# The FlexNett Project

*2015 – 2018*

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# Background

- Surge in PV investments and EVs
- Increased interest in batteries
- Smart Grid maturity
- Infrastructure upgrades or energy flexibility?

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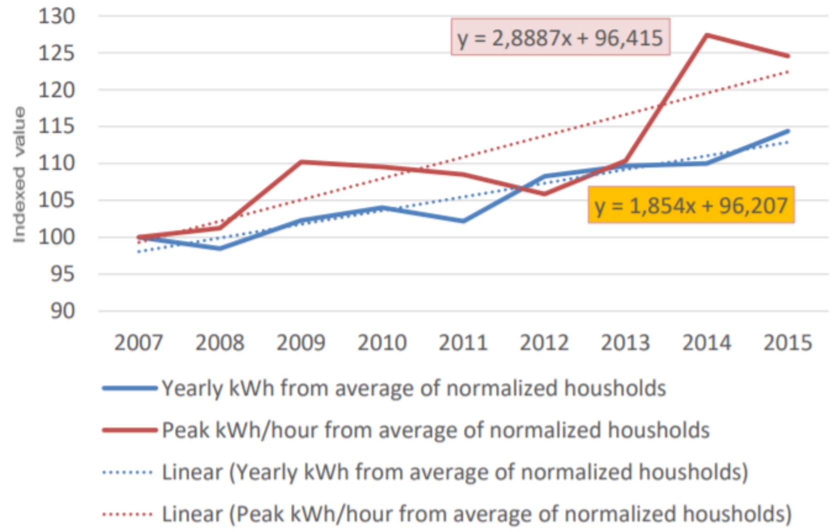
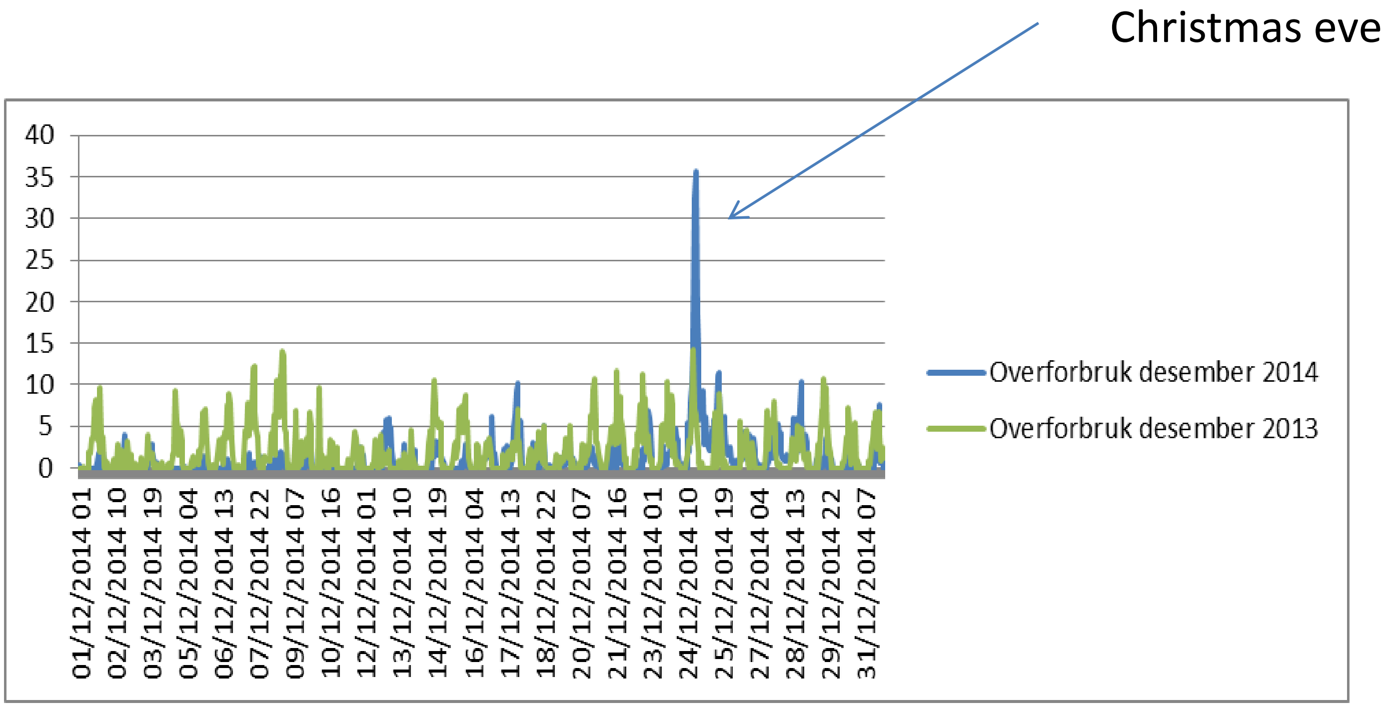
# *Trends in Peak Power and kWh Energy Growth*

- *The yearly consumption and the peak hour consumption is growing at different rate.*
- *Each year the percentage change of yearly consumption from 2007 value is increasing by **1.85%** and increasing by **2.89%** for peak-hour.*
- *In 2015 compared to 2007, the yearly consumption has increase by **14.38%** and by **24.57%** for peak hour of the year*




