Evaluating Demand Response in Large Scale Power System Studies

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Outline

- Integration Studies and Demand Response
- Modelling Demand Response for Large Scale Integration Studies
- Study Outline
- Study Results
- Conclusions

Integration Studies

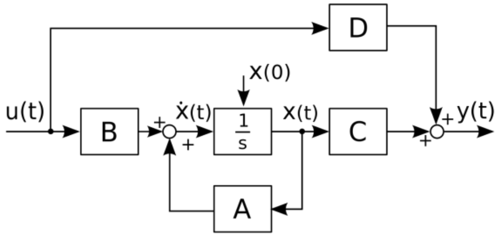
- Used to assess the system impact of novel technologies, policies etc.
  - Wind
  - Solar
  - Storage
  - Renewable energy targets
  - Carbon taxes, emission limits

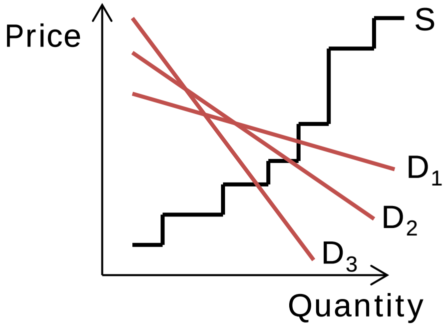
- Comprehensive assessment of benefits, costs, risks over a large geographical region and a (reasonably) long time horizon
  - Production cost modelling

Modelling DR for Integration Studies

- Requires **sufficiently detailed** model to reflect the true physical characteristics and limitations of the resource, but **reasonably coarse** to facilitate multiple sensitivity studies with acceptable computational times.

- **DR Modelling:**

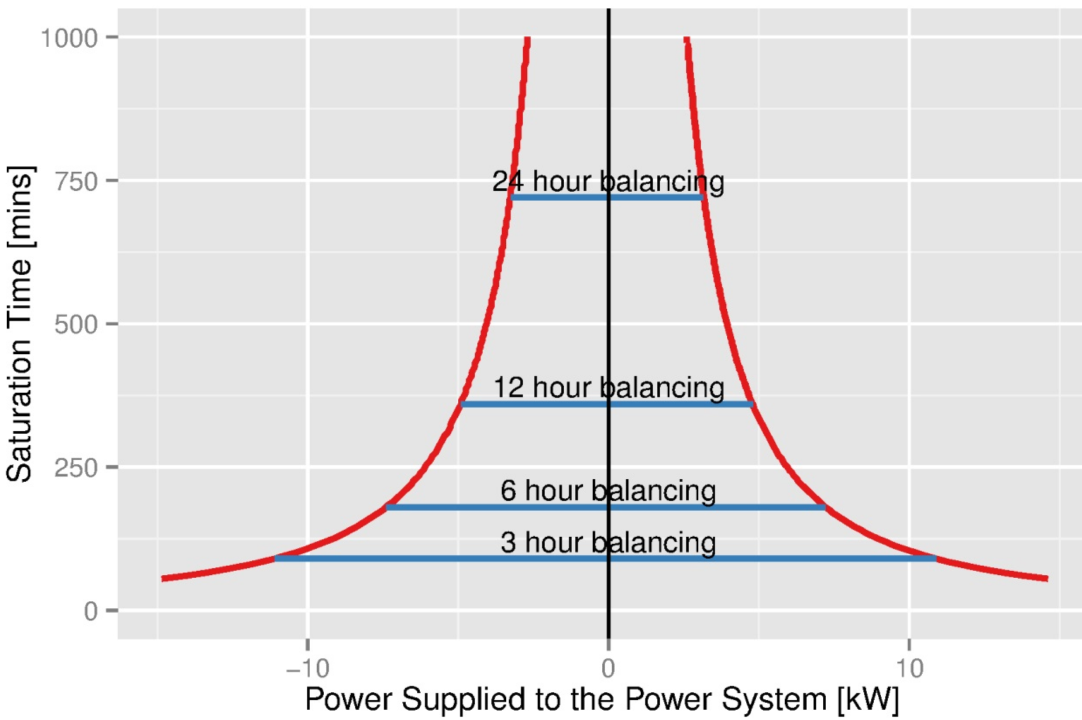




- **What type of DR?**
  - Energy Service
  - Capacity Service (Ancillary Services)

Modelling DR for Integration Studies

- **Focus:** Energy shifting DR
- **Example Flexible Load**: Supermarket Refrigeration



