



# Cost Reduction Potentials in the German Market for Balancing Power

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**Transmission system operator (TSO)**

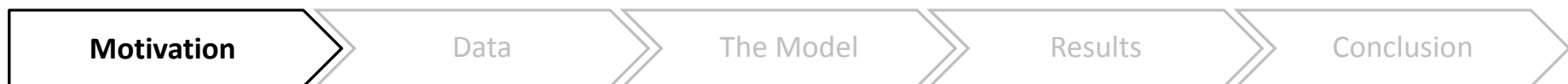
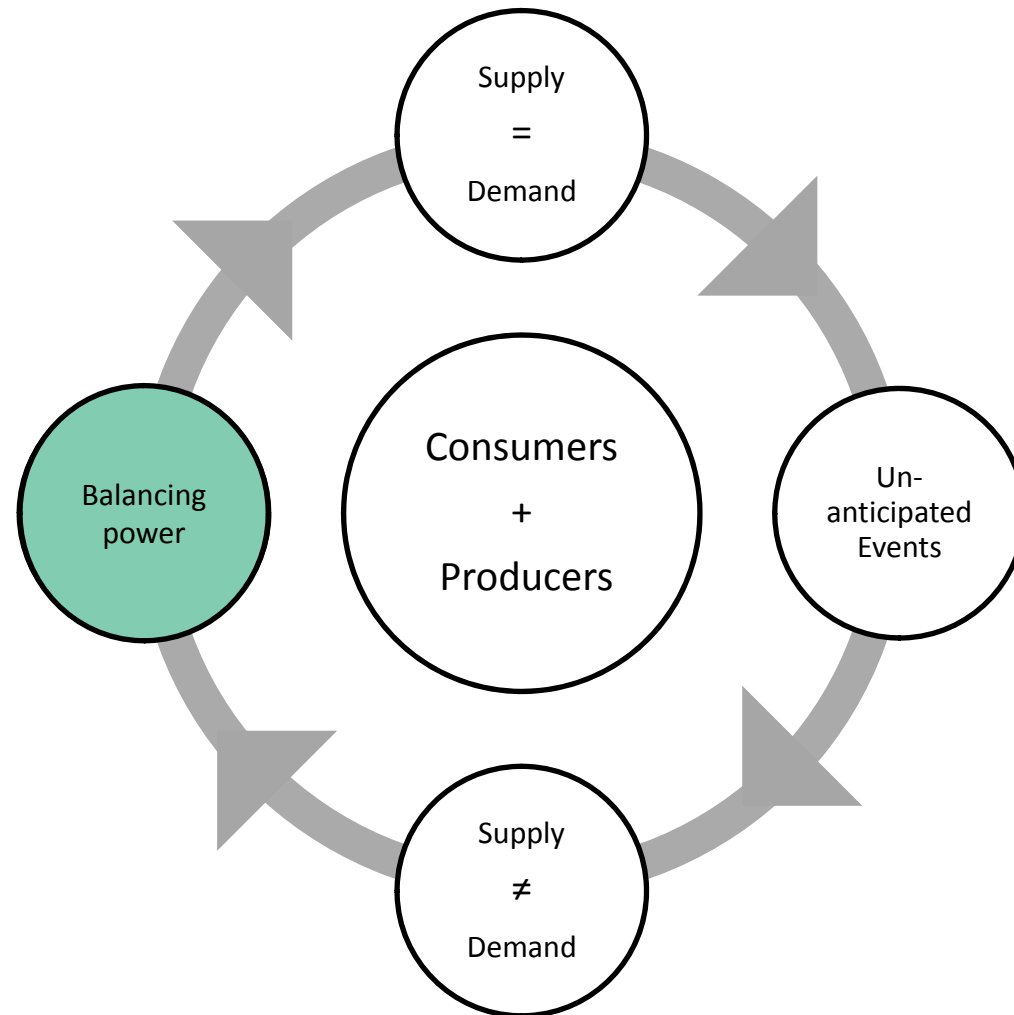
- Provides ancillary services
- Monopsony