Source: Merkebu Zenebe Degefa

# Consumption on specific dates are inflexible

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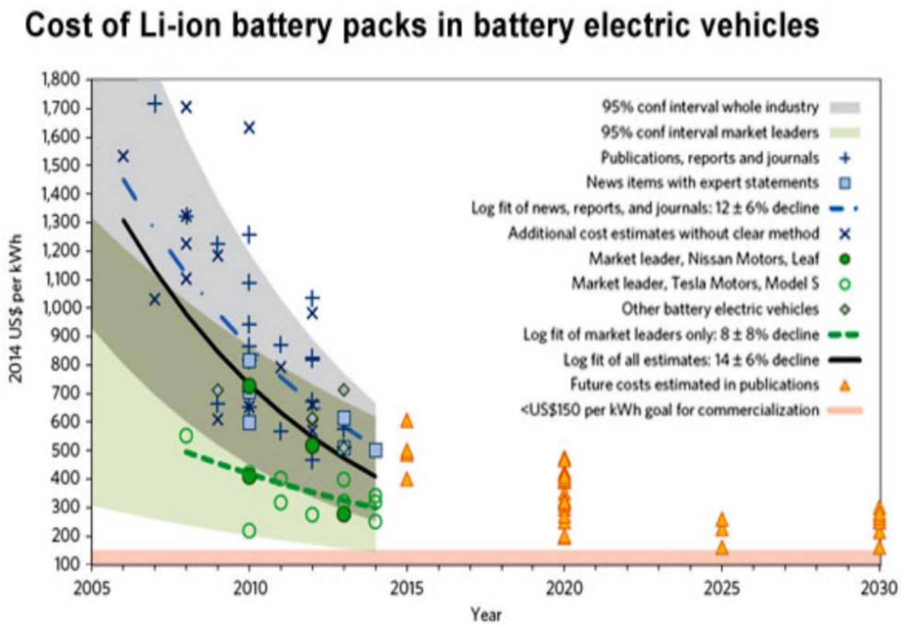
# Batteries – market perspectives




"Rapidly Falling Costs of Battery Packs for Electric Vehicles," *Nature Climate Change*, 2015

2016: €420 per kWh 2020: €170 per kWh

# Project Objectives

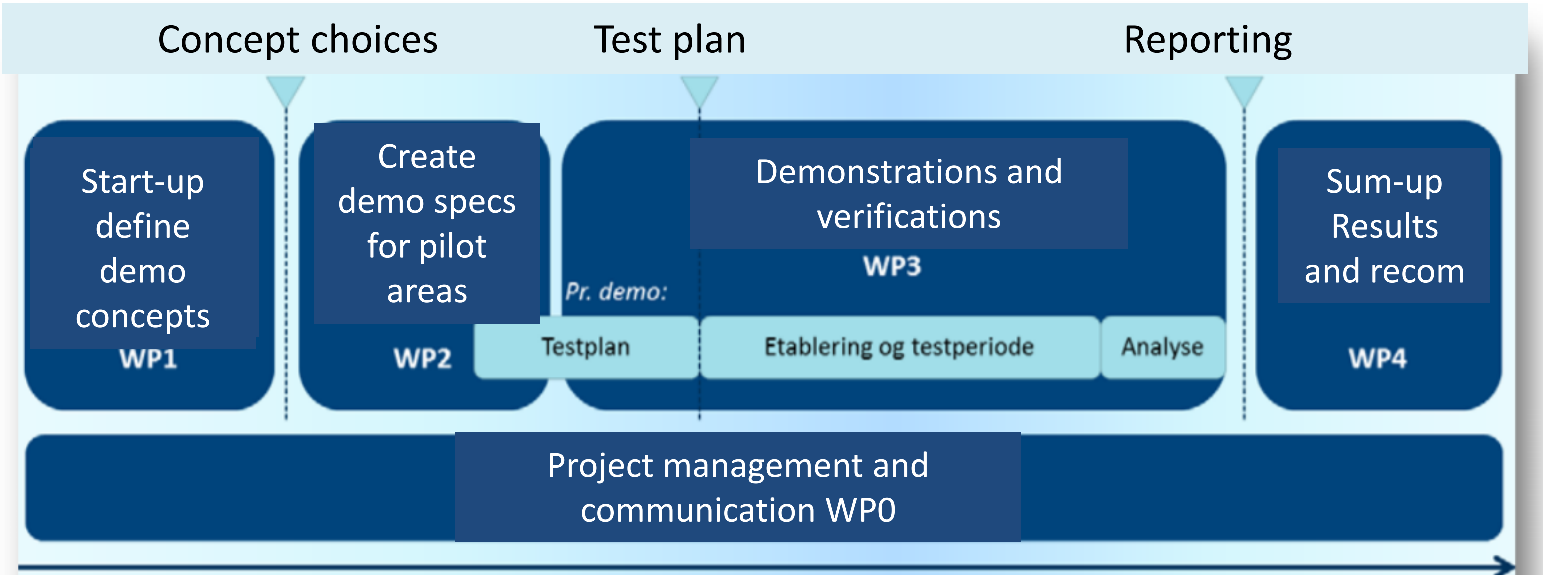
1. Cater for flexibility in the future smart grid
2. Demonstrate and verify technical and market oriented solutions for flexibility at different grid levels and for the benefit of different stakeholders
   a. Consumer flexibility
   b. Prosumer flexibility
   c. Storage
   d. Consolidated flexibility for single and collection of end-users
   e. Real-time monitoring and control through SCADA, DMS and AMS
3. Contribute to efficient handling of ICT-security
4. Honor end-user privacy

# The R&D consortium

- 6 DSOs
- 1 TSO
- 10 Suppliers
- 1 Municipality
- 1 Grid association
- 2 research companies
- 1 consultant

- Project owner: BKK, Bergen
- Project management: SINTEF Energi
- Co-funding: Norwegian Research Council
- Budget: App. €2,5 mill

# Overall project approach




Pilots in:
Bergen Area (West Coast)
Nord-Trøndelag (North)
Hvaler (South)

