DEMAND SIDE FLEXIBILITY, LOAD TARIFFS AND GRID INVESTMENT SAVINGS

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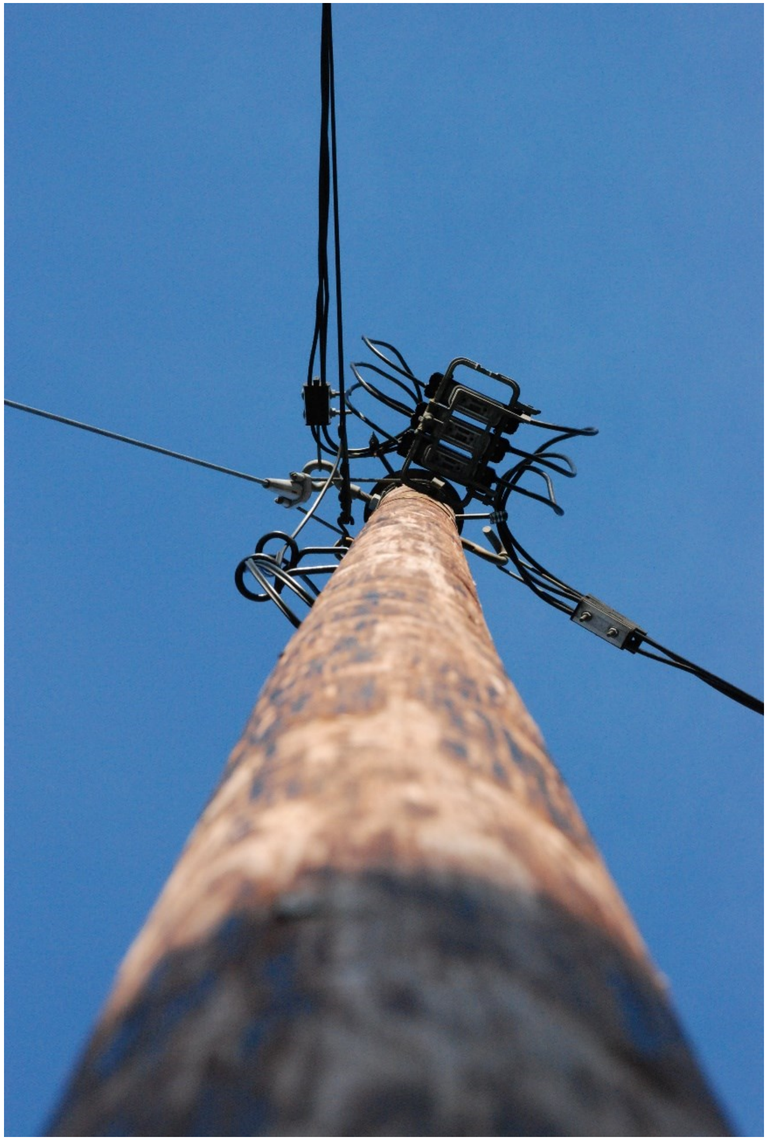
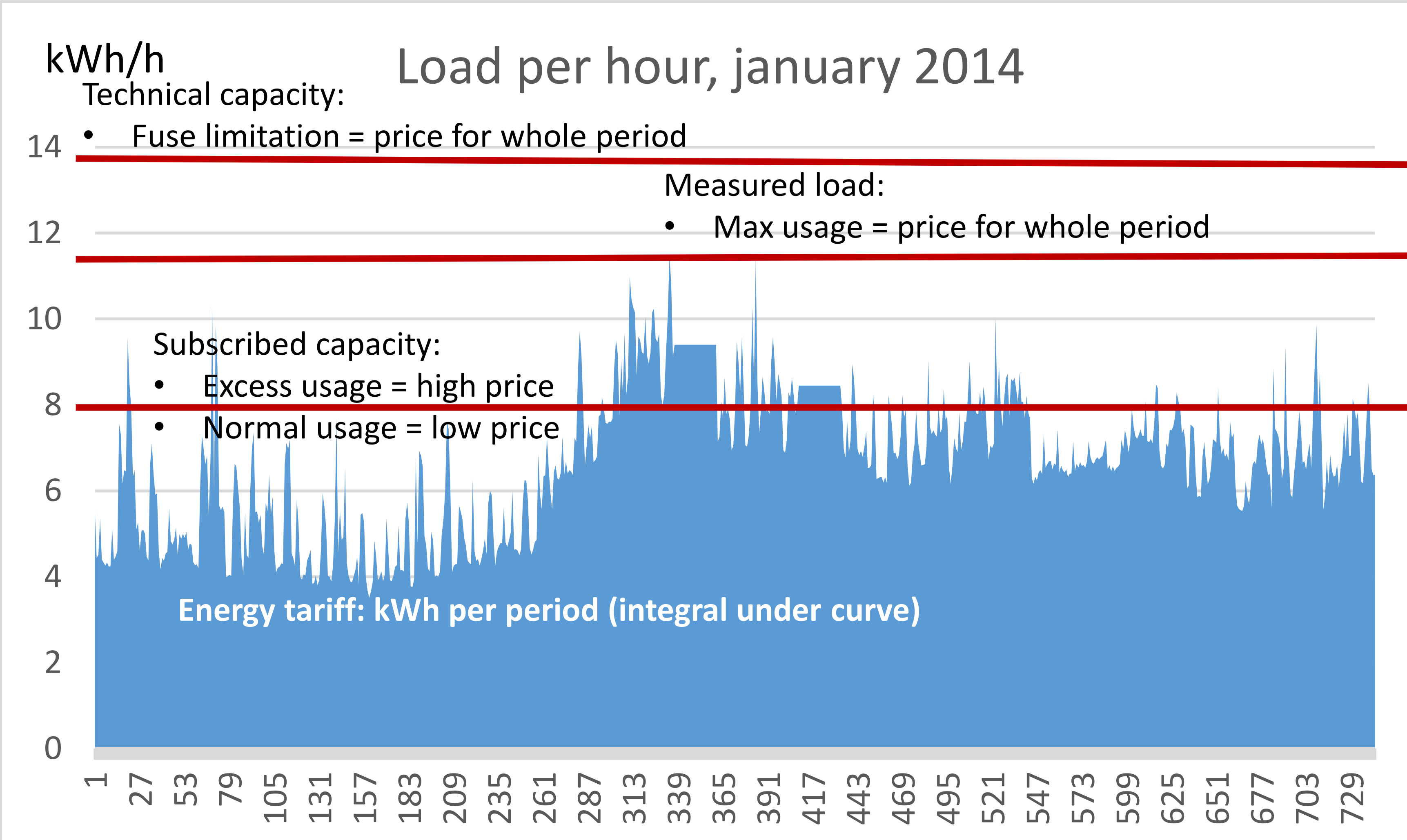
- **Demand side flexibility: Do load tariffs work?**
- **Tariff design, distribution effects and fairness**
- **Is there a potential for grid investment savings?**



