the German energy supply in 2017
(Total 13,594 PJ* - Domestic production 4,024 PJ**)
No, the German energy balance is neither sustainable, resilient nor CO$_2$-free!
part 2: the generation side
Local RE-generation vs. energy imports

What possibilities do we have regarding our energy import dependency?

- Option 1: 100% national or European based renewable energy sources
- Option 2: Still more than 70% import dependency on (renewable) energy sources
  – in the case of Germany
- Option 3: Something in between

But do we even have the theoretical potential of a complete energy independency and how much energy do we need?
Initial Position: The final energy consumption in Germany

Final energy consumption 2017 [TWh/a]

- Households: 675 TWh
- Business, Commerce, Services: 401 TWh
- Traffic: 765 TWh
- Industry: 750 TWh

Total: 2,591 TWh

Primary energy demand 3,780 TWh/a

Electricity “just” 530 TWh/a

Has to be CO₂-free! But how?

Source: AG Energiebilanzen, own representation
Sector coupling significantly increases demand for electricity

100 %-proportion of electricity in Germany means:

› Without efficiency measures up to 3,000 TWh/a
› With efficiency measures up to 1,300 TWh/a

Source: Quaschning, Volker; Sektorkopplung durch die Energiewende; htw Hochschule für Technik und Wirtschaft Berlin, 20. Juni 2016
Disruptive efficiency gains

**Example: vehicles – increase in efficiency 70%**

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Energy Requirements [kWh/100 km]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle with internal combustion engine (10 l/100 km)</td>
<td>100</td>
</tr>
<tr>
<td>Electric vehicle (30 kWh/100 km)</td>
<td>30</td>
</tr>
<tr>
<td>Vehicle with internal combustion engine (5 l/100 km)</td>
<td>50</td>
</tr>
<tr>
<td>Electric vehicle (15 kWh/100 km)</td>
<td>15</td>
</tr>
</tbody>
</table>

**Key figures vehicles:**

- **Vehicle with internal combustion engine**
  - Large car: 10 l per 100 km → ~100 kWh
  - Small car: 5 l per 100 km → ~50 kWh
- **Electric vehicle**
  - Large car: ~30 kWh per 100 km
  - Small car: ~15 kWh per 100 km
Disruptive efficiency gains

Example: heating systems – increase in efficiency 60 – 86%

Key figures vehicles:
- Energy requirement for heating and hot water of 20,000 kWh/a
- Gas: 1 m³ corresponds to ~10 kWh
- Fuel oil: 1 l corresponds to ~10 kWh
Need for additional RE-capacity due to the sector coupling

Development of renewable electricity generation and electricity consumption to achieve climate-neutral energy supply, taking efficiency measures into account

This means:
› about 50 % of efficiency measures

This means:
› about 400 GW of PV
› about 200 GW of onshore wind
› about 75 GW of offshore wind
› (about 20 GW of biomass)
› (about 7 GW of hydro)

Source: Quaschning, Volker; Sektorkopplung durch die Energiewende; htw Hochschule für Technik und Wirtschaft Berlin, 20. Juni 2016
PV potential in Germany

Total area in Germany

Settlement areas

357,580 km²

13,669 km²

3,8%

6,061 km²

1,7%

94.5%

Other areas (mainly vegetation, transport, water)

Industrial and commercial areas

More than enough space for PV systems on built-up areas!

Area needed for

400 GW PV*    2,000 GW PV*

19,730 km²

50.68 %

2,000 km²

10.14 %

10,000 km²

Source: Statistisches Bundesamt (status 2016); own calculations

* 5 m²/kW peak
Theoretically, full energy import independence is possible, and...

...there is a substantial need for additional RE-capacity due to the sector coupling!
By the way, for utilities this means...

What a great opportunity!!
› More RE-capacity and mot backup capacity
› More operation and maintenance
› More digital processes
› ...and maybe more grids

➔ But in any case, just more work!
part 3: the customer side
But what do the customers do?

The customer side – the big unknown...

... and the forgotten one!!