Workshops:
For general engagement
Focus and priorities
Knowledge sharing

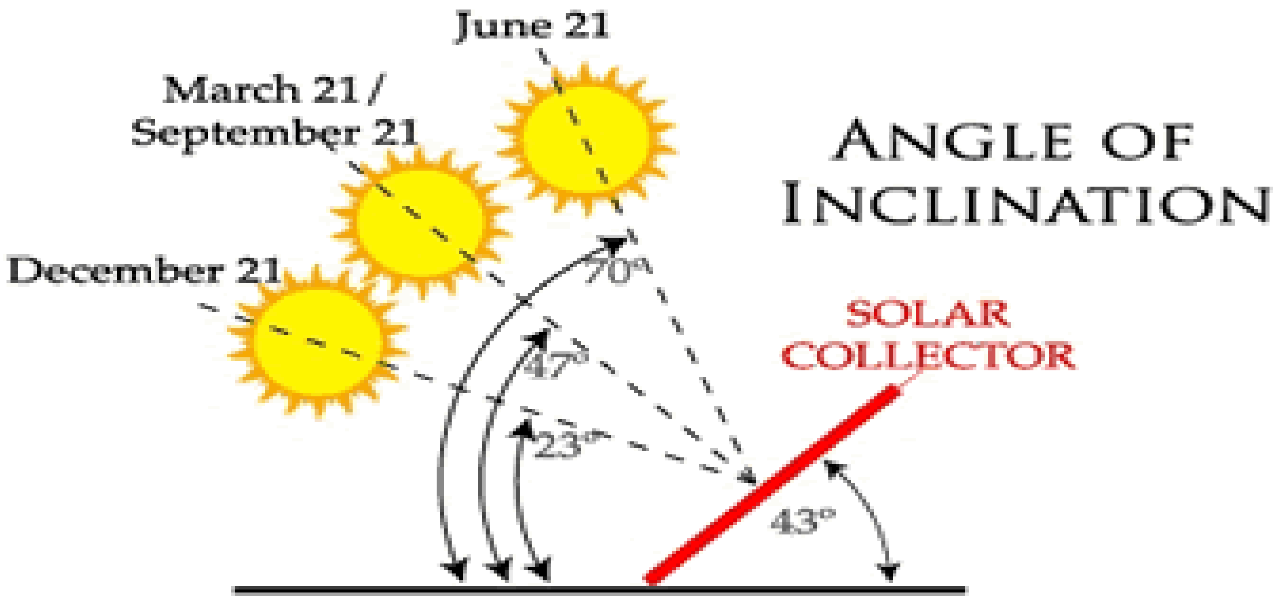
# Key questions: Focus on prosumers and storage

- How can PV-based prosumers contribute to reduced loads in the grid during peak periods?
- How can street batteries work as a local flexibility resource?
- What is the flexibility potential for a prosumer?
- What will be the consequences of a prosumer in a weak radial?
- How does energy flow during the day and year vary and how to manage big power peak changes?

# Also.....

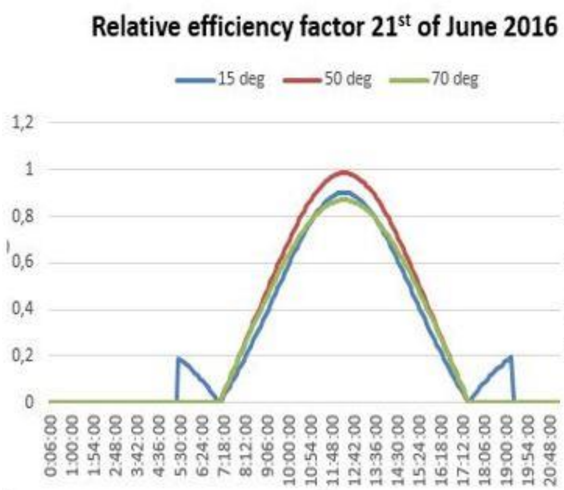
- What effect will alternative storage facilities have (placement and ownership)?
- What are the required functions for future sub-stations to support more flexible grid opertions?
- How to manage information security when different systems are connected (AMS/RTU/DMS/…)?
- How to detect and respond to security threats?

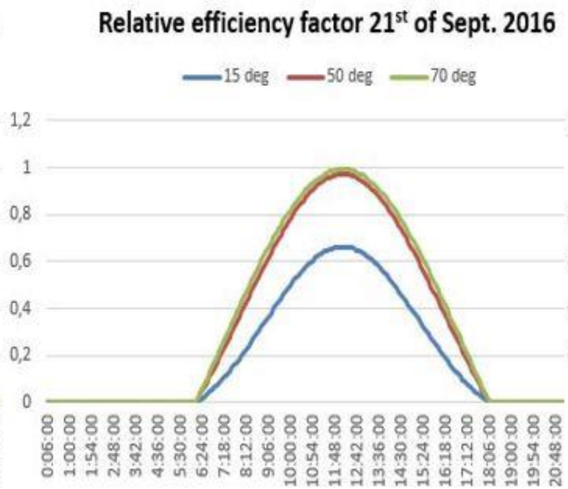
# Prosumers in the northern hemisphere

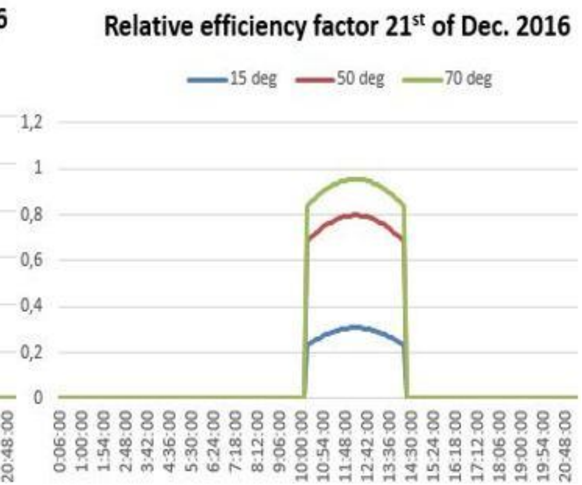



Recorded generation of electricity higher than estimates based on satellite measurements