ALTERNATIVE MAIN MODELS BEING DISCUSSED



IS IT SO THAT….

«Grid customers won't be bothered to shift load»

NO, WE BELIEVE THAT..

There is previous experience in Norway with normal and excess usage tariff models, that clearly contributed to load shifting. Experiences from the US, France, UK etc show that load tariffs, in combination with advanced communication and power management systems, yield significant effects – 10% load shifting is realistic.

Price signals work in all markets, also the power market.

DEMAND RESPONSE – GETTING THERE

- Economic incentives
  - Poll, other research indicate that household customers require appr 1200-1500 kr/year gross saving to react
  - Sources of saving: Grid tariff, power cost, electricity taxes
  - In the future: sale of flexibility (aggregator model)
- Communication
  - Make the price signal available, and show impact as soon as possible
  - Explain the tariff
  - Explain what the customer can do
- Technology
  - AMR required
  - Installation of local energy management systems – may be local, very simple, or managed by third parties
- Comfort, fun factor
  - Better perceived comfort for the customers
  - Technology interest, modernity…

There will be no demand response unless customers install load and energy management systems
Participation from third parties is crucial to achieve load shifting and realise potential grid savings

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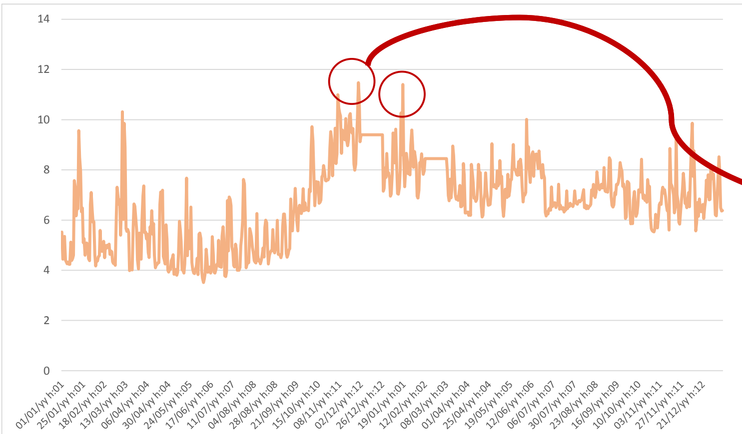
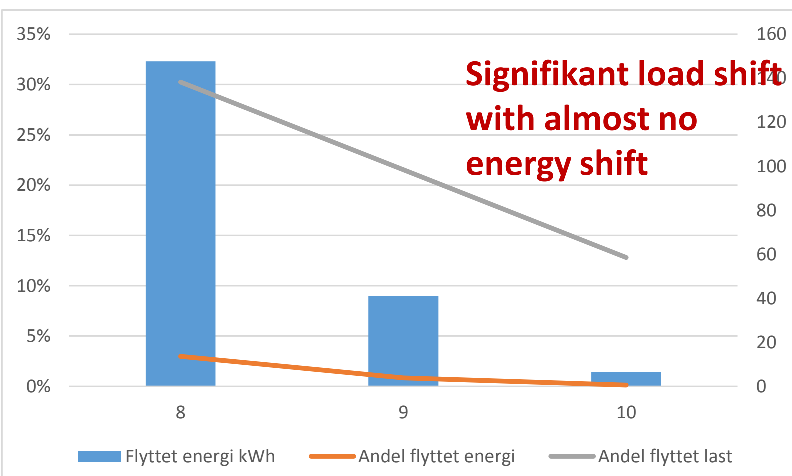
EXAMPLE: SINGLE FAMILY HOUSE, JANUARY 2014

