Value of Lost Load
some issues and reflections

Runar Brännlund

Centre for Environmental and Resource Economics
Umeå School of Business and Economics

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Outline

- What’s the problem and challenges?
- How secure should electricity supply be?
- What is VoLL, and whats the relation to demand flexibility?
- How can we measure VoLL (and demand flexibility)?
- What are the numbers and what do they mean?
- Some final comments..

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What are the problems and challenges?

- A wave of deregulation of electricity markets in Sweden and other countries
- Technical progress (production, distribution, consumption)
- Major shifts in environmental and energy policy
  - CO2 taxes, EU-ETS, feed in tariffs, green certificates, investment subsidies
  - Nuclear phase out (Germany, Sweden)
  - Phase out of capacity reserves

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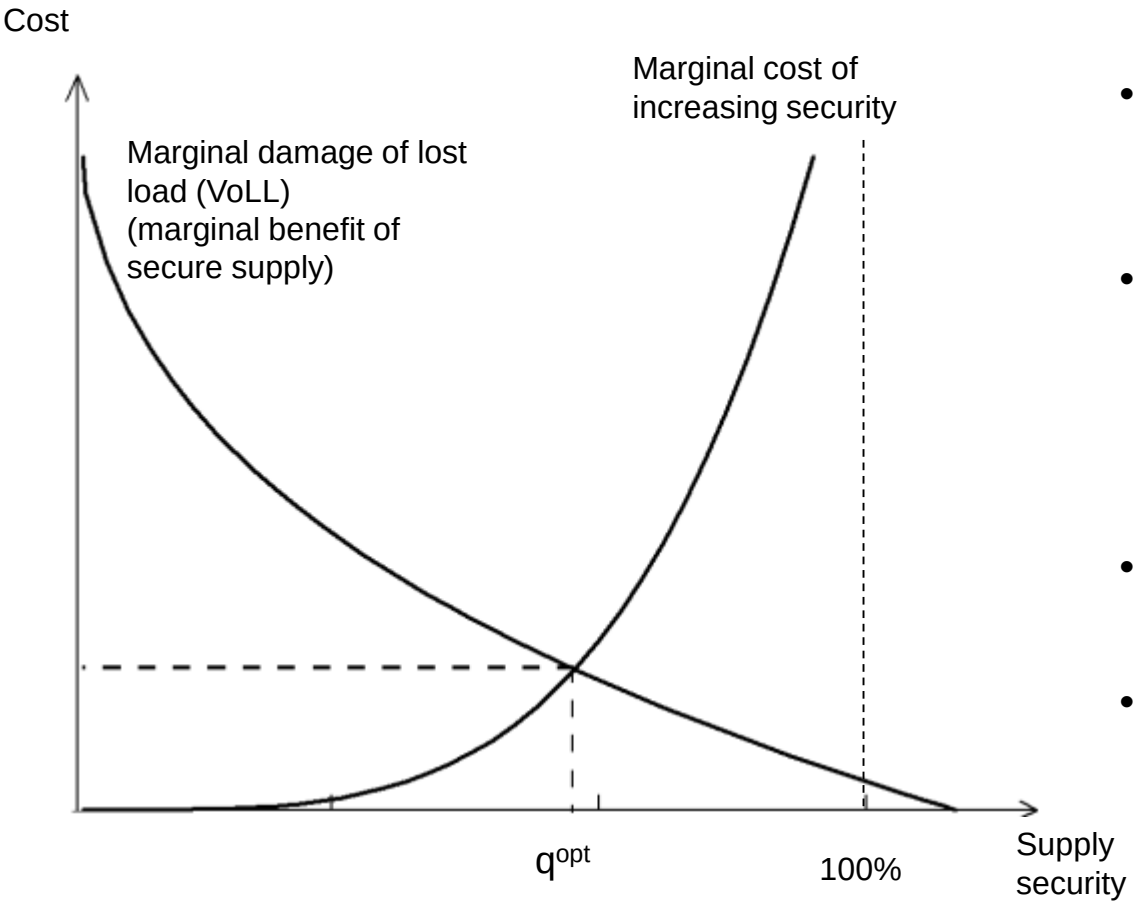
What are the problems and challenges?