# Angle of inclination becomes increasingly important



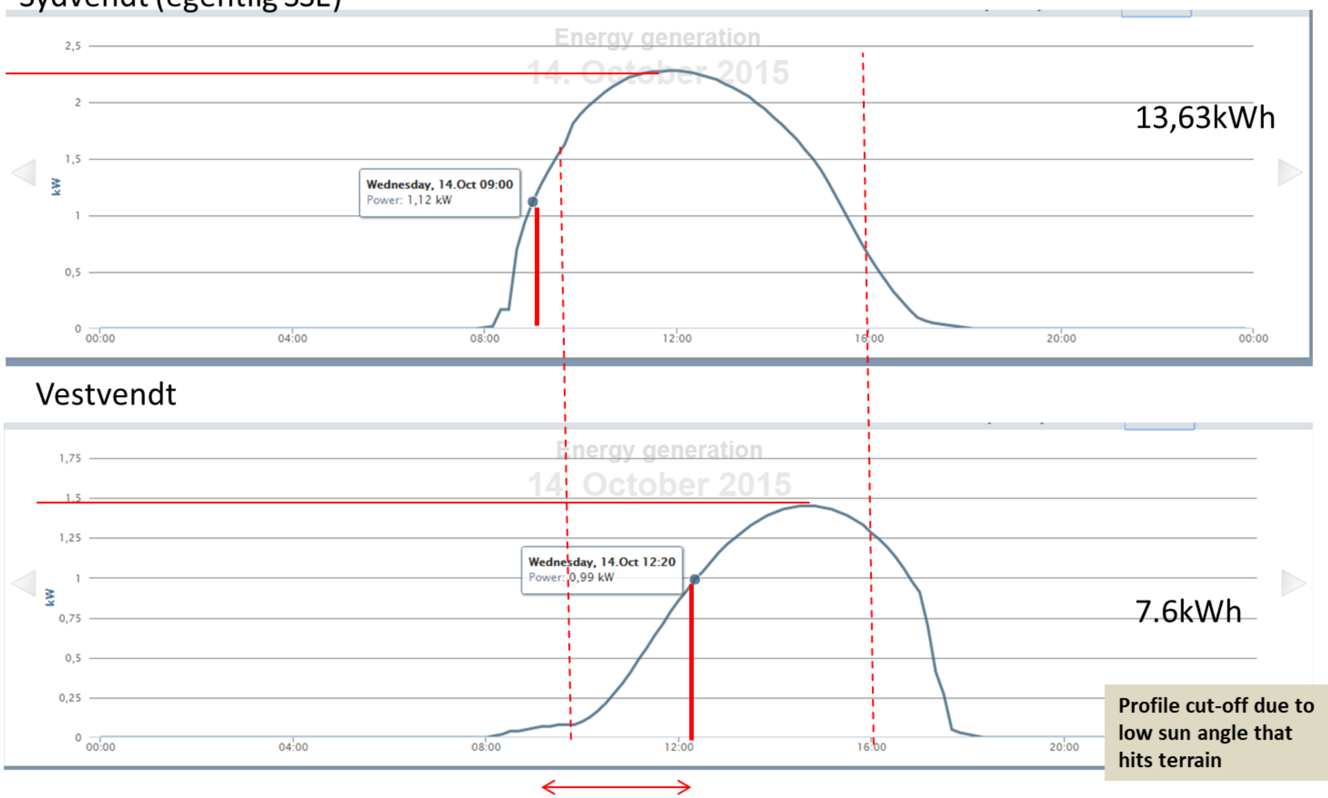



# Orientation with respect to consumption important

South East Sydvendt (egentlig SSE)