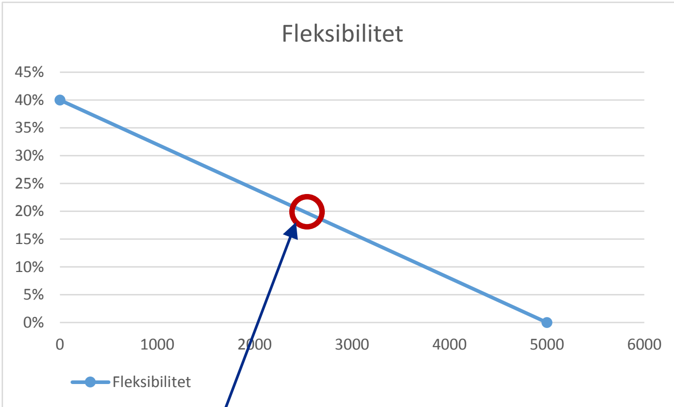
EV charging?



Invoice with load curve



TECHNICAL LOAD SHIFT FLEXIBILITY

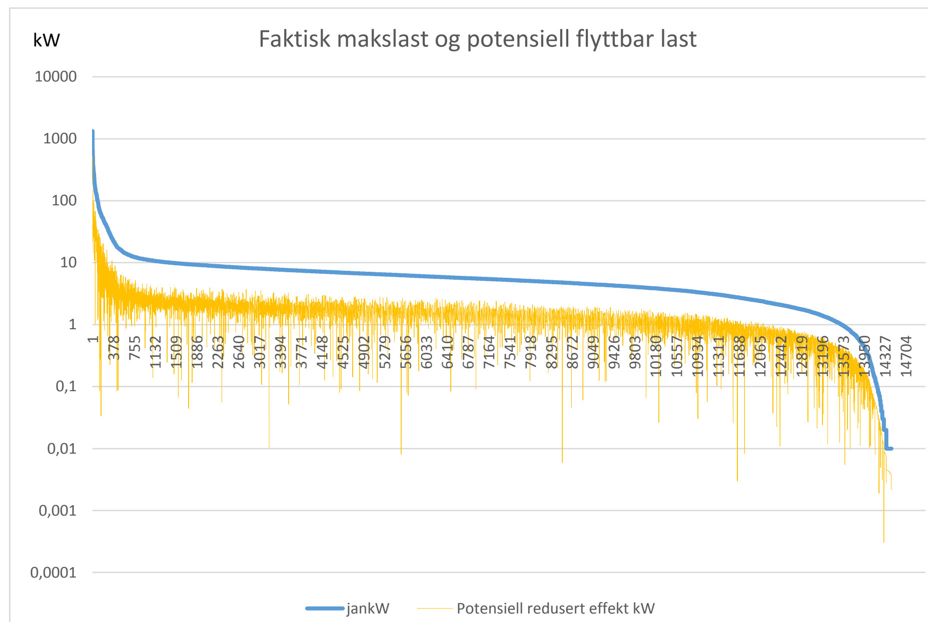


The average customer (2500 t) *may* shift 20%

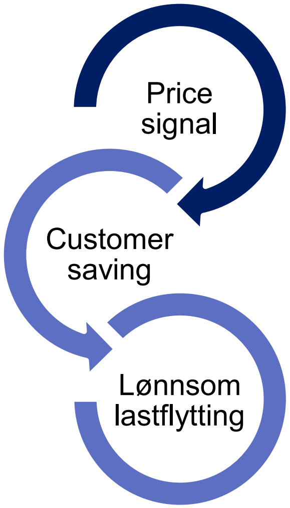
- The potenstial for load shifting is highest for customers with low load factor
- Simulation of technical potential for load shifting (per customer group, month)

Customer group	Technical potential
Residental blocks	29%
SFH	24%
Leisure	33%
Small business	19%
Average	**24%**

