Stadtwerke Wunsiedel (GOFLEX og FEVER projekterne)
Erfaringer og planer for lokal fleksibilitet i en tysk multiforsyning når nettet udfordres af sol- og vindenergi

Torben Bach Pedersen
Aalborg Universitet og FlexShape
Towards a “bottom up” energy system

- Energy is produced “bottom up”
  - Local RES
  - Micro-grids
  - Energy communities
- Should also be controlled “bottom”
Cellular energy systems

- Each cell aims to reach optimal local energy self-sufficiency (while not in islanded mode)
- Cells interact with other cells on peer level
- Higher grid levels act as “safety net” for the lower levels

Autonomous operation or controlled islanding mode
GOFLEX FlexOffer Video

- https://goflex-project.eu/video/2737_BAUM_FLAT_D2001_DE_final_01.mp4
Enabling technologies and solutions - GOFLEX Integrated solution platform (example: DSO Use case)

- Flex extraction
  - Offer to sell flexibility

- FlexOffer
  - Offer flexibility

- Aggregation/disaggregation

- Automated trading
  - Offer to buy flexibility

- FlexOffer

- Distribution Observatory Service
  - Energy transfer costs calc
  - Congestion avoidance & grid balancing

- Forecasting Platform
  - Short term forecasts of state of grid

- Scalable to all levels and all groups of players on the market

- VPS Capacity

- VPS Auction

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Capturing ALL Flexibilities with FlexOffers

- Exact location (meter, radial, transformer, …)
- Aggregatable
- Options: total energy, slice dependencies, production/mixed, grid capacity, …
- It is an OFFER from prosumer to flex purchaser
  - No force/curtailment
  - Explicit offer with commitment
  - Well-defined protocol

- No or simple flexibility patterns
- Complex flexibility patterns

**Time flexibility interval**

- Profile
- Maximum amount, \( a_{max} \)
- Possible amount instantiation
- Minimum amount, \( a_{min} \)

**Amount**

- Earliest start time \( (t_{es}) \)
- Possible start time \( (t_s) \)
- Latest start time \( (t_{ls}) \)
- Latest End time \( (t_{le}) \)

- Slice \( (s^{(1)}, s^{(2)}, s^{(3)}, s^{(4)}, s^{(5)}) \)
Using FlexOffers - In GOFLEX and beyond

- **GOFLEX:** standardized, configurable end-to-end system with standard components
- General integration of many types of loads with many markets
- Scalable (dis)aggregation
- GOFLEX FlexOffer Market matches auto-predicted DSO needs with offered flexibility (as FOs)

Developed/used/validated in:
- MIRABEL (FP7) 2010-13
- Totalflex (DK) 2012-16
- KIBERnet (SI) 2013-16
- Arrowhead (FP7) 2013-16
- DiCyPS (DK) 2015-20
- GOFLEX (H2020) 2016-20
- Flexible Energy Denmark 2019-23
- GIFT (H2020) 2019-23
- FEVER (H2020) 2020-23
- domOS (H2020) 2020-23
GOFLEX demo sites (demonstration, not sim)

Deploy flexibility to have a self-sufficient energy supply
- Meeting energy needs of residential & commercial customers with 100% renewable & regionally produced energy

Explore flexibility offered by the public sector
- Testing the microgrid case of a university as local energy community

Use flexibility to reduce the need of upgrading grid infrastructure
- Optimising the balance for the DSO to reduce corrective costs
- Using demand-side management to reduce peak loads on the distribution grid

GOFLEX Integrated platform Demo projects
- 3 locations: Germany, Cyprus, Switzerland
- Different DSO-centric Use cases: Congestion management and energy balancing in DSO grids, local energy community
- Prosumers: appr. 500 prosumers of all types: environmental, industrial, residential, EVs
PROFILE SWW

- **Multiutility**: DSO, supplier of energy *(Regional Ökostrom)*, heat, water and gas
- **Vision**: local, green energy community: focusing on the consistent production, use and expansion of renewable energy and sustainable technologies (e.g. solar/wind energy, cogeneration, wood as raw material)
- **high RES penetration**, which consists of approximately 1,000 PV sites of all sizes, several wind parks, about hundred heat pumps, battery systems, hydrogen applications (Power-to-Gas (2020); Fuel Cell (2021) and EV charging stations
- consumer/prosumer population covers all types of infrastructures, such as industries, SME, professional RES sites, farms, multifamily residences with common installations and single homes
- furthermore, SWW has taken first steps into flexibility marketing and end user integration through participation in the GOFLEX project.
- Other projects; SPARKS, cloud|E, LEITNING, EdgeFLEX
Results from SWW (by Gerhard Meindl)

- Wunsiedel site: GOFLEX platform (including DOMS) with access to
  - 21 FEMS, 22 HEMS, 154 home appliances not connected to EMS
  - 5 public electric vehicle charging stations
  - 1 private electric vehicle charging station
- Trial period: 01.10.2019 to 16.01.2020
- 90 MWh flexible energy traded on GOFLEX platform >>> upscaled to a year
  500 MWh worth 32.800 EUR
- Sensed requested flexibility on the market: 6,500 MWh >>> upscaled to
  33,500 MWh per year worth 2.2 mio EUR (at assumed price 0.066 €/kWh)