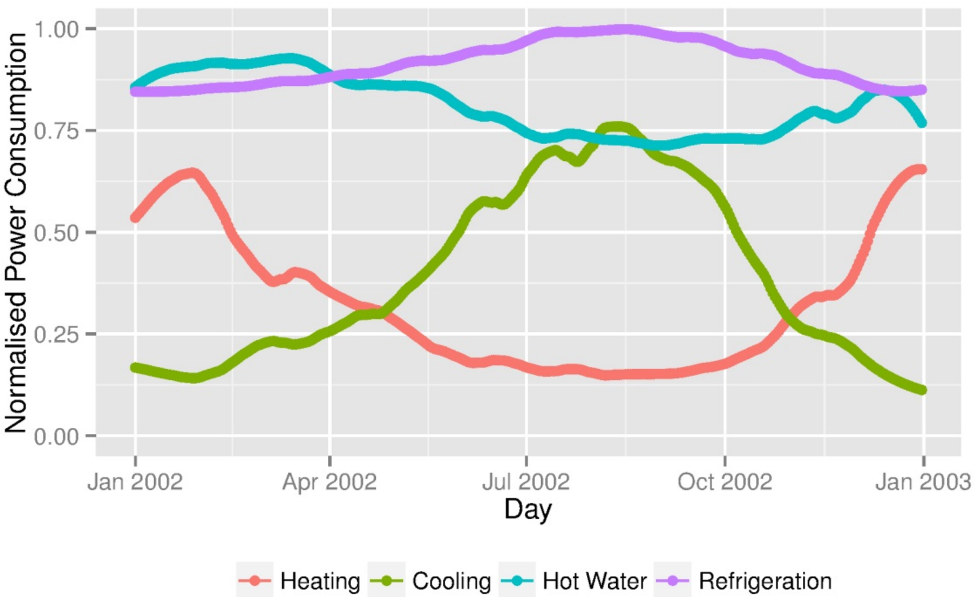
Source: O'Connell *et al.*, 2015

Additional Considerations

- Resource depends on a number of external factors – primarily outdoor temperature

- "Battery" Characteristics change:
  - Energy Capacity
  - Charging/Discharging Rates

- Seasonal dependencies reflected in the DR product definition



Sources: O'Connell *et al.* 2015,
California Energy End-Use Survey, 2006

Case Study

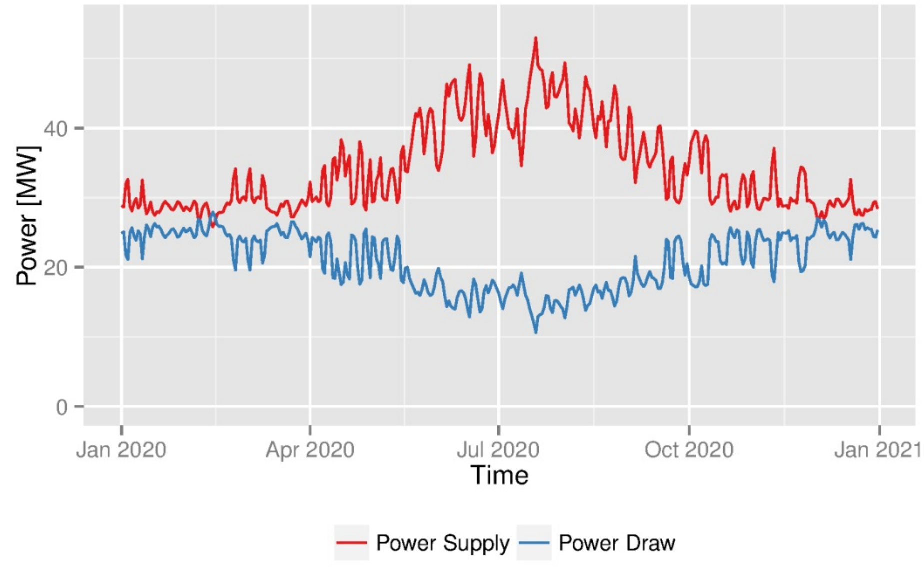
- Integration of energy-shifting DR in Colorado
  - Hourly dispatch
  - Management of system imbalance from load and renewables
- Colorado Power System:
  - 13.7 GW (peak), 79TWh (annual load)
  - 50% *inflexible* generation, 16% renewables (wind and PV 5:1)

fakta 482 (30 kW) føtex 178 (50 kW) Bilka 140 (80 kW)