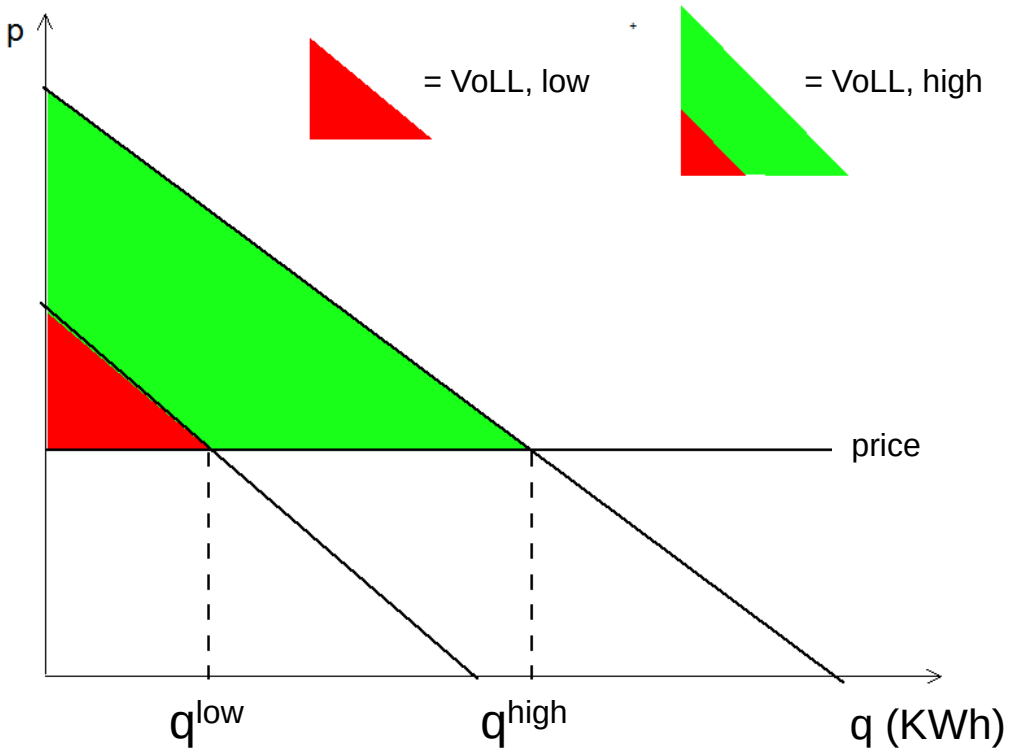
- A considerable change in the power production mix
  - more intermittent and stochastic power generation
- On average an energy surplus (implying low average power price)
- Lack of peak capacity, and hence
  - Periods of very high prices, and/or
  - Increased risk of supply insecurity (black-outs)
- The eventual problems for a single country depends on how well its integrated with international markets, and how well production systems complements each other

How secure should we be?



- The level of security should be increased as long as the benefit is higher than the cost
- In optimum the marginal benefit of increased security (or the cost of lost load) should equal the cost of providing more security
- Given that the market doesn't solve this…
- **we need to quantify VoLL as well as the cost of reducing the risk of lost load.**

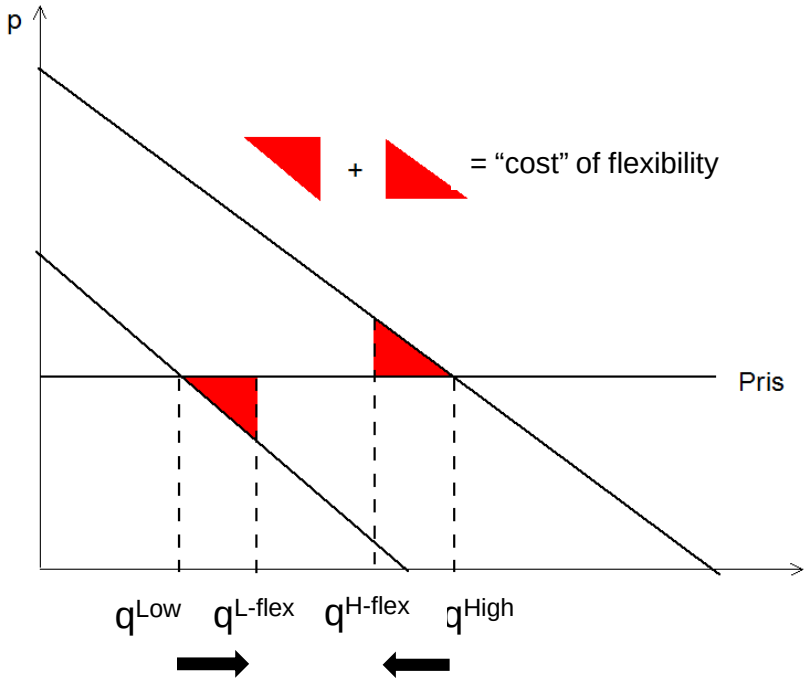
What is VoLL then?