West Vestvendt




*W versus SSE orientation Oct. 14*

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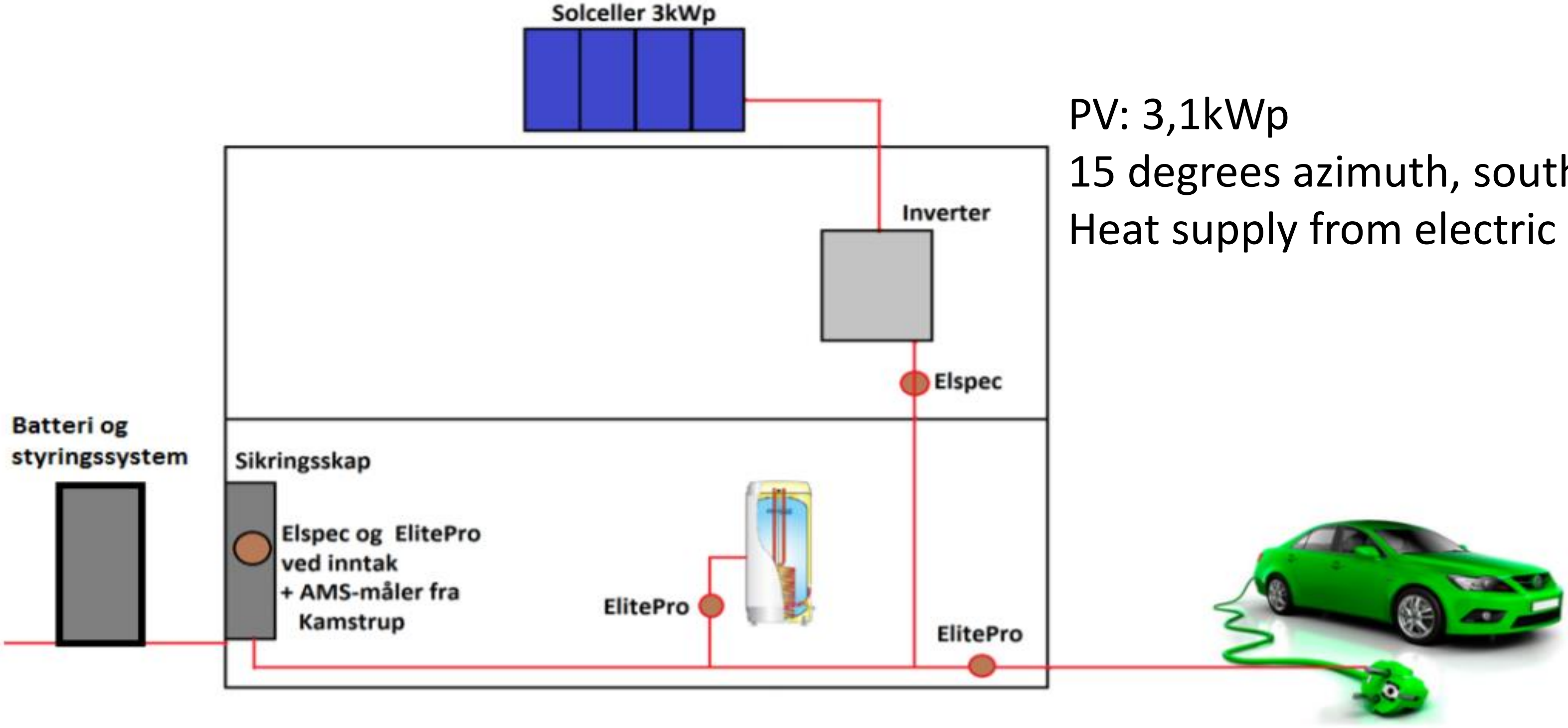
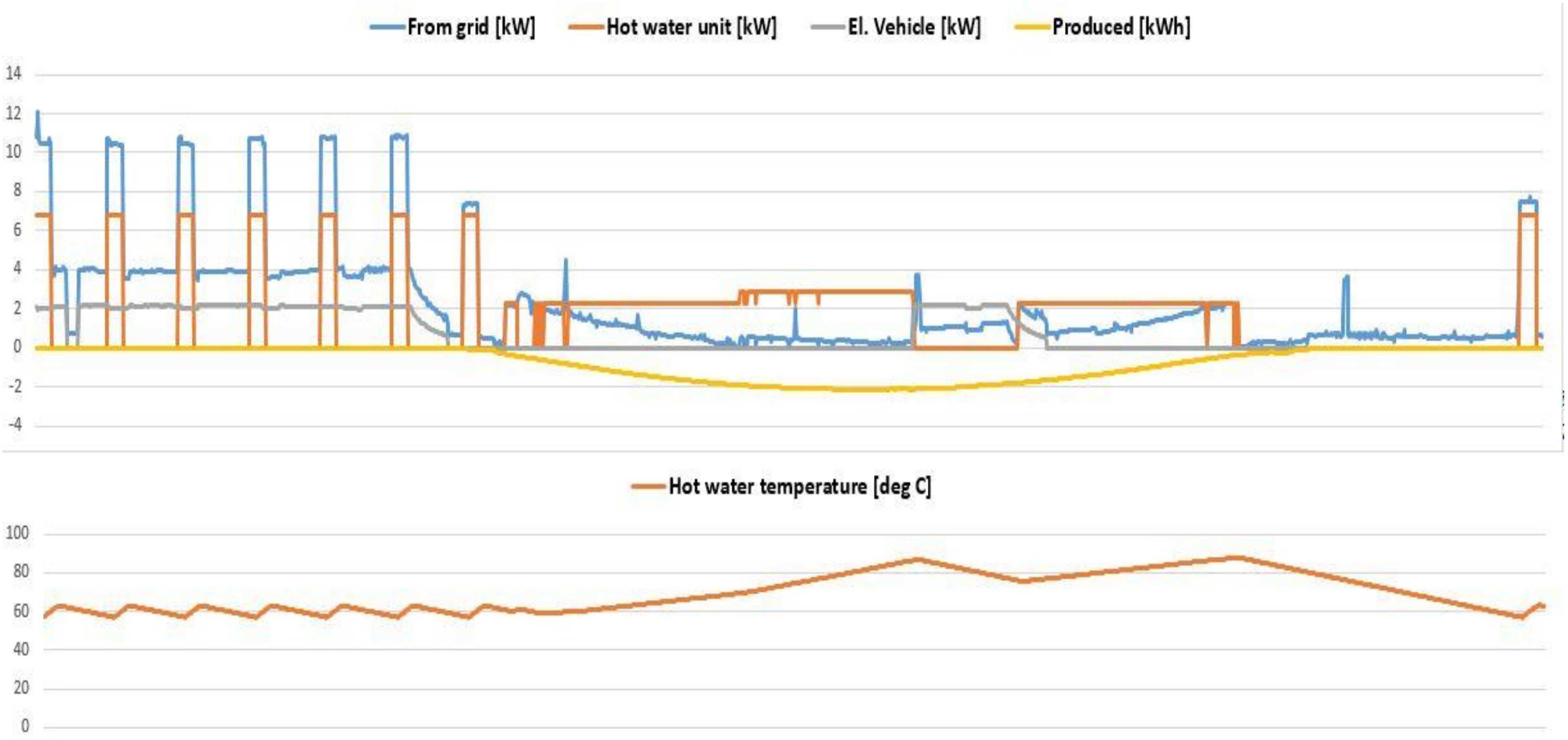
# Case 1: The flexible prosumer




PV: 3,1kWp
15 degrees azimuth, southward
Heat supply from electric boiler

| Total | | Consumed | | Generated | | Delivered to grid |
|---|---|---|---|---|---|---|
| 25215 [kWh] | = | 23695 | + | 2077 | - | 557 |