800 stores

Peak Load Shed: 50 MW

System Share: 0.25% (max)



Source: O'Connell *et al.*, 2015

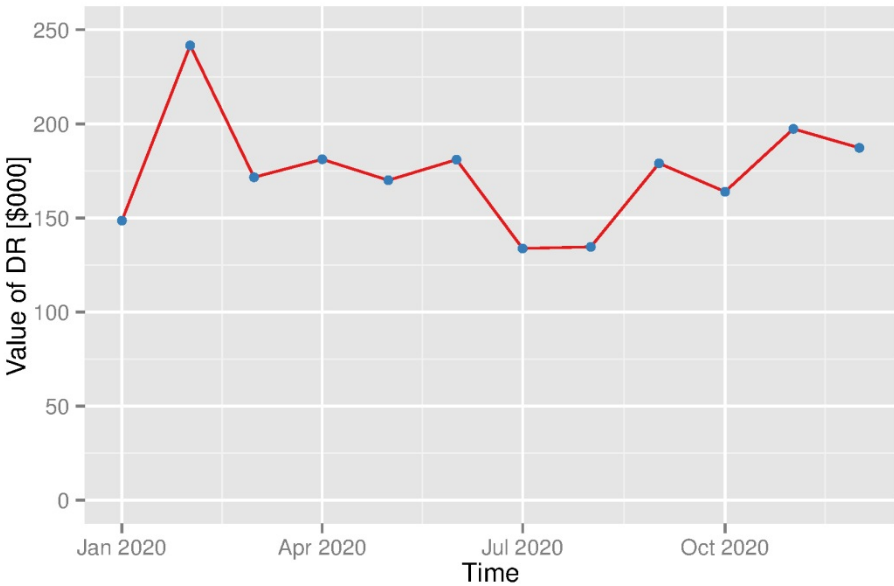
Results

- Caveat:
  - Single DR resource type, single market/product, results are system dependent

- Headline results:
  - Reduces total system costs by 0.014% ($2.1 million)
  - Reduces cost of re-dispatch at real-time by 4.8%
  - Per-unit Value: $32.85/kW-year
  - Achieved through:
    - Reducing curtailment of renewables
    - Supporting more efficient, less flexible generation (Gas CC and Coal)

