## 0000 **Reduction of Curtailment** 0000 by Residential DSM –Secondary Effects on Electricity Markets

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## Outline



Residential Demand-Side Management for Curtailment Reduction Approaches for Quantifying Market Effects of Load Shifting Modelled Prices and Price Changes

Summary

# Residential Demand-Side Management for Curtailment Reduction

### Curtailment of Renewables

- Increasing installed capacity of volatile renewables (solar, wind)
- Curtailment of generation which exceeds grid capacity
- Potentially improved integration of renewables by reduction of curtailment
- Reduction possible by load increase

Residential Demand-Side Management

- Variable electricity rates as incentives for flexible operation times of household appliances
- Load increase possible by load shifting from noncritical time intervals
- Dishwashers, washing machines and dryers considered here as flexible appliances





## Quantifying Market Effects – Modelling of Shifted Load Curves



# Quantifying Market Effects – Approaches to Price Modelling



Deman Supply





**Price Modelling** 2500 2000 Price (€/MWh) 1200 500 Spot Market Bid Curves Energy System Model -500 Simulation of the whole Adjustment of real 15 market data energy system **Lice (€/WWh**) 20 15 Linear optimization Market clearing price • model of the energy calculated via intersection of bid system Calculating of market curves 25 prices based on Inserting new bids or • deleting existing bids marginal costs of represents additional power plants Adjusted load curve or removed supply or as input yields new demand New intersection prices

yields new price



# Quantifying Market Effects – Adjustment of Bid Curves



## Modelled Prices – Base Case for Both Approaches



### **Results** • Mean price differs considerably

• Substantial differences regarding standard deviation and price spreads

### Conclusions

• Varying mean prices may be caused by different reference years

- Differences in standard deviation suggest that the energy system model does not fully represent price characteristics
- Confirmed by analyses of spreads: generally too low, no scarcity prices

Modelling Approach	Model	Curves
Mean price (€/MWh)	42.39	34.20
Standard deviation (€/MWh)	8.88	17.66
Maximum daily price spread (€/MWh)	38.05	114.69
Mean daily price spread (€/MWh)	12.78	30.57
Minimum daily price spread (€/MWh)	0.00	8.13

## Modelled Prices – Effects of Curtailment-Driven Load Shifting



Scenario (Energy System Model)	Base	5.4 %	10.8 %	16.2 %
Mean price (€/MWh)	42.39	42.39	42.39	42.39
Standard deviation (€/MWh)	8.88	8.88	8.88	8.88
Maximum daily price spread (€/MWh)	38.05	38.05	38.05	38.05
Mean daily price spread (€/MWh)	12.78	12.78	12.78	12.78
Minimum daily price spread (€/MWh)	0.00	0.00	0.00	0.00

Scenario (Spot Market Bid Curves)	Base	5.4 %	10.8 %	16.2 %
Mean price (€/MWh)	34.19	34.19	34.19	34.19
Standard deviation (€/MWh)	17.66	17.65	17.63	17.62
Maximum daily price spread (€/MWh)	114.69	115.55	116.41	117.35
Mean daily price spread (€/MWh)	30.57	30.44	30.35	30.28
Minimum daily price spread (€/MWh)	8.13	8.13	8.13	8.13

Results	•	No observable differences in the energy
		system modelling approach

- Mean price in bid curve modelling constant for all scenarios
- Slight smoothing effect on price characteristics
- Increased maximum price spread
- **Conclusions** Energy system model not suitable for quantifying effects of small load changes
  - Adjustment of bid curves allows plausible modelling of price changes
  - Standard deviation and mean daily spread show load shifting from high to low prices
  - Generally, effects are rather small to negligible

## Summary



#### Motivation

- Grid congestion due to high generation from renewables is avoided by curtailment
- Load shifting as an alternative for increased integration of renewables
- Potential effects of shifted load on market prices

#### Methods

- Modelling of load shifting by modification of measured load profiles
- Comparison of two approaches to price modelling: energy system modelling vs. adjustment of bid curves
- Evaluation of different scenarios

#### **Results & Conclusions**

- Energy system model not suitable for modelling price effects of small load changes
- Bid curves allow plausibly quantifying price effects
- Differences compared to base case still low
- No crucial aspect in the design of variable rates



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