



The effect of low-carbon technology diffusion on the adoption of electricity tariffs for demand response

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Low-carbon technologies can be part of both the challenge and the solution



Solution as flexibility provider





It is not clear which tariff design leads to the highest peak reductions



Trials of time-varying tariffs



Combining economic, social, and technical aspects enables a holistic approach





What are the potentials and barriers for flexibility provision of different low-carbon technologies in households?

Research Question 1: How do low-carbon technologies affect household demand load?

Research Question 2: What is the technical flexibility potential of the new loads? Research Question 3: How do different stakeholders perceive demand response with different incentives and why?

Research Question 4: How does the diffusion of low-carbon technologies affect the adoption of different tariffs with different automation levels?



A mixed-methods approach supports the integration of different perspectives

Actors in the electricity system

15 Interviews:

- Electricity retailer (3)
- Electricity service provider (1)
- Municipal utility (2)
- Distribution grid operators (6)
- Transmission grid operators (1)
- Academia (1)
- NGO (1)

Households

Survey

- Heat pump owners
- Electric vehicles owners
- Photovoltaic installations
- Storage technologies
- None of the above

Research Question 3: How do different stakeholders perceive demand response with different incentives and why?

Research Question 4:

How does the diffusion of low-carbon technologies affect the adoption of different tariffs with different automation levels?



More complicated time-varying tariffs might neither be attractive for households nor for the electricity system

Potential for electricity system "It is questionable if time-varying tariffs are the right instrument to achieve this" (DNO)

- Networks might need to be reinforced anyways
- Geographical differences based on demand and renewable energy supply
- Reliability issue: DNOs prefer direct load control

Role of households

"Households will not put in any effort for the small benefit they can get" (DNO)

- Adaptation of **behaviour** cannot be expected
- **Planning insecurities**, particularly regarding electric vehicles
- No concerns about low diversity factor
- Smart meter rollout as pre-condition
- Social inequality
- Limited incentives for DNOs: operational costs increase with smart solutions and conventional network reinforcement is supported by the government
- Regulatory changes required
- Billing process complicated for small DNOs

Barriers for implementation

Different combinations of automation levels and tariff types



Sample characteristics

280 responses; full-time employed men with a university degree and an own house are dominant in the sample





Low-carbon technology diffusion in the sample



Technology diffusion in households



The effect of low-carbon technology diffusion on tariff selection



Percentage share of people with specific technology choosing a specific tariff



Attractiveness of combinations of tariffs with automation levels



Likert Scale from totally unattractive (0) to totally attractive (7)



Most important decision criteria for tariff selection





"Technology" is the most significant influencing factor for tariff selection



None of the technologies

- Choose the **electricity saving** tariff significantly more often
- Do significantly more often **not switch** to any of the offered tariffs

PV

Choose dynamic time-of-use tariff
significantly more often

PV and EVs

Choose real-time pricing tariff significantly more often

PV, storage, and EVs

 Choose dynamic time-of-use tariff significantly more often



"Current tariff" significantly affects tariff selection

Significant influencing factors of tariff choice



Green electricity tariff

Choose static time-of-use tariff significantly more often

Basic supply tariff

Choose high-load tariff significantly more often

Heat pump tariff

Significantly less likely to switch to any of the tariffs



Risk-averse people are less likely to select time-varying tariffs

Significant influencing factors of tariff choice



Higher price difference between periods

- Three times as likely to choose a time-varying tariff
- **Risk-averse** people are less likely to find timevarying tariffs attractive



Key take-aways

Electricity system

- Reliability issue: DNOs prefer direct load control
- Geographical differences based on demand and renewable energy supply
- Regulatory changes might be required to incentivize smart solutions

Households' tariff
selection

- Saving money and positive climate impact are main reasons for choosing a specific tariff
- PVs, EVs and storage are the determining technologies for choosing time-varying tariffs rather than heat pumps
- Electricity saving and high-load tariff are likely to be more attractive to people not owning lowcarbon technologies and currently using a basic supply tariff (if they switch at all)
- Risk-averse people are less likely to find time-varying tariffs attractive
- While automation is welcomed, the ability to use an override option is desired

Implications

- Direct load control might be best option for system as well as households, particularly for heat pumps
- Simple tariffs might be enough for the system and preferred by households
- Further research: use of override option
- Future supply and demand of flexibility at both transmission and distribution level
- Different options for flexibility procurement: competing or complementary?

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Thank you for your attention and I am looking forward to the discussion!

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