Results

Somewhat seasonal value

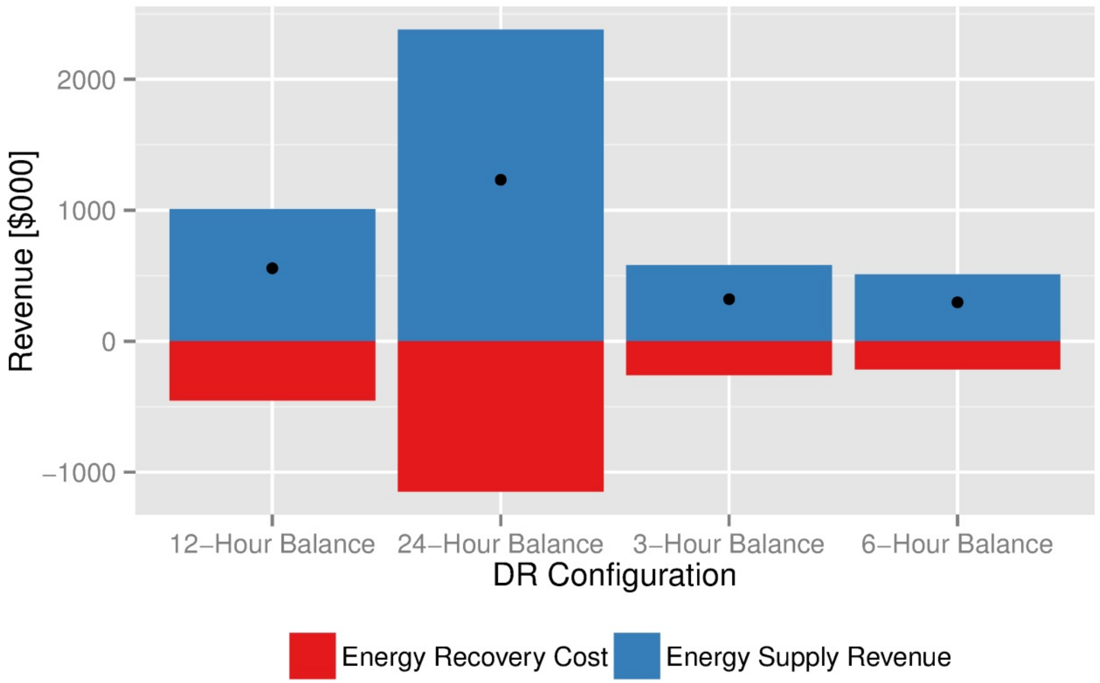


No clear seasonal trend in revenue

Source: O'Connell *et al.*, 2015

Results

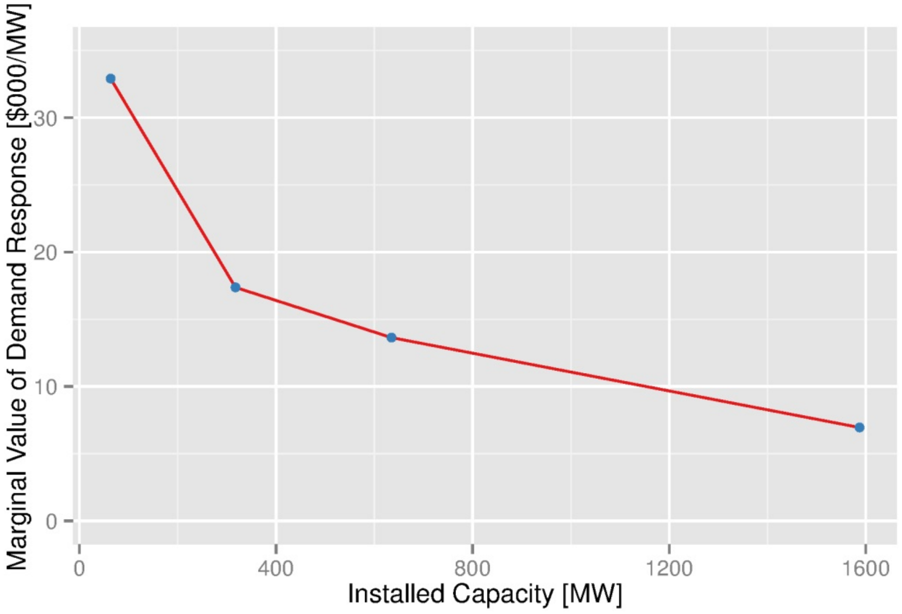
Preference for longer horizon products