Image source: http://www.marketing-blog.biz
The customer role: initial position and step one

**Initial behaviour:**
- Customer without PV-system or battery
- 100% electricity from grid
- 24/7 grid connection required

**Step one behaviour:**
- Customer with PV-system
- 100% electricity from grid
- 100% feed in due to feed in law
- Feed in tariff > tariff for electricity
- 24/7 grid connection required

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The customer role: step two and three

Adapted step two behaviour:
› Customer with PV-system and self-consumption
› 24/7 grid connection required
› 20 – 40 % self-consumption rate
› feed in tariff < tariff for electricity

Adapted step three behaviour:
› PV-system, self-consumption and battery
› ~70 % self-consumption rate
› feed in tariff < tariff for electricity
› 24/7 grid connection not necessarily required (depending on battery system)
The customer role: step four

**Adapted behaviour:**

- Customer with PV-system, self-consumption, battery, e-heating and e-mobility
- ~40 % electricity from grid
- ~60 % self-consumption
- 24/7 grid connection *not necessarily* required (depending on battery system)
Customers will be generating, store and consuming more and more energy themselves...

...and the behaviour at the grid connection point will change completely (forget the standard load profiles or any other profiles)!
part 4: the customer side, next level
And what are the customers doing locally?

The customer – the big unknown...

...and what happens at the local level (behind the meter)?
**The “new” customers – a visionary outlook (1/2)**

**Customer 1 with battery storage**
- Average energy demand of 10 kWh/a (3,650 kWh/a)
- Stand-alone battery storage with 40 kWh storage capacity and at least 20 kW power
- 10% rolling losses (365 kWh/a)
- (heating via district heating or passive energy house)

**This means**
- Customer flexibility potential of up to 72 h
- Only every 3 days a grid connection of 2 h with a power of about 20 kW necessary
- Customer requires a maximum of 245 h/a of grid connection - that corresponds to just 2.8% of the hours of a year

![Diagram of battery storage system](image-url)
The “new” customers – a visionary outlook (2/2)
– In extreme case, this means at the grid transfer point

**Customer 2 with battery storage and PV-system**

- Average energy demand of 10 kWh/a (3,650 kWh/a)
- Stand-alone battery storage with 40 kWh storage capacity and at least 20 kW power
- 10 kW_{peak} PV-system with 10,000 kWh/a generation and a maximum daily generation of 65 kWh

**This means**

- Only a maximum daily power supply of about 2.5 h with about 20 kW is necessary for power purchase and feed in
  – when generating >40 kWh/d, a (partial) grid feed-in at PV production times is necessary
- Customer requires a maximum of 500 h/a of grid connection - that corresponds to just 5.7 % of the hours of a year, assuming that there are less than 180 sunny days per year

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And then add heat pumps and electric vehicles!
The customers’ role: The local shift load potentials

Three examples of local flexibility and load management potentials:

› (Small scale) stationary battery systems
  – Assumption: 50% of the residential buildings (10 m) with battery system (aver. capacity of 10 kW)
  – **Additional capacity of 100 GW**

› (Small scale) moveable battery storage (e-mobility)
  – Assumption: 50% as e-vehicles (25 m) with aver. charge capacity of 20 kW
  – **Additional capacity of 500 GW**

› Heat storage (hybrid heating)
  – Heating rod with a backup heating system based on gas, oil, heat pumps, etc.
  – Assumption: 50% of the residential buildings (10 m) with a heating rod (average capacity of 10 kW)
  – **Additional capacity of 100 GW**
If the customer have a grid connection capacity of 35 kW, they will also use it in the future...

...and no longer the "planned" average capacity of the grid operators of about 2 kW!
But what does that mean for utilities?

**Answers from utilities**

- More customer focused solutions
- More local renewable energies and storage solutions
- More energy efficiency
- More island network capabilities
- More decentralised IT-infrastructures
- Better software and more hackers protection

But that also means that the utilities have to reinvent themselves.

**Business opportunities**

- More decentralised solutions
- Less grid dependency
- Less demand
- Less grid dependency
- More decentralised solutions
- Less attack surfaces

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Impact on the CoNDyNet2-project?

The customer – the big unknown?

Maybe, but in any case with a disruptively changed network usage behaviour – don’t forget them!

Image source: http://www.marketing-blog.biz
Customer behaviour – and not only that of household customers – will change fundamentally...

...with corresponding serious effects on grid usage behaviour!
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