**Three types of balancing power**

- Primary balancing power
- Secondary balancing power
- Tertiary balancing power

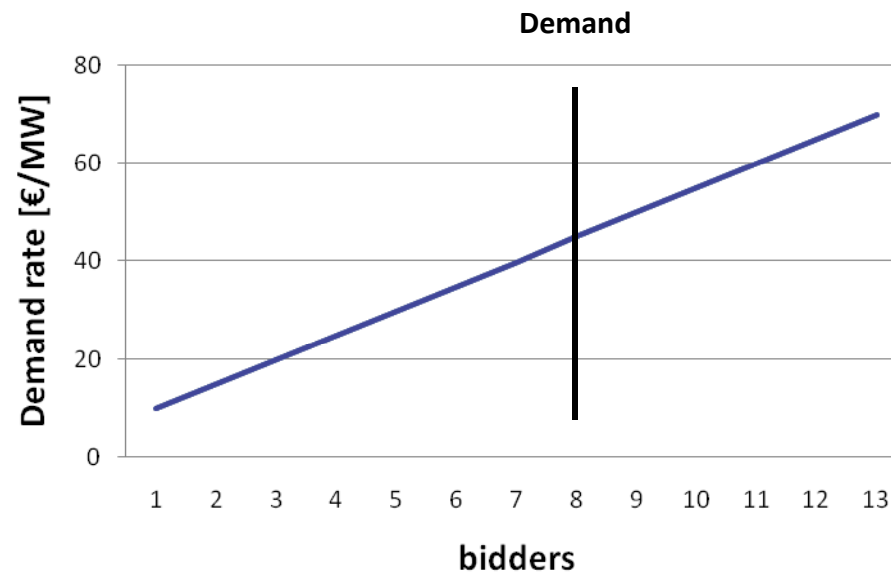
**Control areas**

- Four areas:  
EnBW, e.on, RWE, Vattenfall
- Each area is controlled separately



# Procurement of balancing power

1. TSO specifies demand
2. TSO buys quantities by auction
3. Suppliers submit bids (demand rate, energy rate)
4. TSO orders bids by demand rate (*scoring rule*)