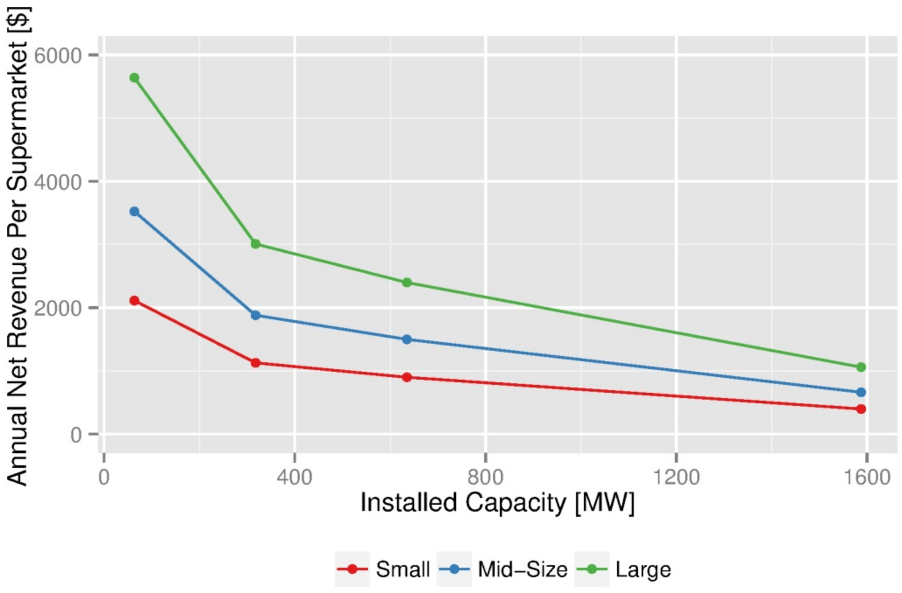


Source: O'Connell *et al.*, 2015

Sensitivity Studies: DR Resource Size

Decreasing marginal value and revenue with increasing DR resource