Illustrative numbers



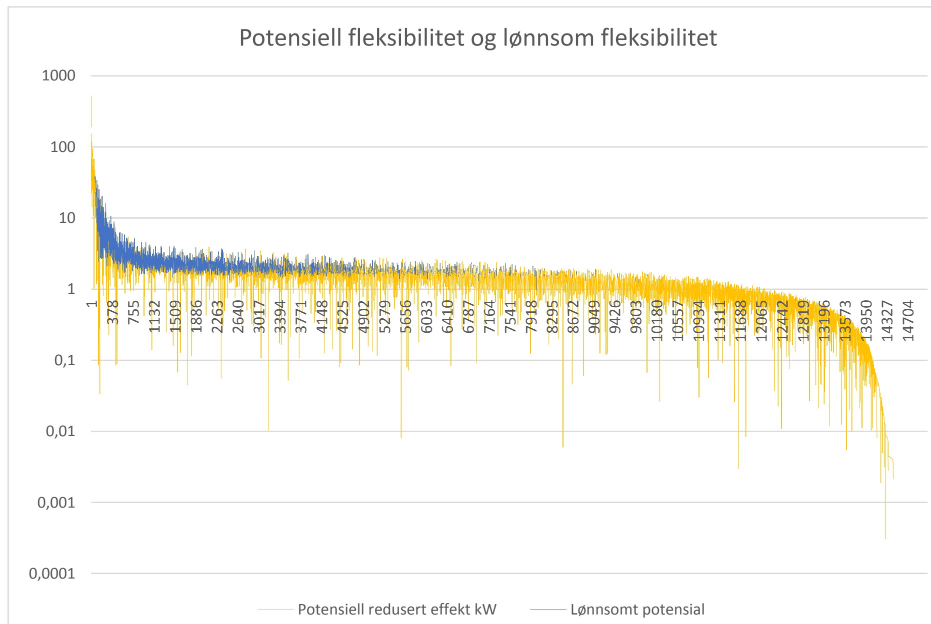
ECONOMIC POTENTIAL



- The price signal enables a grid tariff saving
- The customer shifts load only if the saving is high enough. Threshold value?
- Used 1500 NOK/year for illustration, yields 13% economic potential

Customer group	Technical potential	Economic potential
Residental blocks	29%	0%
SFH	24%	12%
Leisure	33%	20%
Small business	19%	16%
Average	**24%**	**13%**

Illustrative numbers



IS IT SO THAT....

«Load tariffs give higher grid costs to the customers and hurt new, renewable energy and energy conservation»

NO, WE BELIEVE THAT..

This is a tariff distribution issue. With the current energy-based grid tariff, customers with EVs, PV, load-demanding equirpment are subsidised by other customers. This is socially biased and unfair, and leads to over-investment in load-demanding infrastructure.

Politicians may decide to subsidise new energy-efficient technology, but the grid tariff is the wrong place to achieve that mean

THE FAIRNESS ISSUE

Passive house

- Annual energy consumption: 5.000 kWh
- Max grid load: 20 kW (EV, induction top…)

Old SFH

- Annual energy consumption: 25.000 kWh
- Max grid load: 20 kW (electric heating)

With load tariffs, the two houses would face approximately the same tariff

Source: Agder Energi Nett (2014)
Grid tariff based on Agder Energi Nett tariffs from 2013. Grid loss differences may justify a tariff difference of 500 NOK

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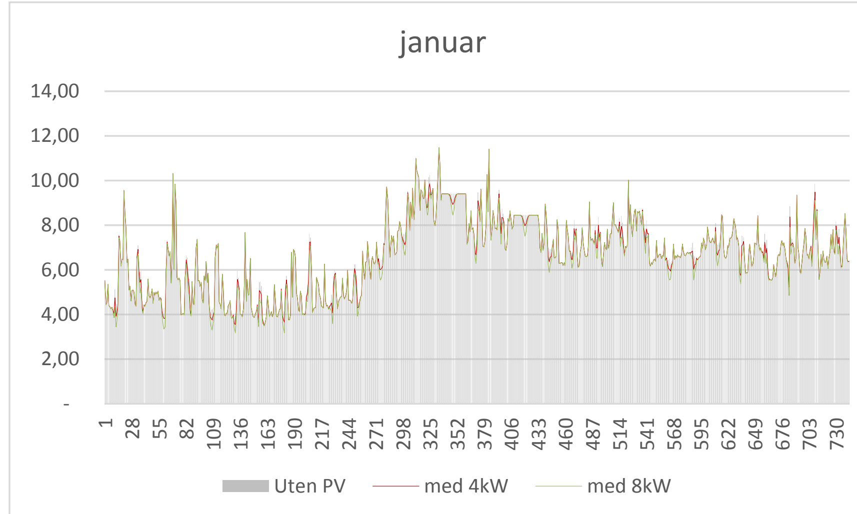
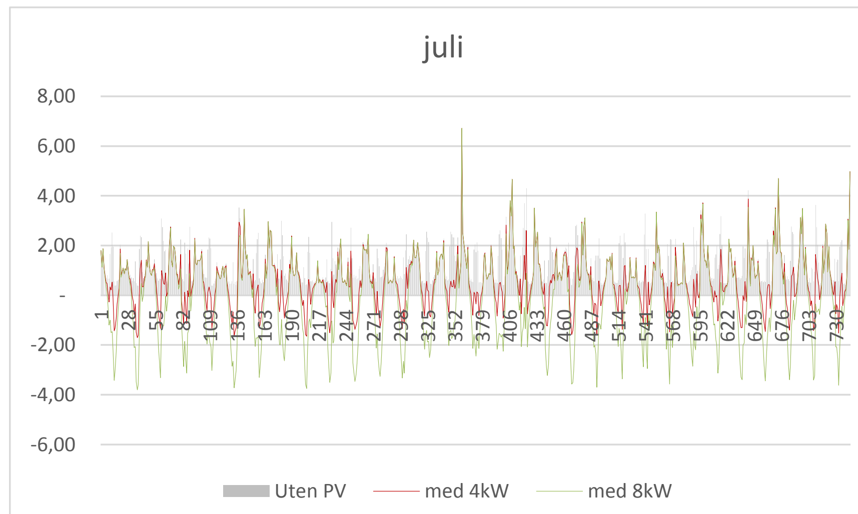
SOCIO-ECONOMIC IMPACTS