Motivation

Data

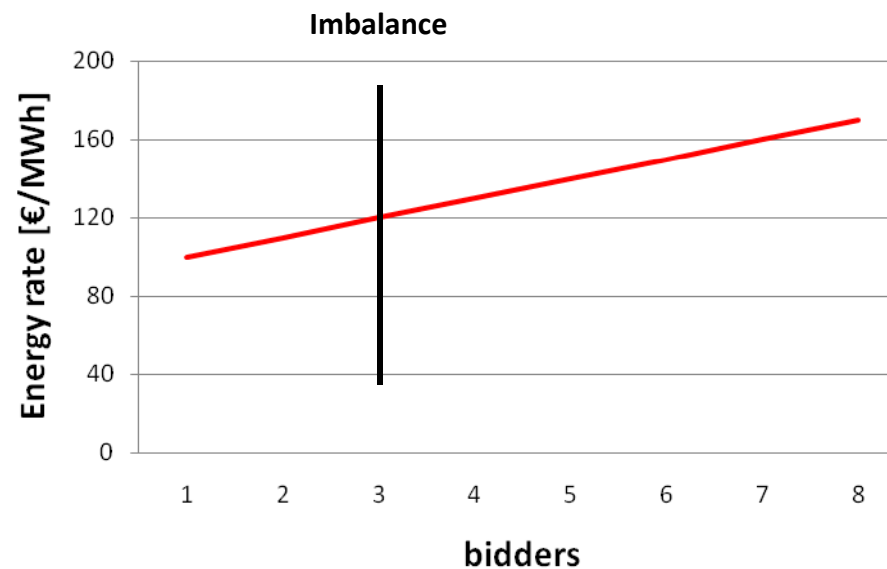
The Model

Results

Conclusion

# Activation of balancing power

1. Control area imbalance occurs
2. TSO orders suppliers by energy rate (*settlement rule*)



Motivation

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# Cost reduction potentials

1. Effect: **Netting antipodal use of balancing power**



2. Effect: **More efficient procurement auctions**



3. Effect: **Less provision of balancing power**



**Motivation**

Data

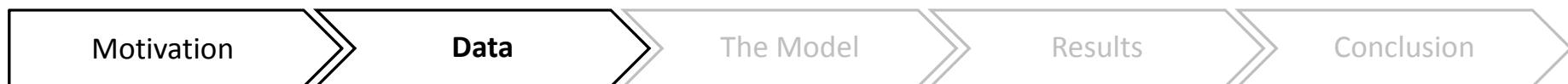
The Model

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# Data

- Observed Period
  - 12 months
  - Dec 2007 – Nov 2008
- Source
  - Websites of TSOs
- Two distinct datasets
  1. Auction data (bids from procurement auctions)
  2. Activation data (power flows)



# 1. Auction Data

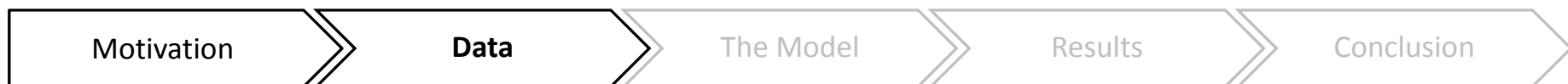
## Primary Balancing Power

### Secondary Balancing Power

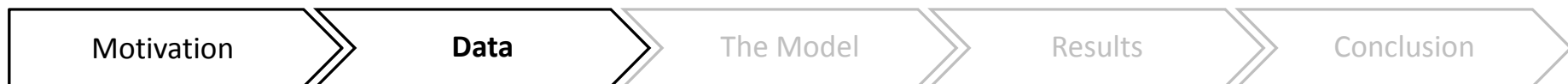
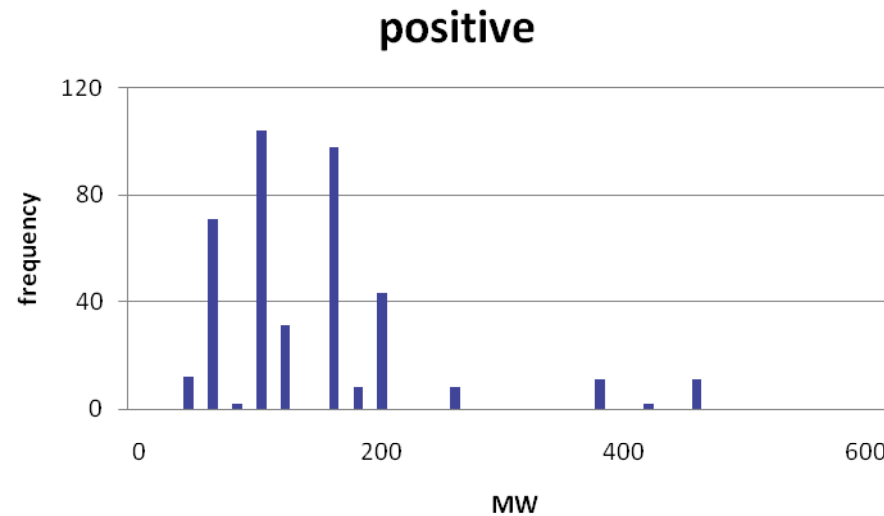
- Bids are valid for 1 month
- Positive / negative
- Peak- / offpeak