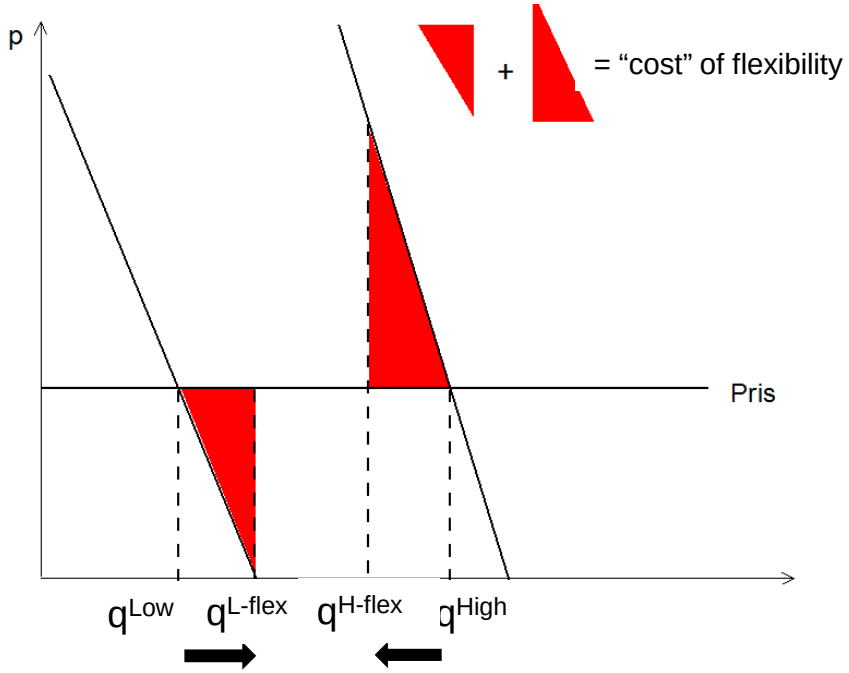
- VoLL is the loss in consumer surplus as a result of lost load (usually divided by the amount of power lost)
- Means that there is no single universal VoLL
- VoLL depends on the price sensitivity (flexibility)
- Which in turn depends on
  - when during the year, month, week, and day the loss occur
  - who and how many that is subject to the disruption
  - the duration of the disruption
  - how frequent it occurs
  - Whether the disruption is planned or not

VoLL and demand flexibility

High price sensitivity



Low price sensitivity



The cost of “demand flexibility”, a “partial” VoLL

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Measuring VoLL and dem flex?

- Revealed preferences, RP (observed behavior)
  - Marginal cost of installed back-up power (or batteries)
  - Estimating demand curves from observed price and quantity data
- Pros and cons
  - \+ Consistent with economic theory
  - \+ Utilizes actual behavior, non-hypothetical
  - – Costs of lost load may be substantially higher than the costs for back-up (e.g. hospitals)
  - – consumer price may not correctly reveal actual preferences or generation costs.
  - – Black-outs are very rare, no revealed preferences for extremes (no market data)