>>> Obviously applied pricing model didn’t allow prosumers to sell more FlexOffers

But: rough calculation came up with 5 mio EUR extra gross profit for SWW if bringing power of
their own and local prosumers’ generators to the local market
### Impact 1

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Target Value</th>
<th>Achieved Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe increase of installed capacity of renewable energy sources</td>
<td>&gt;15%</td>
<td>59,2%</td>
</tr>
<tr>
<td>Adaptability of energy load with respect to peak demand</td>
<td>&gt;15%</td>
<td>24,8%</td>
</tr>
<tr>
<td>Estimated profit(revenue?) from supplying/activating aggregating demand response</td>
<td>&gt;€35,000/MW/year + €200/MWh</td>
<td>85.297€*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.218€*</td>
</tr>
<tr>
<td>Reduction in peak demand</td>
<td>&gt;15%</td>
<td>13%</td>
</tr>
<tr>
<td>Increase in self-consumed energy</td>
<td>&gt;10%</td>
<td>10%</td>
</tr>
<tr>
<td>Coverage of grid state variables of interest with distribution observability and management system</td>
<td>&gt;80%</td>
<td>82%</td>
</tr>
<tr>
<td>Likelihood of correct prediction of congestion</td>
<td>&gt;90%</td>
<td>80,53%</td>
</tr>
<tr>
<td>Accuracy of forecasts at substation level</td>
<td>&lt;10%</td>
<td>n/a</td>
</tr>
<tr>
<td>Accuracy of forecasts at BRP level</td>
<td>&lt;5%</td>
<td>1,54%</td>
</tr>
<tr>
<td>Service platform query response time</td>
<td>&lt; 1 minute</td>
<td>1.25 seconds</td>
</tr>
<tr>
<td>Service platform availability of observations</td>
<td>&lt; 5 minutes</td>
<td>0.23 seconds</td>
</tr>
<tr>
<td>Service platform availability of next forecast update</td>
<td>&lt; 30 minutes</td>
<td>26 seconds</td>
</tr>
<tr>
<td>Variation of electric vehicle charging load at public stations</td>
<td>+10 / -30 %</td>
<td>&gt;30% for both directions</td>
</tr>
<tr>
<td>Variation of electric vehicle charging load at private station, depending on parking time</td>
<td>2 hours: +/- 10% 8 hours: +/- 25%</td>
<td>+10%  +12%</td>
</tr>
<tr>
<td>Reduction in electric vehicle charging time and peak load at private station</td>
<td>&gt;15%</td>
<td>Not needed due to strong prosumer grids</td>
</tr>
</tbody>
</table>

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## Impact 2

<table>
<thead>
<tr>
<th>Steps</th>
<th>Business KPIs</th>
<th>Target value during GOFLEX test phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1-4</td>
<td>KPI 1.1 Level of self-generation in % Target: 100%</td>
<td>75%&lt;br&gt;155%*</td>
</tr>
<tr>
<td>Step 1-4</td>
<td>KPI 1.2 Deviations from balance in the balance group in %</td>
<td>5%&lt;br&gt;0%</td>
</tr>
<tr>
<td>Step 1-4</td>
<td>KPI 1.3 Amount of flexibility achievable in kWh</td>
<td>60.558.669 kWh&lt;br&gt;79.000.000 kWh (+)*</td>
</tr>
<tr>
<td>Step 1-4</td>
<td>KPI 1.4 Amount of flexibility achieved in kWh</td>
<td>60.558.669 kWh&lt;br&gt;33.550.825 kWh*</td>
</tr>
<tr>
<td>Step 1-4</td>
<td>KPI 1.5 Amount of money achieved for flexibility in EURO</td>
<td>10.516.000 €&lt;br&gt;2.217.710 €*</td>
</tr>
<tr>
<td>Step 1-4</td>
<td>KPI 1.6 Flexibility out of storage</td>
<td>20.000.000 kWh&lt;br&gt;Not applied in project</td>
</tr>
<tr>
<td>Step 1-4</td>
<td>KPI 1.7 Earnings out of Virtual Power Plant (VPP)</td>
<td>1.000.000 €&lt;br&gt;Not applied in project</td>
</tr>
<tr>
<td>Step 1-4</td>
<td>KPI 1.8 Earnings out of aggregation of flexibility</td>
<td>1.350.000 €&lt;br&gt;2.218.304€*</td>
</tr>
<tr>
<td>Step 1-4</td>
<td>KPI 1.9 Number of new PV-installations</td>
<td>&gt;5%&lt;br&gt;35%*</td>
</tr>
<tr>
<td>Step 1-4</td>
<td>KPI 1.10 Number of new battery operators</td>
<td>10&lt;br&gt;17*</td>
</tr>
<tr>
<td>Step 1-4</td>
<td>KPI 1.11 Number of Prosumers that provide energy data</td>
<td>50&lt;br&gt;55*</td>
</tr>
</tbody>
</table>
Cost Benefit Analysis SWW

D9.2 (2017) For SWW the calculated prize for “tradable” flexibility based on business data of 2016 was calculated with 0.0267€/kWh and the calculated prize for avoided procurement was 0,0629 €/kWh.