- Energy tariffs subsidise certain customers
  - PV, air-to-air heat pump, EV…
- Example: PV
  - Installation appr 20,000 NOK/kW
  - With energy tariff: IRR at about 4% with current power price and taxes
  - With load tariff: IRR -0,5% with current power price and taxes
- Impacts
  - Over-investment in new technology (true price signals not revealed)
  - Extra, local tax on customers that do not invest – lead to under-consumption and loss of utility to these customers

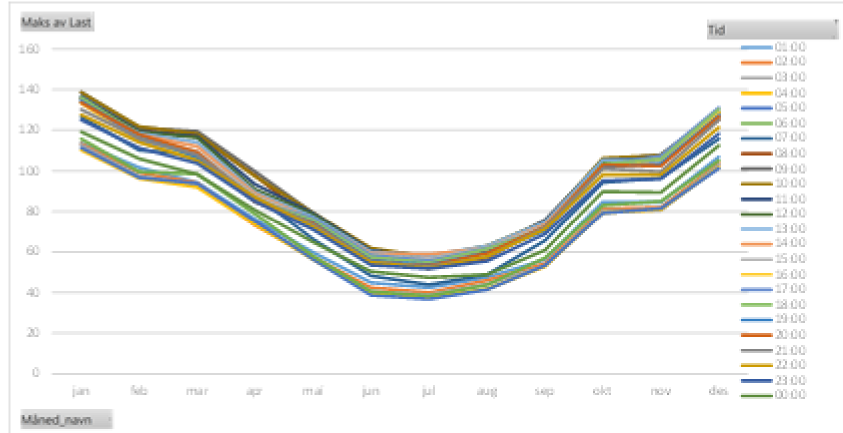




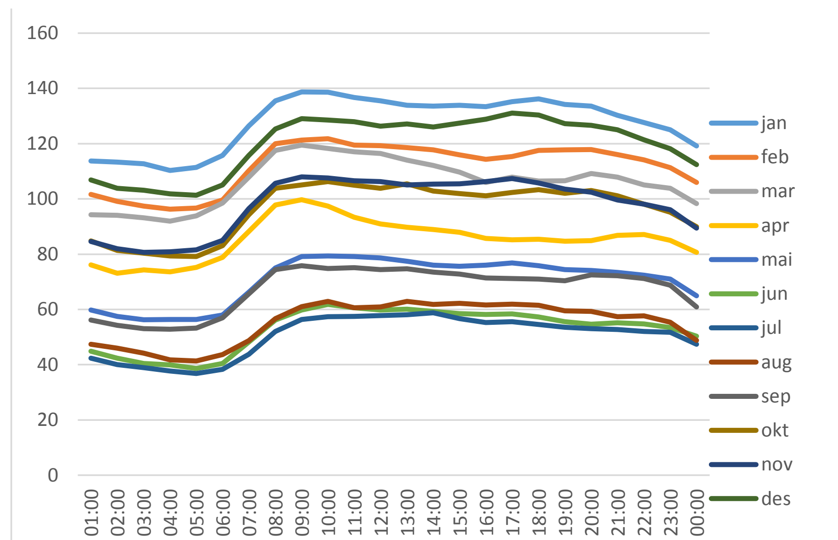
TARIFF DESIGN: HOURS OF REFERENCE

- The tariff design must reflect actual load patterns
  - Options include season, month, time-of-day, day-of-week…, peak / off-peak..
  - In line with actual system load pattern
- Case: Ringerikskraft
  - When min load in January is higher than max load i April, time-of-day differentiation makes little sense
  - Use seasonal load pricing

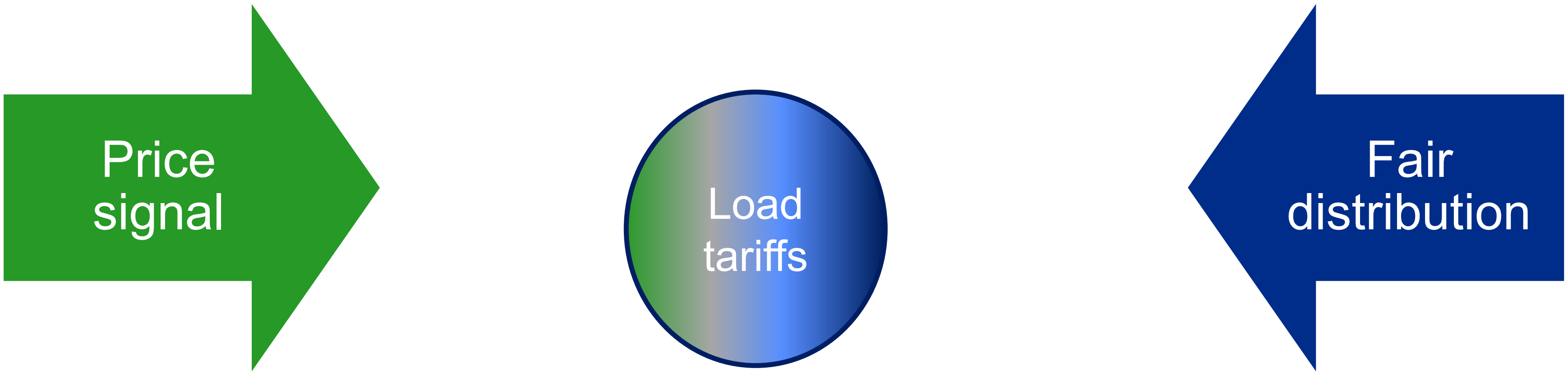
Actual max hourly load per month and time-of-day in Ringeriks-Kraft Nett (2012-2014)