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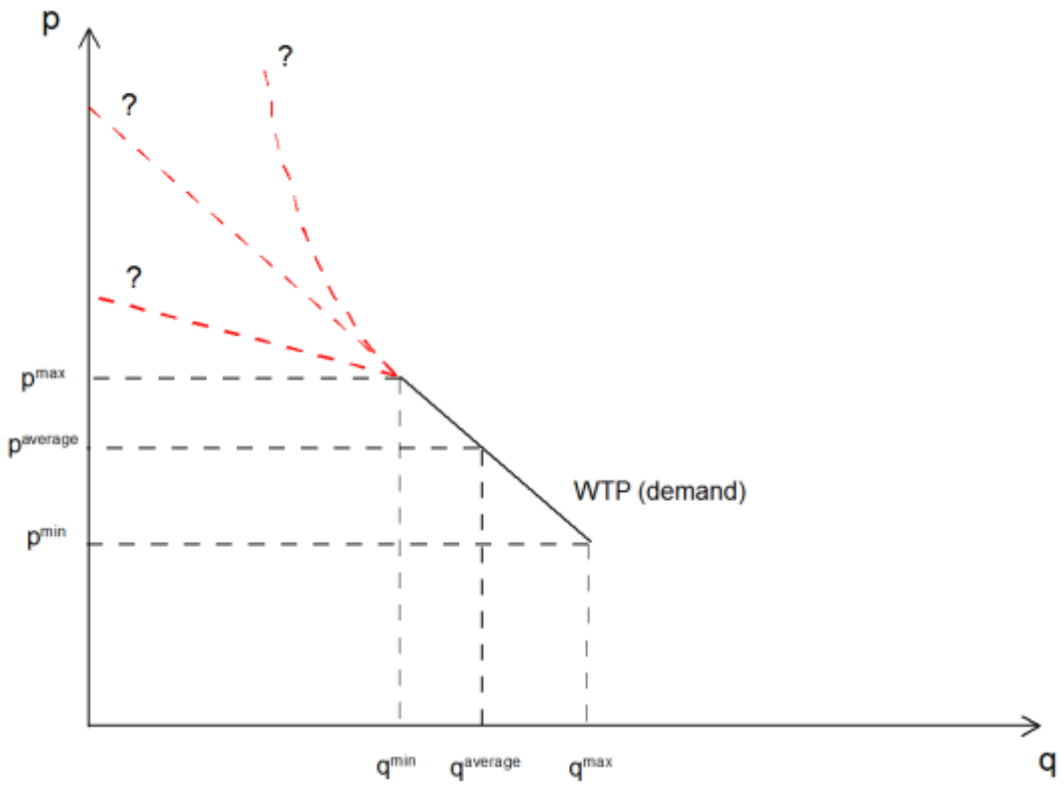
Measuring VoLL and dem flex?

- Stated preferences, SP (“stated” behavior)
  - Estimates consumer surplus through a “hypothetical market”
- Pros and cons
  - \+ Direct estimate of WTP/WTA (consumer surplus) for a specific scenario
  - \+ Can get individual preferences for specific (hypothetic) scenarios
  - – It is a hypothetical setting.
  - – Consumers may have difficulties to answer, or answer strategically
  - – What to ask about, willingness to pay for avoiding a blackout, or willingness to accept (compensation needed) for having a blackout?