D9.4 (2019) For 2018 the calculated prize for “tradable” flexibility in SWW based on business data of 2018 is calculated with 0,0475€/kWh and the calculated prize for avoided procurement is 0,0661 €/kWh.
Cost Benefit Analysis SWW and Prosumer

**SWW** Re-Calculating the 2018 Business case in electricity by using the assumptions shown, results in an increase of contribution margin from 2.822.000€ to 7.720.144€ when introducing flexibility trading.

**Prosumer** Under the assumption of SWW offering the prosumers to split profits for “traded” flexibility 50/50, the share is 1.108.855€ for the 210 prosumers/participants in one year.
ROIs

- **Factory Energy Management System (FEMS) group**
  - 21 FEMS achieving 9,242,761 kWh
  - 0,0331 €/kWh ea accounts to 305,935 €
  - Average FEMS operator earned 14,568 €
  - 28,000 € CAPEX and 500 € per year OPEX
  - 29,000 € for 2 years
  - **2 years of ROI**
ROIs

- **Direct control group (direct device control, smart plugs)**
  
  154 DirCon achieving 3,378,440kWh
  
  0,0331€/kWh ea accounts to 111,826€
  
  average DirCon operator earned 726€
  
  1,350€ avg CAPEX (some much smaller) and 50€ per year OPEX
  
  1,450€ for 2 years
  
  2 years of ROI
Home Energy Management Systems (HEMS)

Due to a breakdown of battery in early stage

22 HEMS achieving only 28.902 kWh
7.500€ CAPEX and 250€ per year OPEX
8.000€ for 2 years (battery not included)

To achieve a **breakeven** with the CAPEX and OPEX figures shown above we need a period of **5 years with a 10 kW battery**
ROIs

- SWW (half & half)
  
  achieving 1.110.532€ with 210 partners
  average share per partner 5.228€
  1.726T€ CAPEX and 140T€ per year OPEX
  8.888€ for 2 years
  **1,7-1,8 years of ROI**

  Rough pre-calcualtory guess for starting flexibility business as a DSO
Model for island operation in Wunsiedel

- Maximum positive / negative demand side flexibility needed:
  10 MW / -13.7 MW (65 % / 90 % of maximum demand)

- Accumulated needed demand side flexibility equivalent to a (central or distributed) energy storage with capacity of 2.0 GWh

- Ratio between the maximum accumulated flexibility and instantaneous flexibility shows: flexibility must be rather from a long-term storage like power-to-gas than a lithium-ion battery or other short-term flexibility.
Decentral vs. central flexibility provision

- cold reserve Irsching:
  - most effective gas power station
  - maximum call off: 800 MW
- Wunsiedel maximum negative demand side flexibility: -13.7 MW

>>> 60 Wunsiedels to replace 1 Irsching
SWW Extended Observability Period

- SWW is so happy with the GOFLEX system that they will **pay themselves** to continue running it
  - The *first time* this happens for a Horizon 2020 project?
  - 3 year period March 2020-February 2023
- Tech partners contracted
  - INEA (platform integrator, flexibility trading, EMSs, device integration)
  - IBM (distribution observability system)
  - FlexShape (flexibility management, aggregation, device integration)
  - ETREL (EV charging stations)
  - Robotina (Home energy management)
Marco Krassner video

- SWW CEO Marco Krassner shares his experiences with and plans for the GOFLEX system at SWW
- [https://www.youtube.com/watch?v=VbbAl8MV94s](https://www.youtube.com/watch?v=VbbAl8MV94s)
Flexible Energy Production, Demand and Storage-based Virtual Power Plants for Electricity Markets and Resilient DSO Operation (FEVER)

- **FEVER Summary**

  ✓ Topic  "LC-SC3-ES-1-2019: Flexibility & retail market options for the distribution grid"

  ✓ ~10 M€ Project duration  42M 01/02/20

  ✓ The "bottom-up" project in this H2020 call

  ✓ Sister project: "top-down" Platone

  ✓ Planned collaboration about joint standard (FlexOffers and protocols) => the de facto European standard for (local) flexibility?
**FEVER SCOPE**

Develop, implement and demonstrate almost market-ready solutions and services aiming to increase distribution grid security and resilience by leveraging energy flexibility towards supporting grid operation under normal, critical and emergency conditions.

- **Spatio-temporal extraction, aggregation & management of distributed flexibility capacities for supporting distribution grid & market operation**

- **Advanced monitoring and management tools/services implemented on the top of DSO’s legacy systems**

- **Advanced market mechanisms enabling flexibility trading at local and market level**
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FLEXIBILITY BRIDGE BETWEEN SWH AND SWW
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- Torben Bach Pedersen contact
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All information provided reflects the status of the FEVER project at the time of writing and may be subject to change. All information reflects only the author’s view and the Innovation and Networks Executive Agency (INEA) is not responsible for any use that may be made of the information contained in this publication.