# Boiler as a buffer to increase yield

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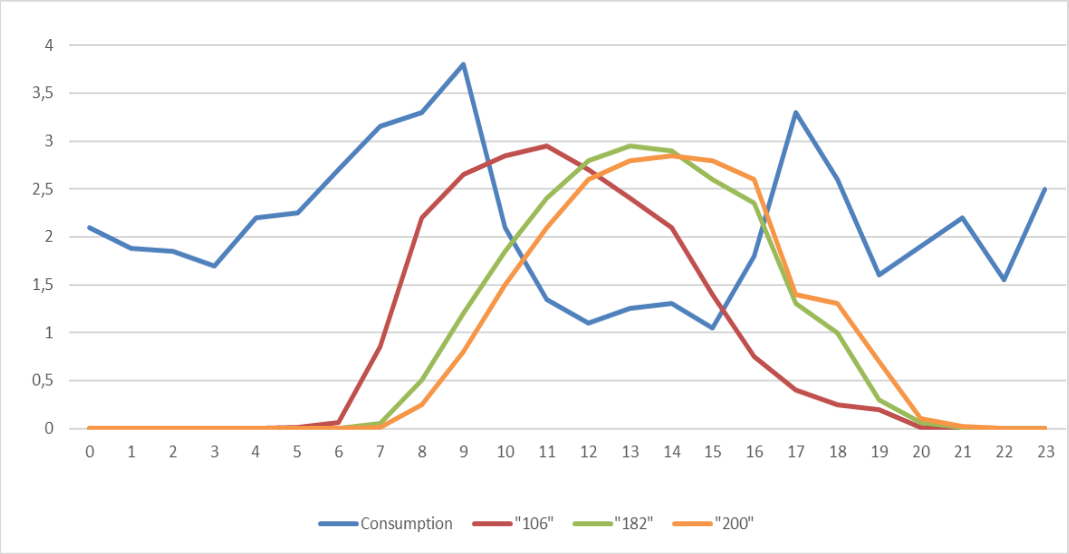
# Case 2: Prosumers exposed to power tariffs

Important with orientation that increases self-consumption




| Degrees | PV panel capacity [kWp] | Annual yield [kWh] | Energy part of tariff (€) | Power part of tariff (€) | Sum variable tariff (€) |
|---|---|---|---|---|---|
| 182 | 3,1 | 3320 | 287,1 | 355 | 622,2 |
| 106 | 3,1 | 2759 | 290,5 | 312 | 602,2 |

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# Power oriented tariff compared to energy tariff

- From the demo area – tariff with energy and fixed part only

| Type of customer | Fixed fee | per kWh (summer) | per kWh (winter) | Power cost kW/month |
|---|---|---|---|---|
| Residences | €214 | ¢3,9 | ¢4,1 | 0 |

- From the demo area – tariff that includes a power part

| Type of customer | Fixed fee | per kWh (summer) | per kWh (winter) | Power cost kW/month*) | |
|---|---|---|---|---|---|
| Residences | €62,5 | ¢2,6 | ¢2,8 | 26,03 | €6,2 |

*) The power tariff is calculated as the average kW of the three highest peaks during a month.
1kW peak average a month implies a cost of €74,4 per year

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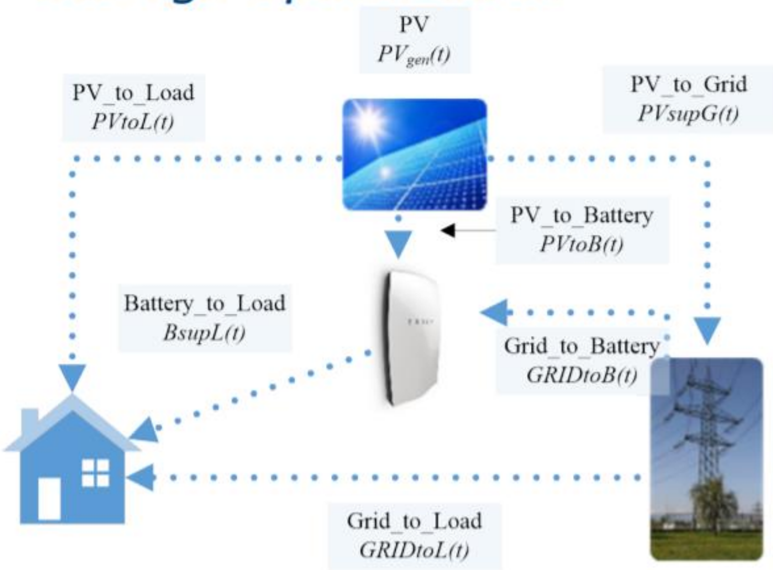
# How to control the power tariff?

- The three highest peak readings from the smart meter of a resident during a month is saved at all times
- These peaks are made transparent to the residence owner
- These records are removed each month
- Forecasts based on historic records are made continuously
- Residence owner will receive warnings (push) or choose to invoke decoupling of certain loads at a certain ceiling by a Smart Energy Service Provider (SESP)
- The ceiling will be based on historic consumption patterns (machine learning) for the household and preferences defined by the household itself.