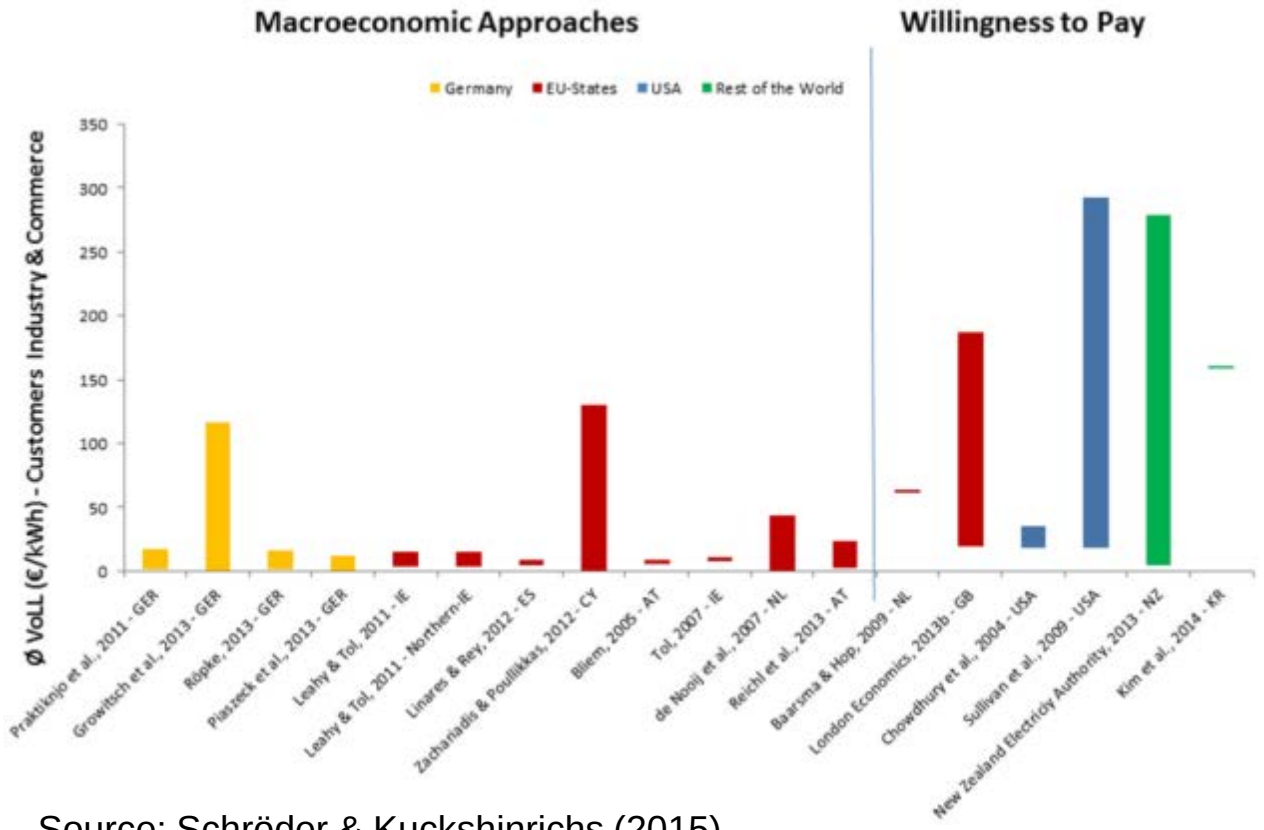
Revealed vs stated preferences



- Lack of knowledge about behavior and preferences outside “normal” market variation makes RP very uncertain
- SP may be the only reliable method to estimate losses of load for households
- For commercial firms RP may be good since we may directly observe a relation between value added (or profits) and electricity use

What are the numbers?

Commercial end users

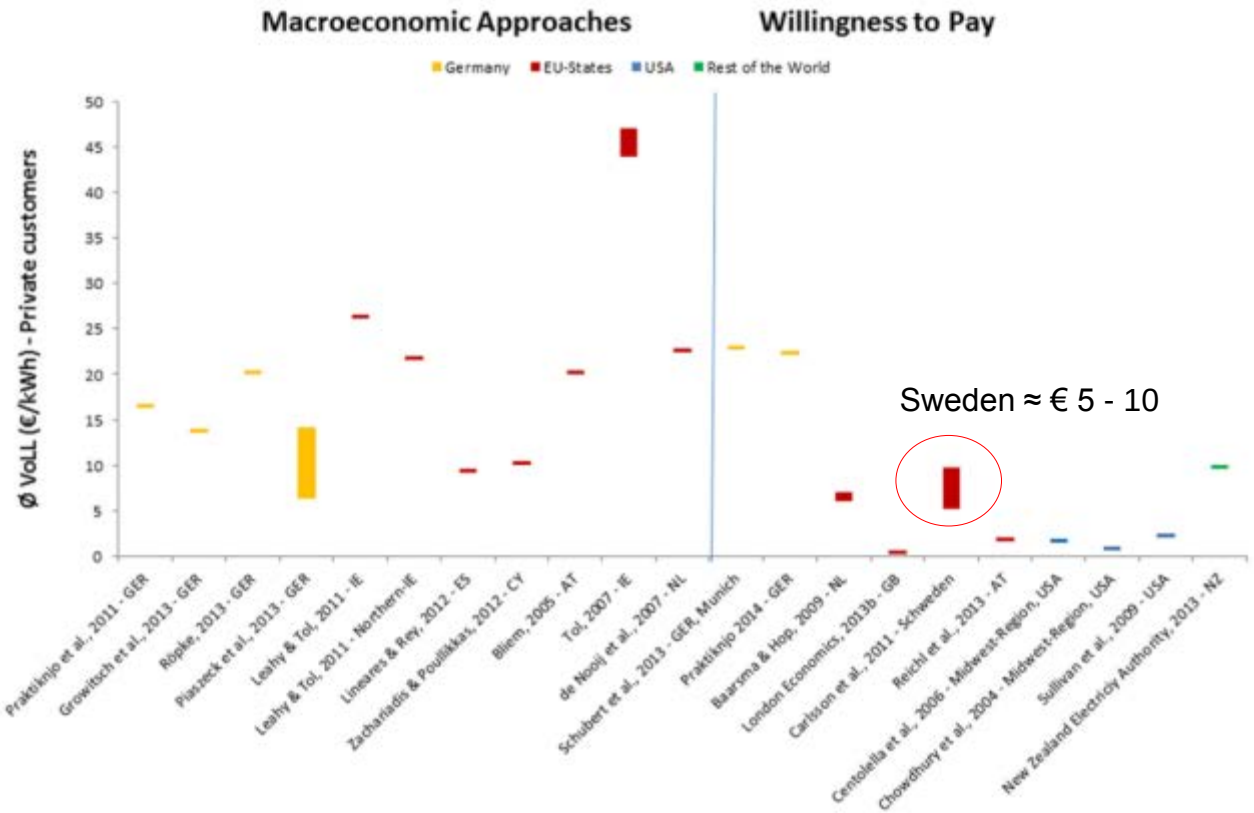


- Wide range of estimates, both within and between.
- Between € 3 – 250
- Different methods
- Specification of scenarios differs (duration, time of the year, etc.
- SP (WTP) estimates tend to be higher

Source: Schröder & Kuckshinrichs (2015)

What are the numbers?