### Tertiary Balancing Power

- Bids are valid for 4 hours
- Positive / negative



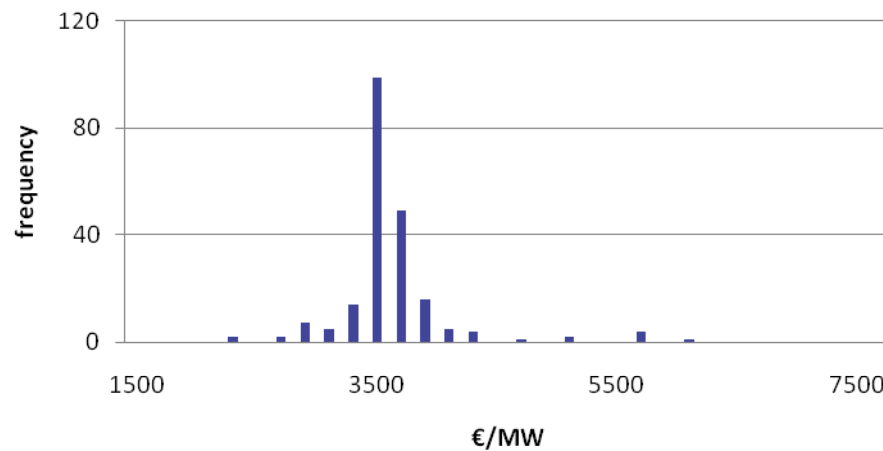
# Secondary balancing power: Bid sizes



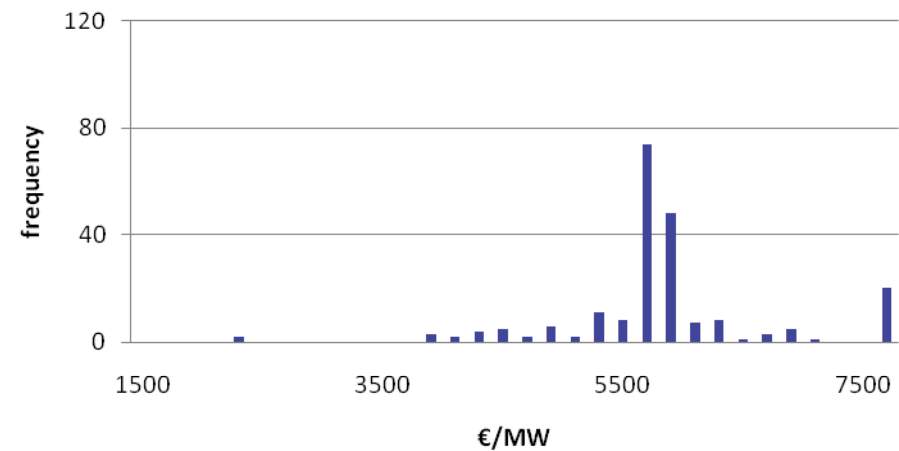


# Demand rates

offpeak, positive



peak, positive



Motivation

Data

The Model

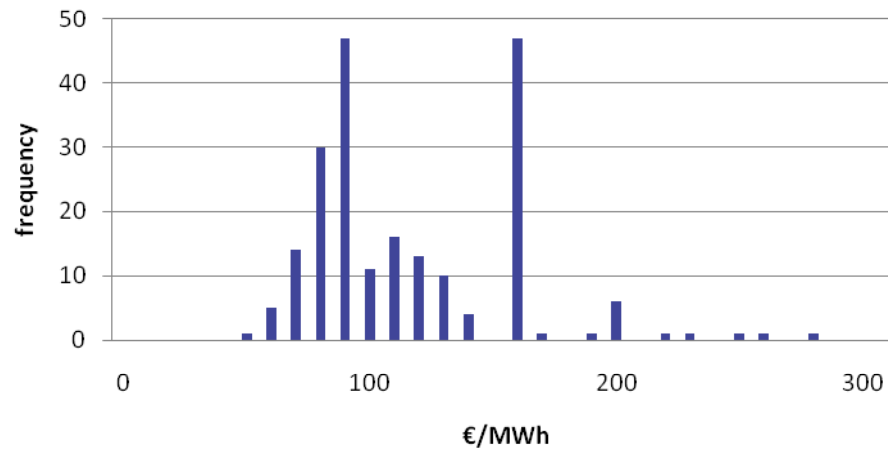
Results