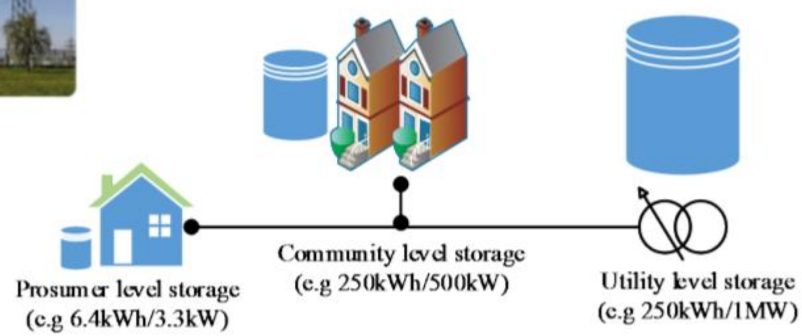
# Case 3: Benefits of batteries

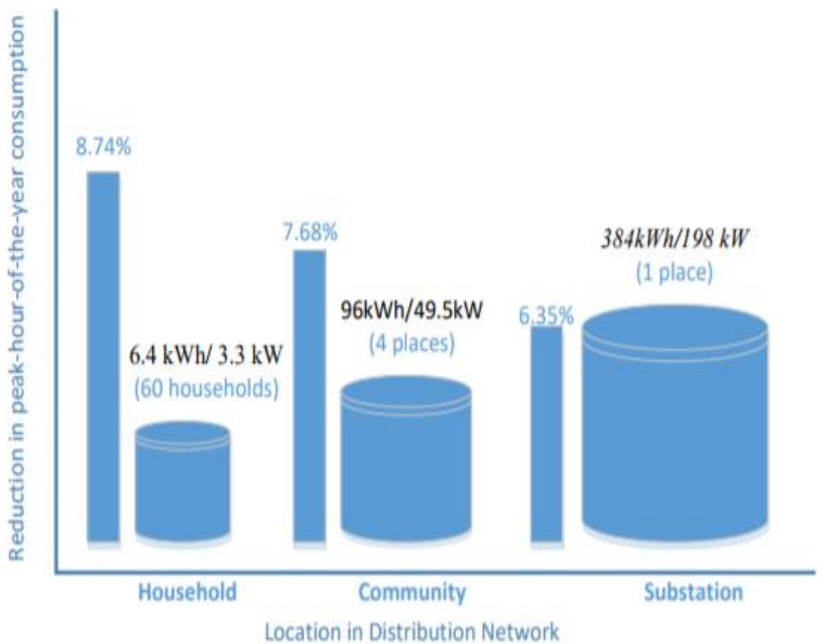
## *Storage Optimization*




The storage battery types analyzed are:

- Prosumer owned battery at household level (Size: small scale distributed)
- Community owned (Size: medium scale)
- Utility owned battery at MV/LV substation level (Size: large scale)






- Distributed household level battery storage system could defer network investment needs at MV/LV substation by 3 years compared to the year investment would have been needed if no optimal PV-battery system utilization is implemented.

# Business models & investments

- A battery could typically create a local ecosystem/local market
- We foresee a breakthrough for batteries in 2020-2021
- Investment in battery capacity to  cut 0,5 kW – 1,2 kW under current power tariff regime is already cost effective
  - Reward is amplified for apartments with district heating and “passive houses” with low electric base load for heating
- The availability of EVs opens up significant possibilities for V2G
  - Batteries with wheels
  - Issue with availability during peak hours, must be investigated

Figure 6: Storage needs along the value chain. Source: Berger, 2017

# Street batteries – attractive to end-users

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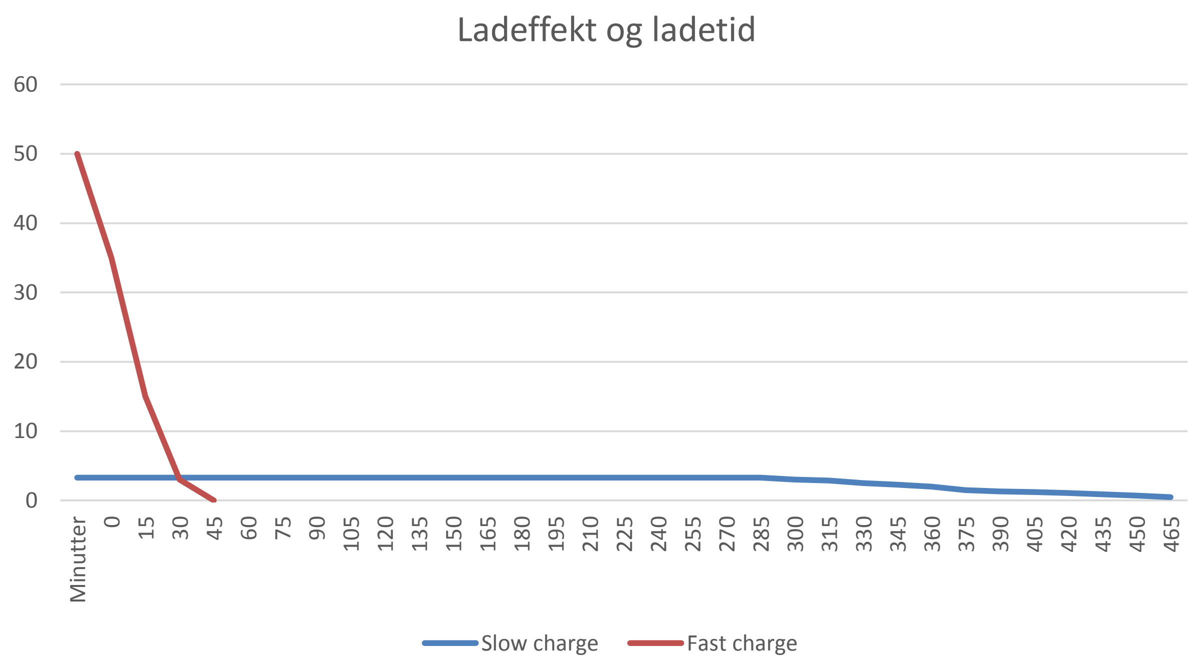
# Faster charging improves the business case for batteries