Private end users



- Wide range of estimates between different studies.
- Between € 0 – 50
- Different methods
- Specification of scenarios differs (duration, time of the year, etc.
- SP (WTP) estimates tend to be lower
- A significant share of the respondents states zero loss even for long durations

Source: Schröder & Kuckshinrichs (2015)

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Swedish numbers

SP 1: Contingent valuation VoLL= WTP/(30 KWh*duration/24)

Duration hours	Mean WTP €	Min €	Max €	Share of zero	Mean VoLL €/KWh	min - max VoLL €/KWh
1	0.95	0.00	52.63	0.86	0.76	0 - 42.11
4	3.89	0.00	78.95	0.68	0.78	0 - 15.79
8	11.37	1.58	210.53	0.46	1.14	0.16 - 21.05
24	23.47	9.47	315.79	0.36	0.78	0.32 - 10.53

Source: Carlsson & Martinsson (2006)

SP 2: Choice experiment

Duration hours	WTP €	VoLL €/KWh
4	3.05	2.44
8	3.89	0.78
24	13.16	1.32

Source: Carlsson & Martinsson (2008)

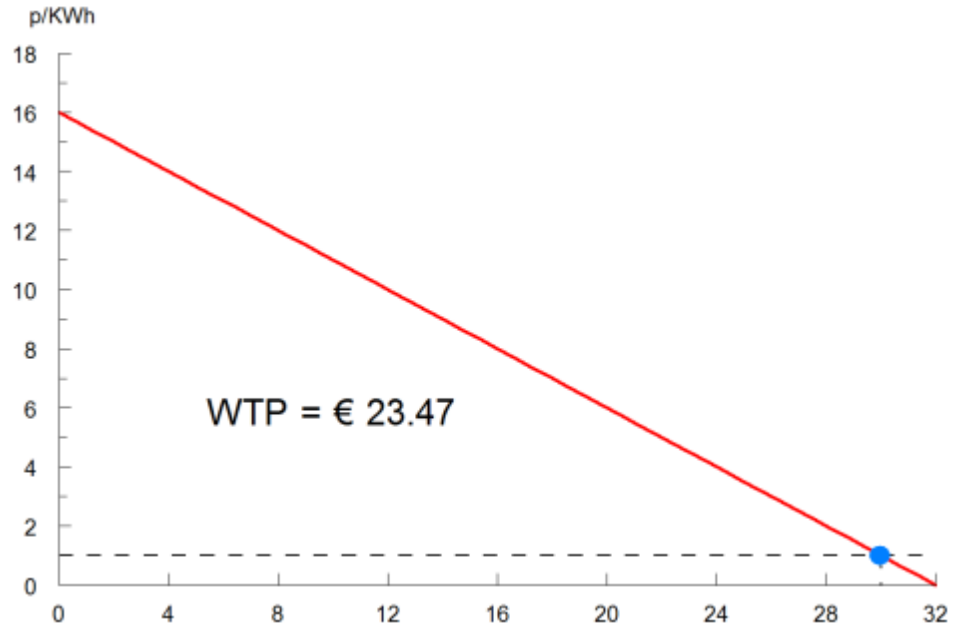
SP 1:

- WTP is (almost) linear in duration
- Implies a (more or less) constant VoLL
- Relative low VoLL
- Due to large share who states no utility loss

SP 2:

- WTP is less linear
- VoLL is higher for short durations

What does the SP numbers reveal?



Given the quantity used, the price, and assuming a linear demand function we can solve for the price sensitivity (elasticity).

p = SEK 1 per KWh
q = 30 per day (a villa),
then we get the demand function:

q = 32 - 2*p

dq/dp = -2, a price increase from SEK 1 to SEK 2 implies that electricity use goes from 30 KWh to 28 KWh