Conclusion

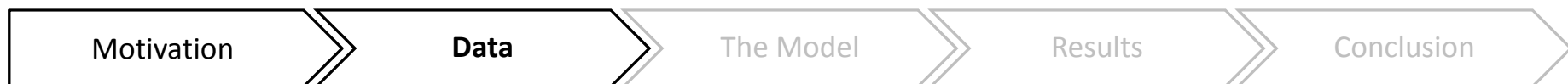
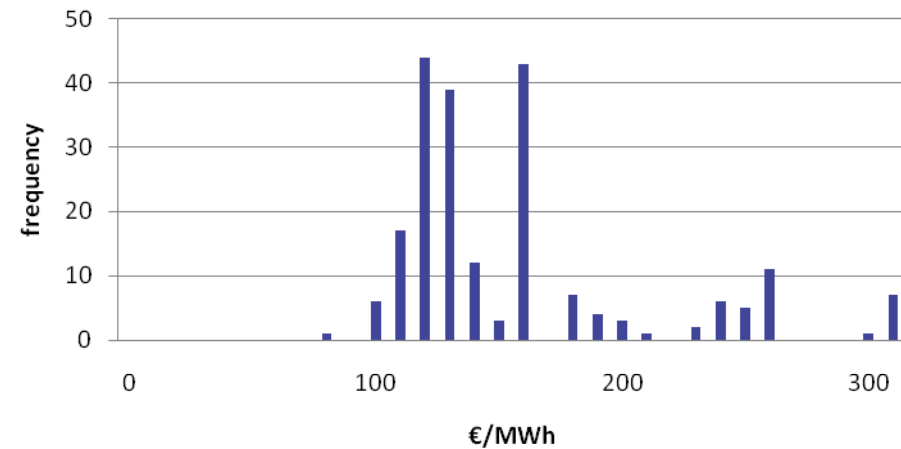


# Energy rates

**offpeak, positive**



**peak, positive**

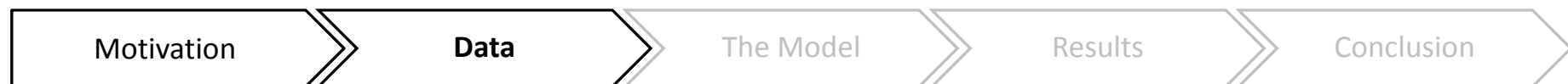


## 2. Activation Data

Actual power flows

Data frequency

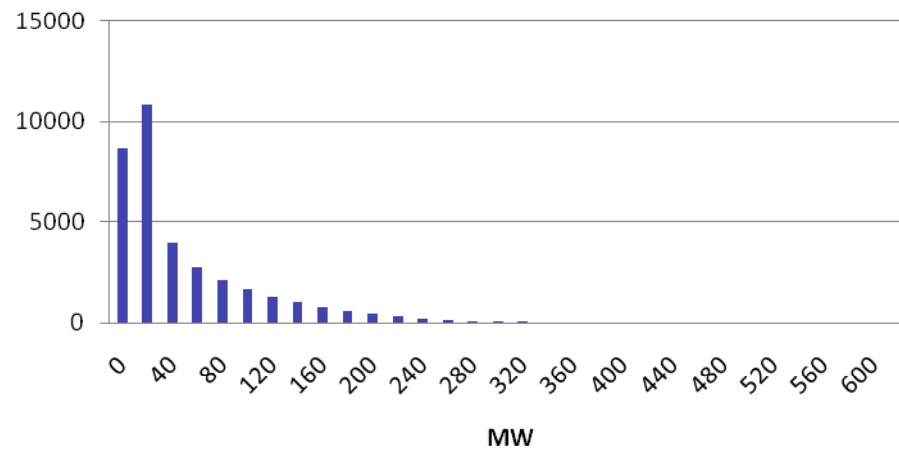
- Quarter of an hour
- 35,136 observations