Max hourly load profile per month in Ringeriks-kraft Nett (2012-2014)



THE TWO MAIN CONCERNS

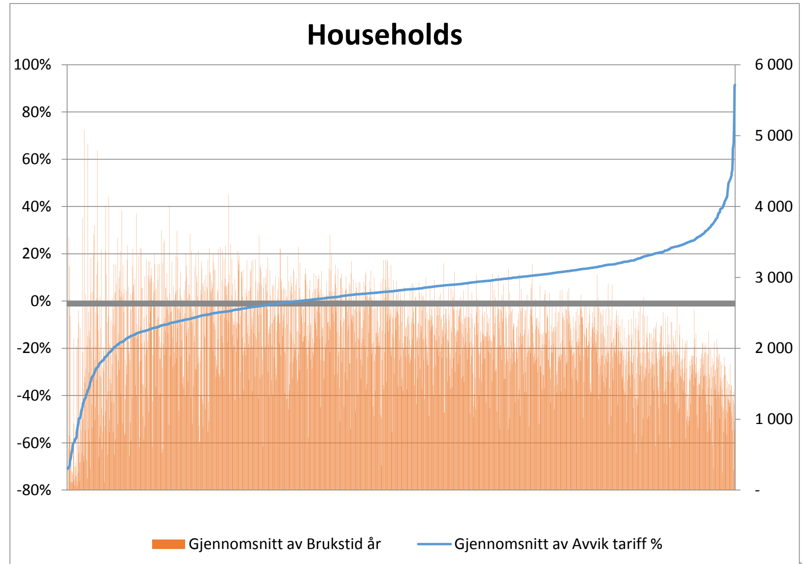


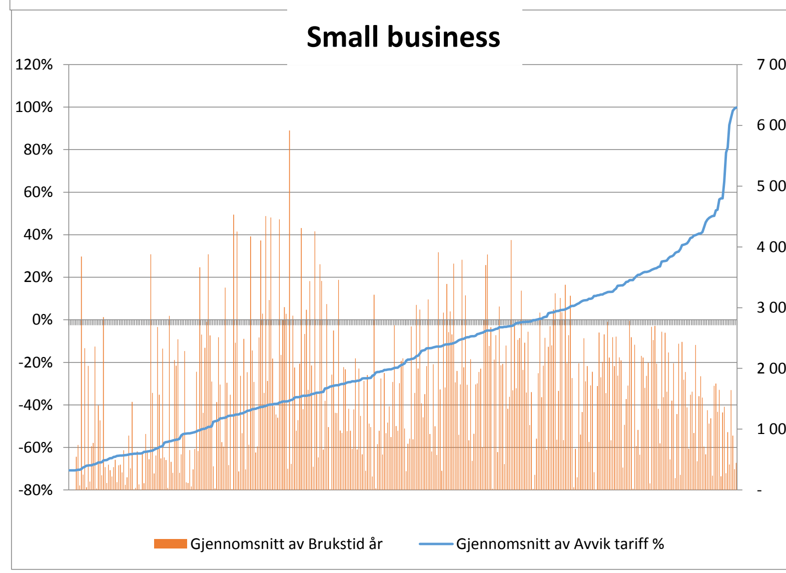
- To achieve load shifting
- Potential gain must exceed expected utility loss to customers
- «No queue pricing when there is no queue»
- Tariff requirements
    - Real price signal, aligned with expected utility
    - Reference load at peak
    - Effective communication, enable customer to take action
    - Installation of energy and load management systems crucial

- To achieve fair distribution of tariff cost
- No load shifting expected, hence no utility loss to customers
- Tariff requirements
    - Neutral price signal, only reflecting customer's fair share of capacity
    - Reference load average og multiple hours, fuse,….
    - No communication requirement
    - No installation of energy and load management systems required

PRACTICAL EXAMPLE: HVALER MUNICIPALITY

- Principles
  - Total income unaltered
  - Minimum legal levesl on fixed fee, grid loss
  - Load element: average of 3 highest hours per month
  - Differentiation winter/summer for housholds and small business, same all year for leisure buildings
  - Load element stands for 80% of tariff before taxes
- Impact per customer group
  - Less than 2% change in total cost per customer group
  - Significant differences within groups, notably due to differences in load factor





Bars: Load factor in hours
Line: Change in annual tariff cost from energy to load based tariff, in % of energy based tariff

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IS IT SO THAT....