Implying a price elasticity of -0.07

Within the range of empirical estimates

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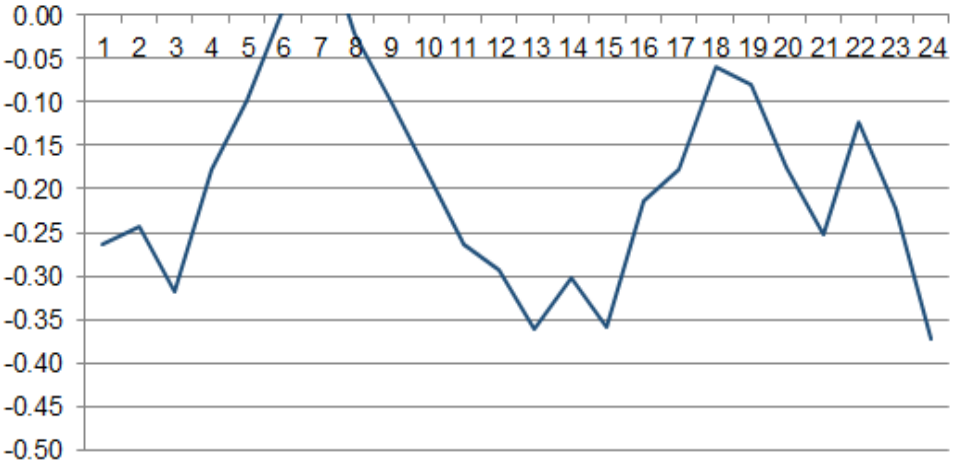
Some new results

- Preferences for electricity varies in time
- More valuable in the morning and evening (for most of us)
- Should be revealed through price elasticities
- If so VoLL for different hours and different durations could be estimated using this knowledge

Time allocated price elasticities



Preliminary estimates of hourly demand functions reveals that consumers responds differently in different hours to price changes.

- less responsive in mornings and evenings
- More responsive during the night and in the middle of the day