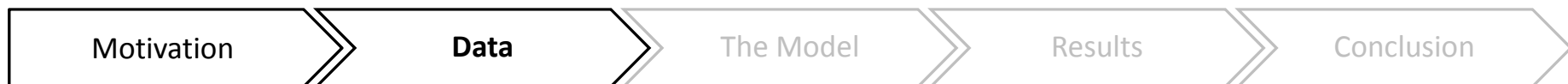
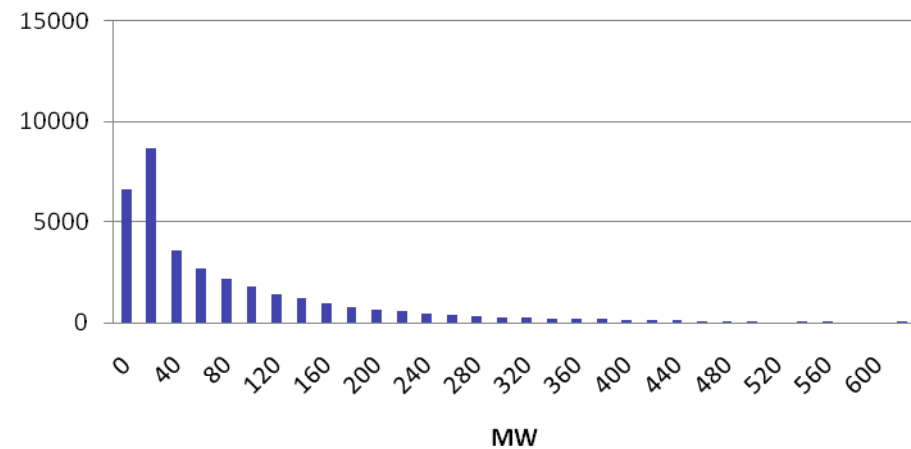
# Secondary balancing power [MW]

## EnBW

positive



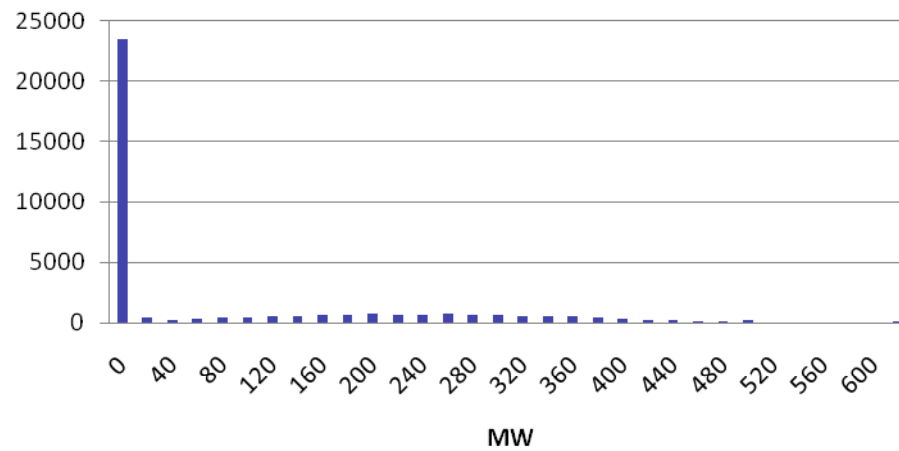
negative



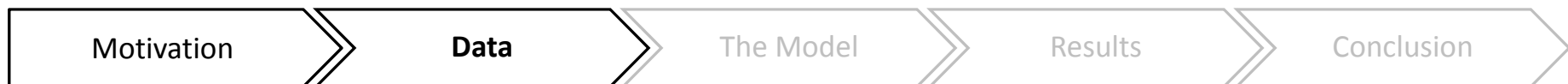
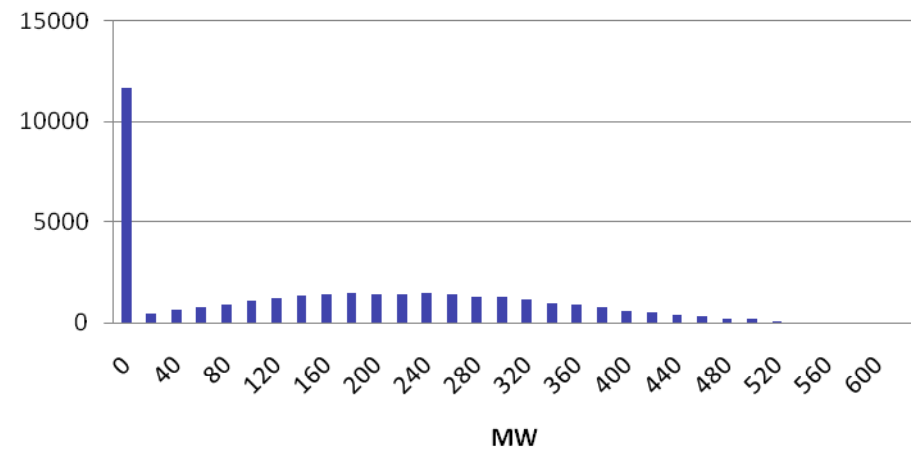