«We have plenty of grid capacity, and load shifting would not change our investment needs»

NO, WE BELIEVE THAT..

Grid investments are growing rapidly on all grid levels. New load requirements – e.g. electrical vehicles – will require more capacity in itself. Underlying trends indicate that the load factor is going down, with resulting lower capacity utilisation in the grid.

The grid and the grid customers will have significant value of exploiting the current capacity longer. Load shifting may contribute to postponing investments in new capacity, and early reinvestments alike.

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SOURCES TO INCREASED GRID UTILITY

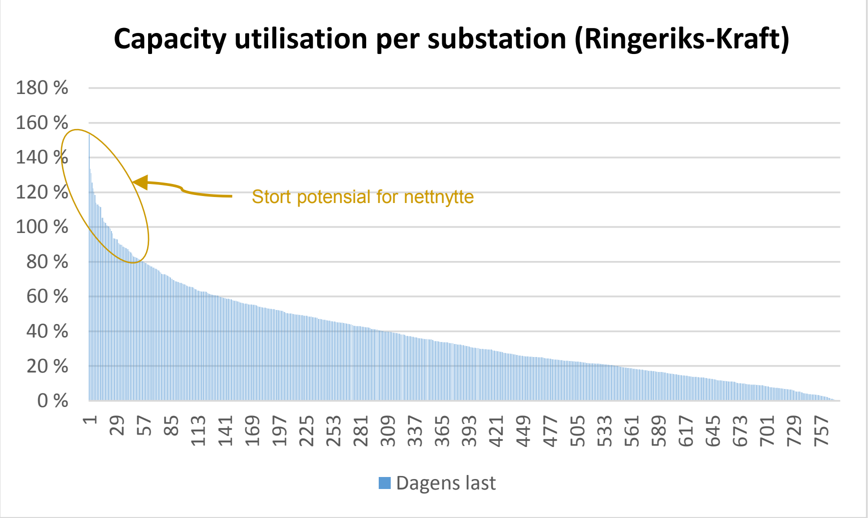
- Using as little resources as possible to achieve as much «grid» as possible is obviously good for society

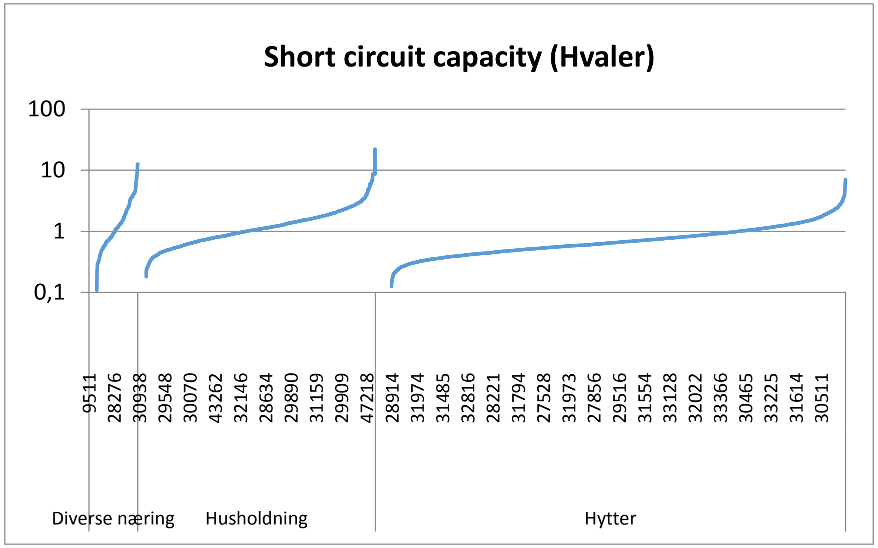
Reduced resource usage

- Postponed investments
  - Prolong the exploitation of existing capacity
  - Optimise the reinvestment timing, avoid early reinvestments
- Better dimensioning of new investments
  - Postponed investments provide better information on actual load patterns and load shifting, and hence better decision support for new investments
- Reduced grid losses
  - Not very much, but a positive element

BOTTOM-UP ANALYSIS: DISTRIBUTION GRID

- Two cases: Ringeriks-Kraft and Hvaler
  - Postpone capacity increases in substations
  - Postpone capacity increase in LV distribution grid
  - Reduced grid losses
  - Not included: Postpone capacity increase in HV distribution grid, Central grid
- Methodology
  - Linking customers with economic incentive to load shifting to their respective substations, LV grids
  - Postponed investments based on combination of customers with incentoives, and grid with high capacity utilisation
- **Results(Hvaler, Ringerikskraft)**
  - Appr 5-7% potential for reduced, annual total grid costs
  - Seems a lot?