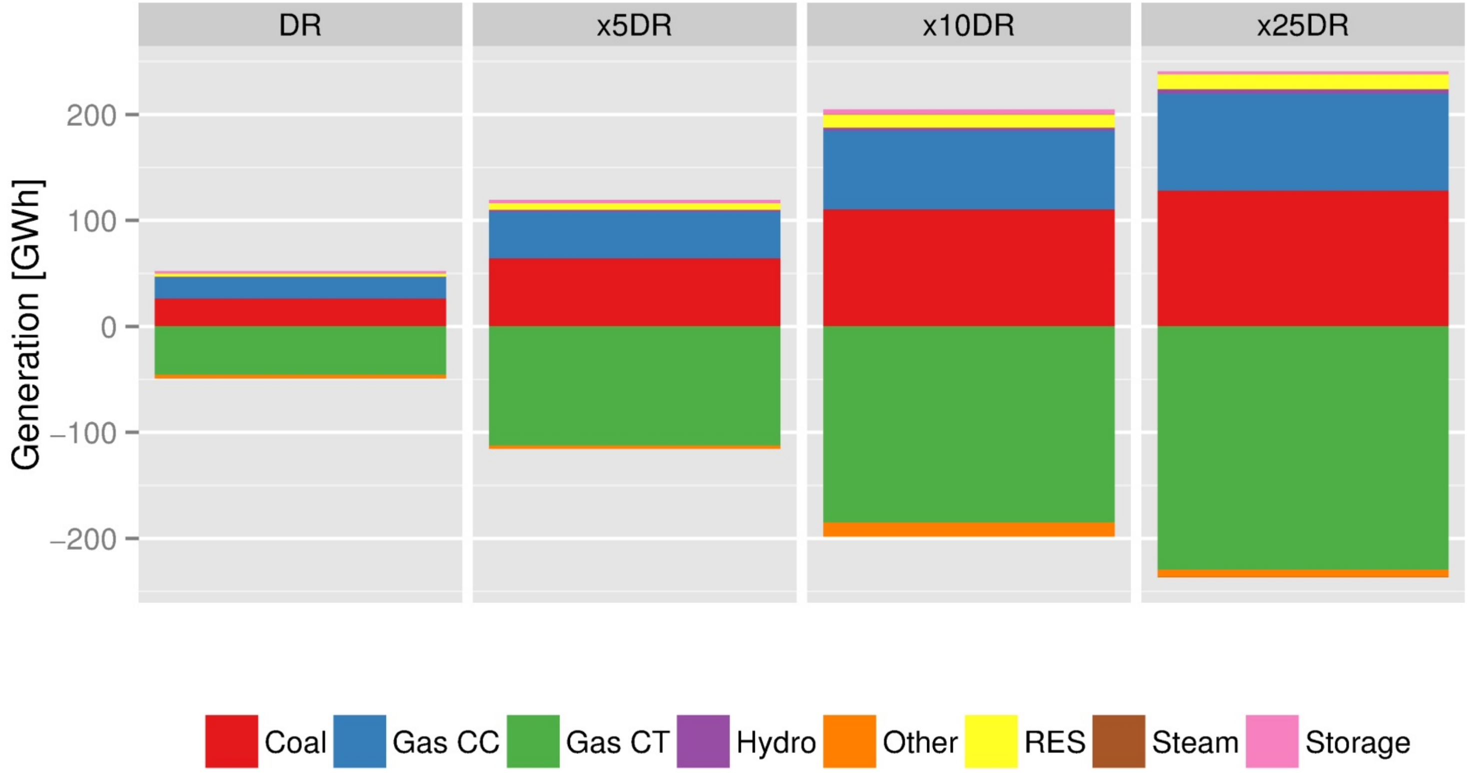




Source: O'Connell *et al*., 2015

Sensitivity Studies: DR Resource Size

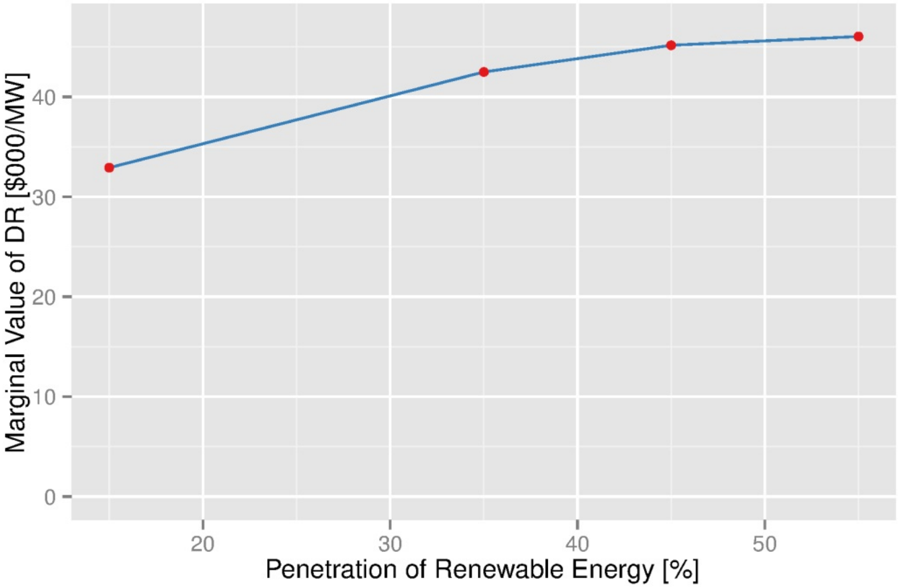
Supports more efficient, but less flexible generation, and renewables