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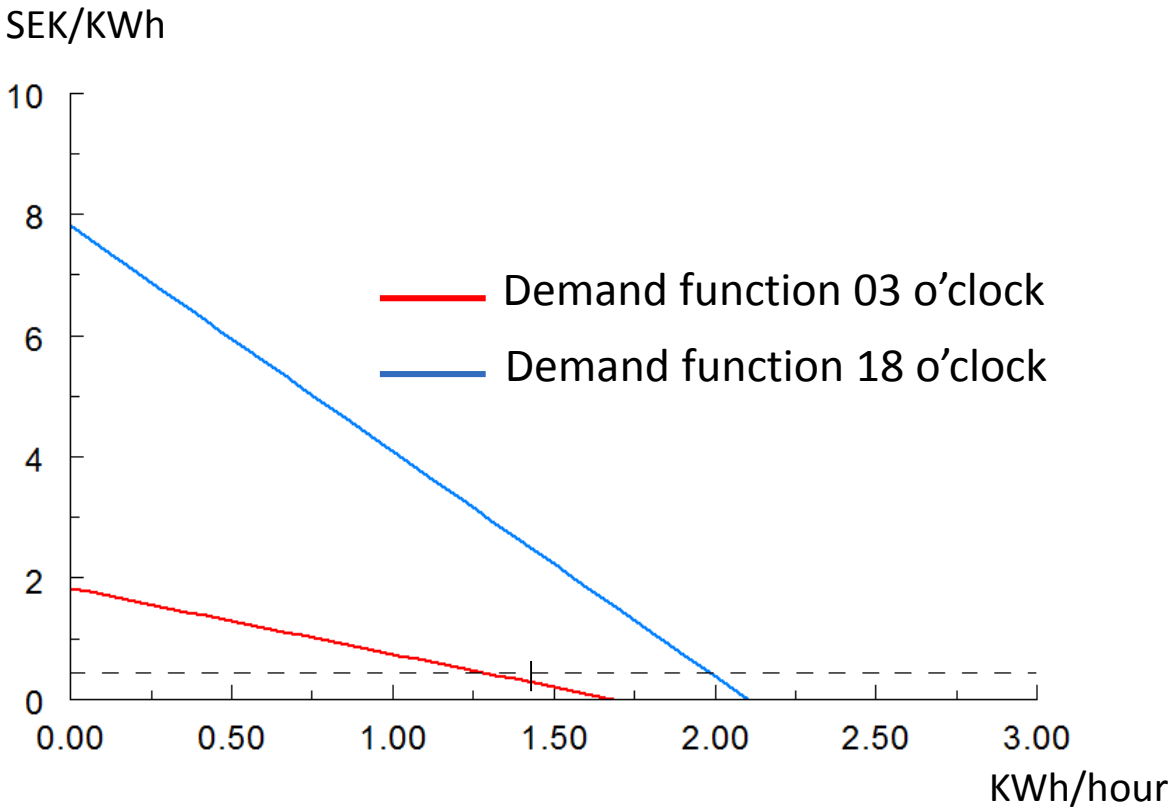
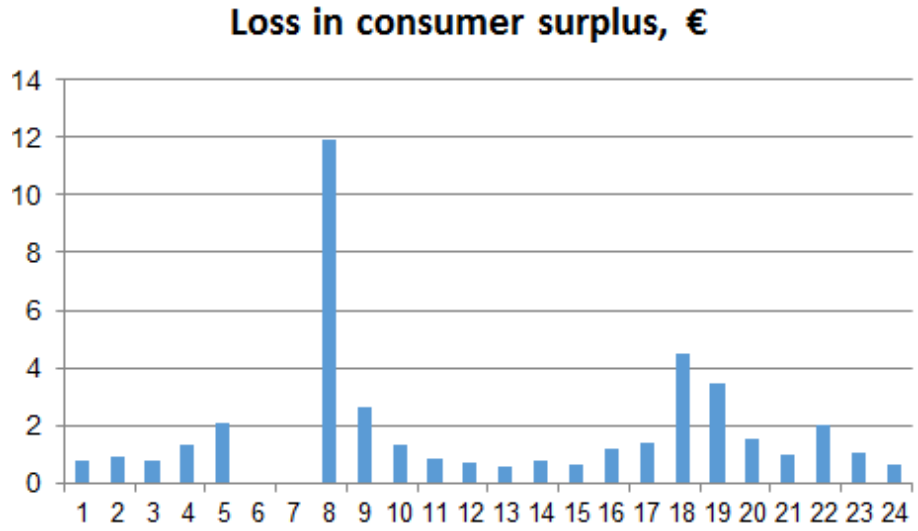
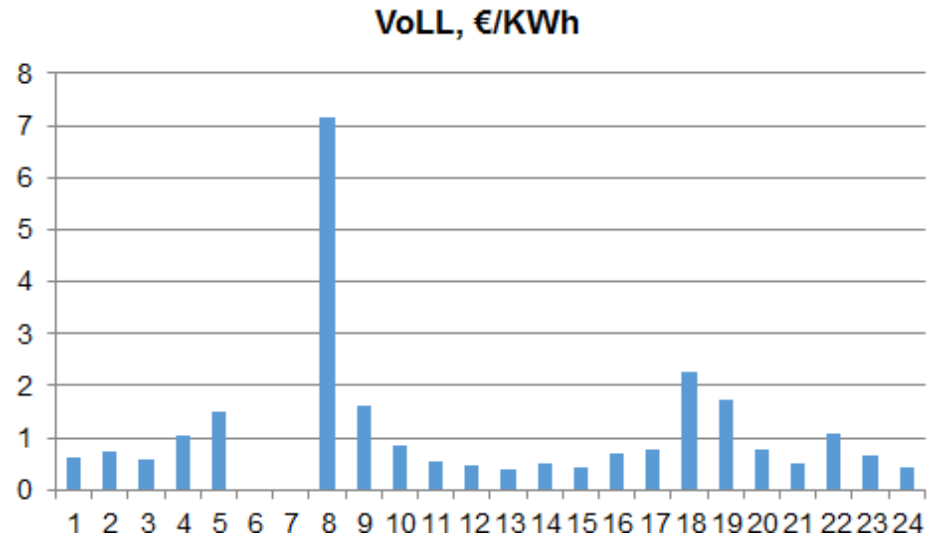
Some new results



- At any given price consumers use less electricity in the night than in, say, the afternoon
- An increase in the price will reinforce the difference in use between the hours
- Less loss of comfort to adjust during night

Some new results





Given the hourly demand functions

CS and VoLL CS for a one hour black-out is higher during morning and evening hours

- more electricity is used those hours
- consumers are less keen to reduce their use

These results are in line with previous studies on demand flexibility (Broberg & Persson, 2016, Broberg et.al. 2015.

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Final comments

- The optimal level of supply security is where costs for providing higher security is balanced by the benefits
- We don’t have to worry much about that on a unregulated market (in my opinion)
- If we for some reason want a target for supply security, then we need to know VoLL
- VoLL can be estimated by
  - Revealed preferences
  - Stated preferences
- Both methods are used frequently in the literature

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Final comments

- Results are difficult to compare, especially those from SP studies
  - Scenarios differs with respect to duration, time of year and day, frequency, and more.
- Large shares of respondents states zero VoLL in many SP studies (WTP studies in particular)
  - May reflect “protest answers”
- RP studies are mostly used in macro- and industry studies of VoLL
- SP studies of VoLL for households should be complemented with RP studies, and vice versa
- RP estimates can, for example, be used as input in SP studies