A SIMPLE ENVELOPE CALCULATION…

- How much would reduced investment levels account for?
  - Capital accounts for ~40% of the total cost basis
  - Highest for HV grid (50%), lower for distribution grid (35%)
- Case: reduced investments, all other costs stable
  - Based on projections and data from Statnett, Energi Norge
  - Split between reinvestments (that may be postponed) and new capacity investments

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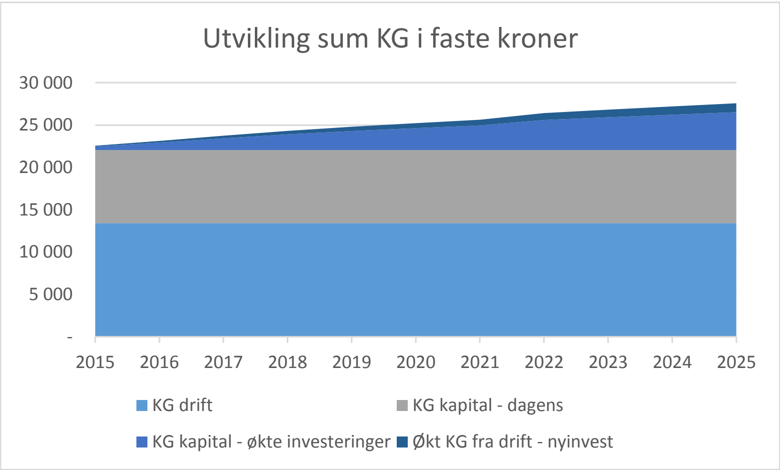
CASE RESULTS



«Base case»: Increased total tariff cost (real terms) ~22% in 10 years. Equivalent to 5 BNOK/year

«Sensitivity»: vary re- and new investments by 0.5-1.5 of projection respectively

		Reinvestments				
		0,5	0,75	1	1,25	1,5
New invest-ments	0,5	108 %	110 %	112 %	115 %	117 %
	0,75	113 %	115 %	117 %	119 %	121 %
	1	118 %	120 %	122 %	124 %	126 %
	1,25	123 %	125 %	127 %	129 %	131 %
	1,5	128 %	130 %	132 %	134 %	136 %

1,8 BNOK more per year

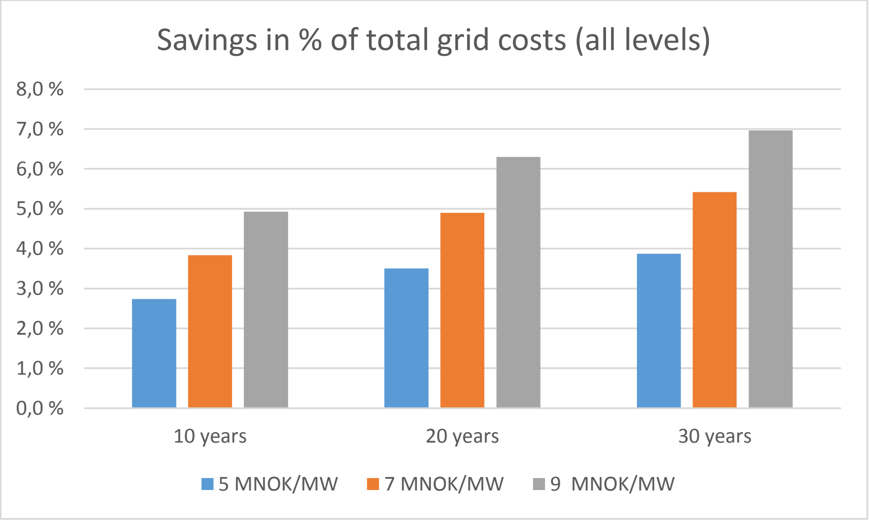
5 BNOK more per year

8 BNOK more per year

A difference of 2.5 BNOK equals ~10% of total grid costs

TOP-DOWN ANALYSIS

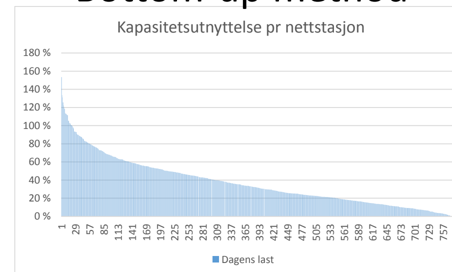
- National level illustration
  - Unaltered energy consumption
  - Load factor reduced over time, in line with Statnett's Masterplan for the Oslo area (appr 1% per year)
  - Marginal expansion cost 5-9 MNOK/MW (all grid levels)
    - Current average replacement cost of Norwegian grid is appr 10 MNOK/MW
  - Load shift potential: 10% of total load
- Results
  - Aggregate effects indicate potential in the order of 5-7% within 10-20 years



POTENTIAL FOR REDUCED GRID COSTS

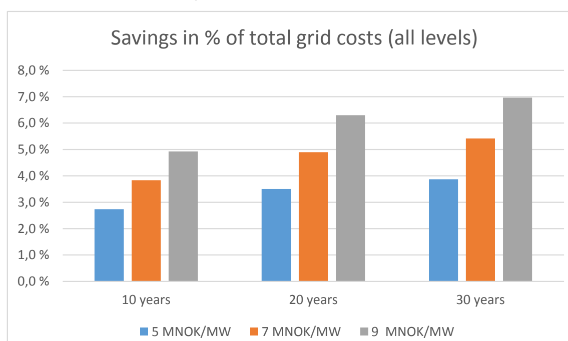
Envelope method

Bottom-up method



5%-10% difference in total costs in 10-20 years

Top-down method



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