"All" of capacity applied to  cut peak

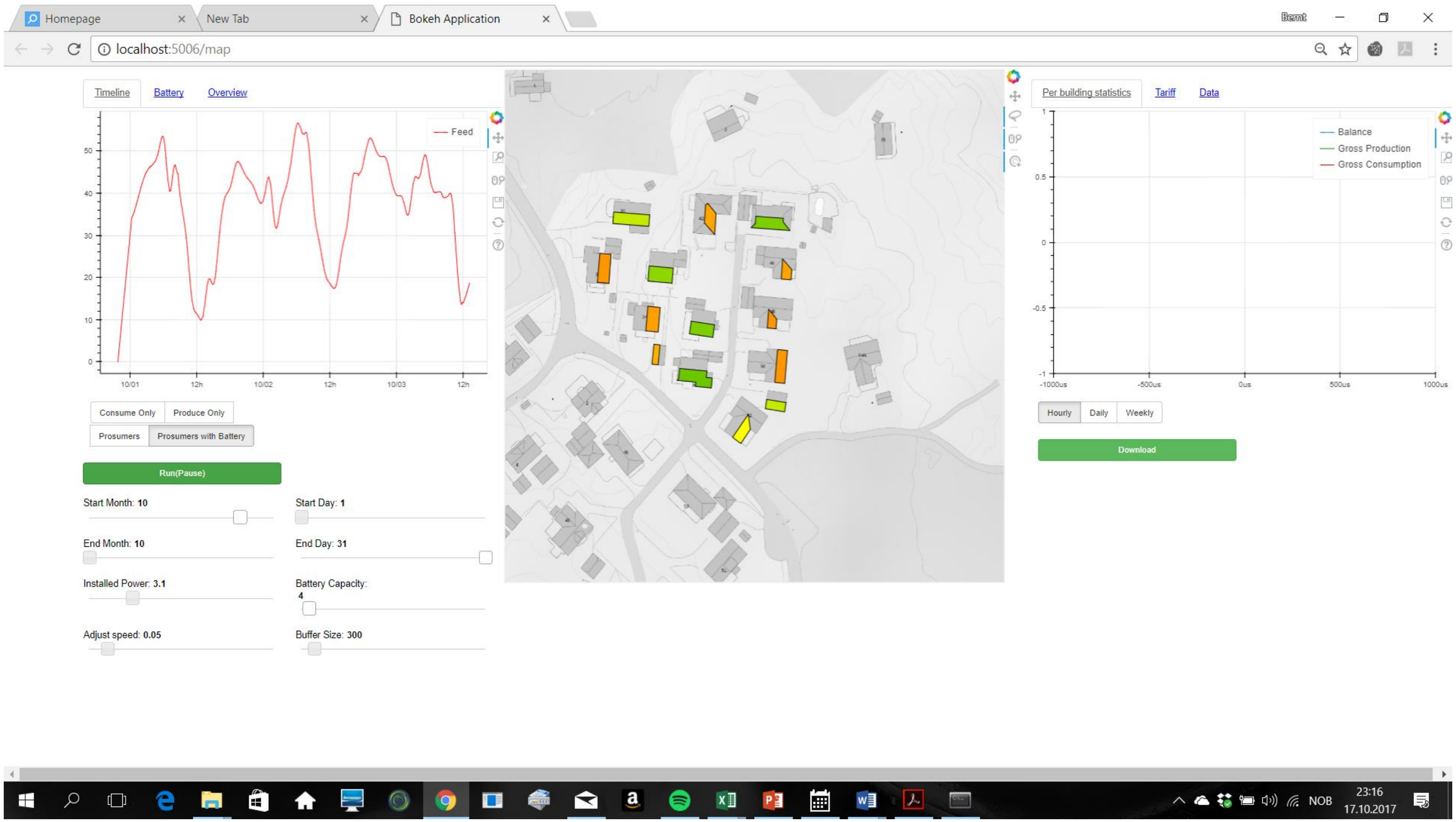
# The case for EV car pools

(Kilde: Håkon Duus, Smart Innovation Norway)

| Enhet | Kapasitet | Pris | NOK/kWH |
|---|---|---|---|
| **Tesla 75 D** | 75 kWh | 622 700 | 8 302 |
| **Tesla 100 D** | 100 kWh | 795 650 | 7 956 |
| **Tesla P100D** | 100 kWh | 1 105 150 | 11 015 |
| **Nissan Leaf** | 40 kWh | 290 850 | 7 271 |
| **VW eGolf** | 35,8kWh | 310 900 | 8 684 |
| **Tesla Power wall** | 14 kWh | 57 000 | 4 071 |
| **Opel Ampera-E** | 60 kWh | 359 900 | 5 998 |

"Battery on wheels" and V2G suggests an interesting investment alternative to stationary batteries considering the value of transportation in addition to energy storage.

# Behavior of neighborhoods with PVs

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# Summing up

- PV-orientation is important for the prosumer and the grid owner
  - Important to orient PV panels in accordance with consumption profile
  - Power tariffs amplify this need
  - Creates a win-win for prosumer and grid owner – the latter must be proactive
- Despite much higher consumption than production surplus is still fed into the grid during the day, sometimes in significant, short bursts
  - Use of local energy storage could buffer momentarily production surplus and by that prevent feeding energy into the grid
  - Batteries help to
  - Still a cost issue
  - Generally cost beneficial from 2020
  - 0,5 – 1kW power peak cuts/battery capacity today could be cost efficient today
- Because the consumption always is higher than the production on a daily basis, the storage does not need (for this purpose) to be larger than daily quantity of energy fed into the grid.
- Distributed household batteries (behind the meter) could defer investments in LV/MV grid by 3 years
  - Batteries placed closed to the end-user increases business options
  - Stacking of services on top of battery
- As the consumption is essentially for heating thermal  storage is cheap and useful
  - Currently more attractive than batteries
  - V2G is an attractive option – but not perfectly compatible with household consumption profiles