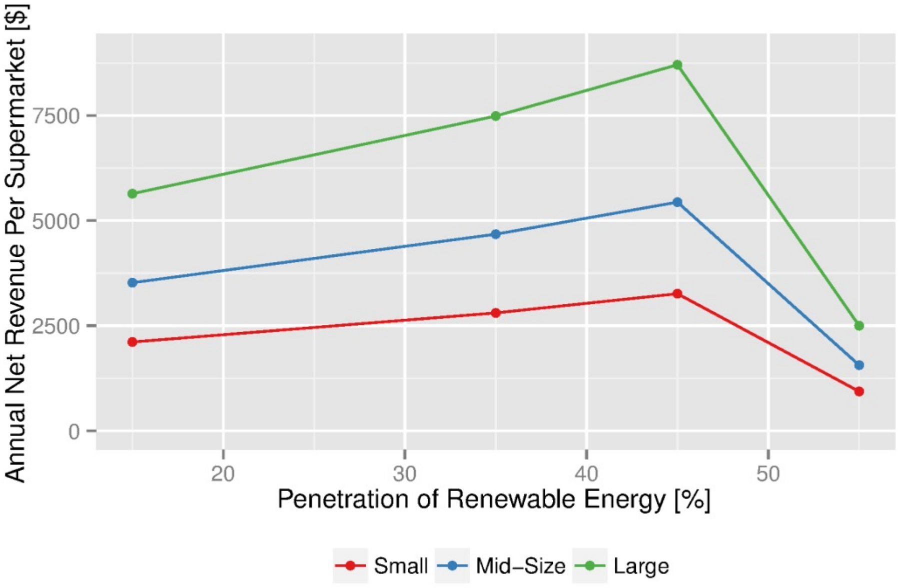
Source: O'Connell *et al.*, 2015

Sensitivity Studies: RES Penetration

Increasing, but saturating value



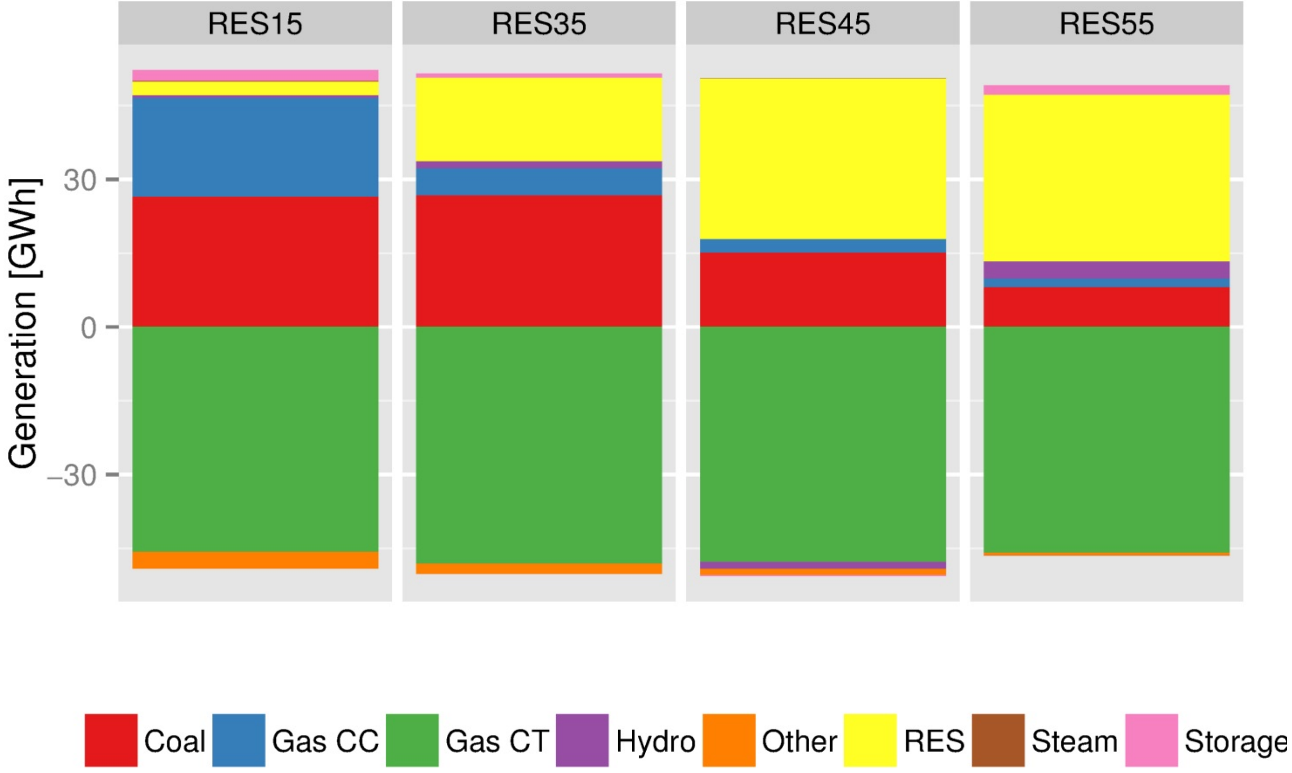
Peaking revenue



Source: O'Connell *et al.*, 2015

Sensitivity Studies: RES Penetration

Moves from supporting efficient fossil fuels to reducing curtailment of renewables



Key Take-Away Points

- Necessary to model DR with a degree of detail, even (especially) for large scale studies, simplifications must be balanced with maintaining acceptable representation of resource.
  - Assess value, resource revenue, sensitivity, risk
  - Evaluate need for incentives

- Value of DR primarily comes from displacement of expensive, flexible, fossil generation, coupled with avoided curtailment of renewables.

- Supermarkets have the potential to provide DR, but their magnitude is small, and they need to cooperate with other resources to overcome steep drop-off in per-unit value.
  - Revenue per supermarket is also low, possibly necessitating incentive payments.

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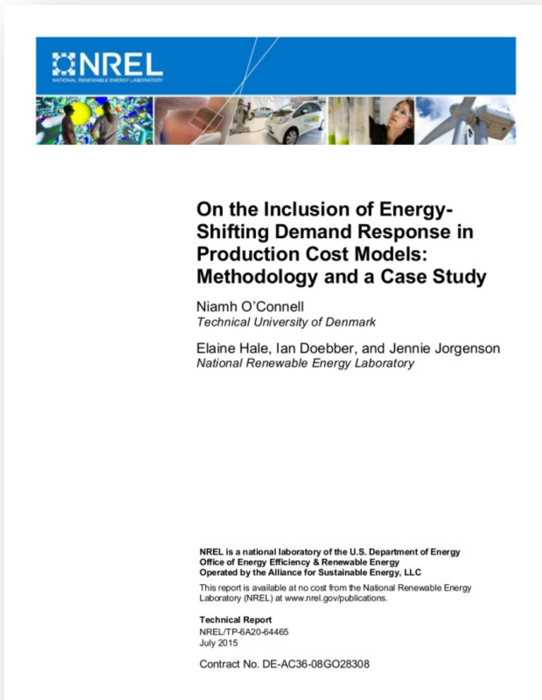

NREL NATIONAL RENEWABLE ENERGY LABORATORY

On the Inclusion of Energy-Shifting Demand Response in Production Cost Models: Methodology and a Case Study

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Office of Energy Efficiency & Renewable Energy
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http://www.nrel.gov/docs/fy15osti/64465.pdf