# e.on

positive



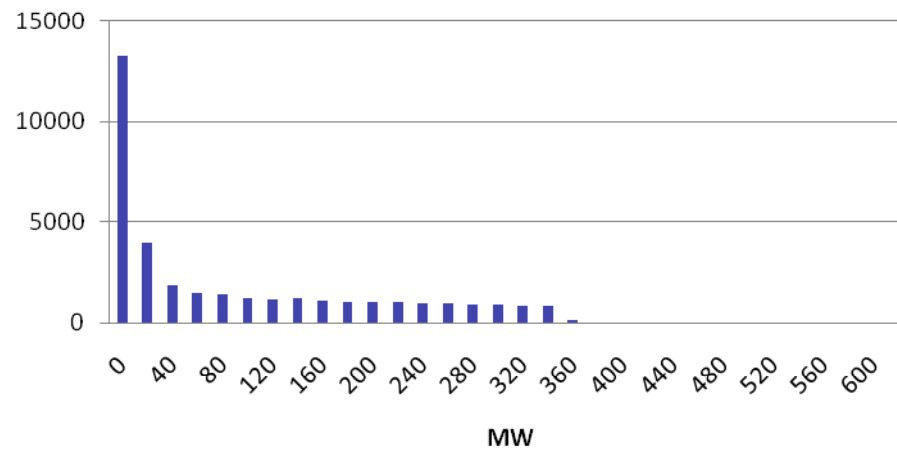
negative



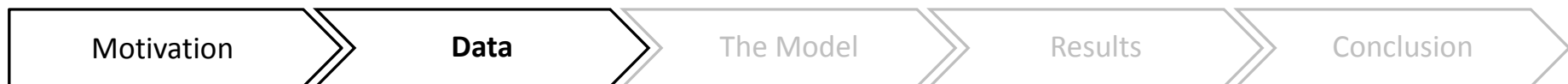
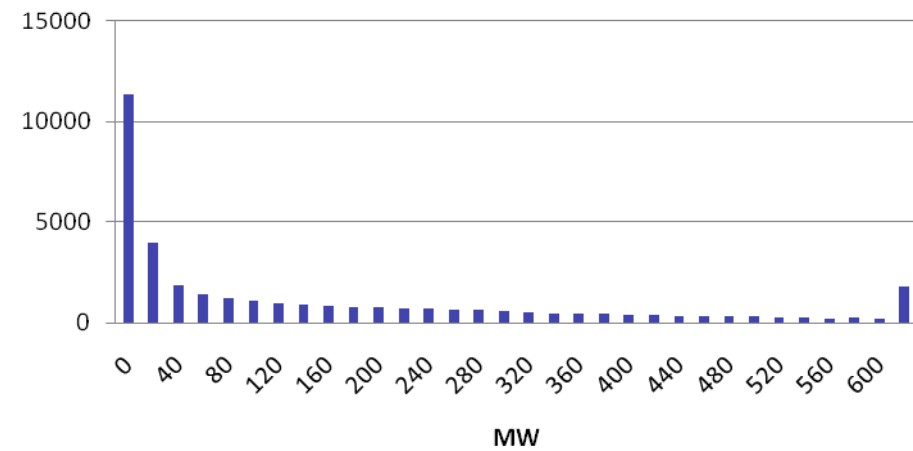


# RWE

positive



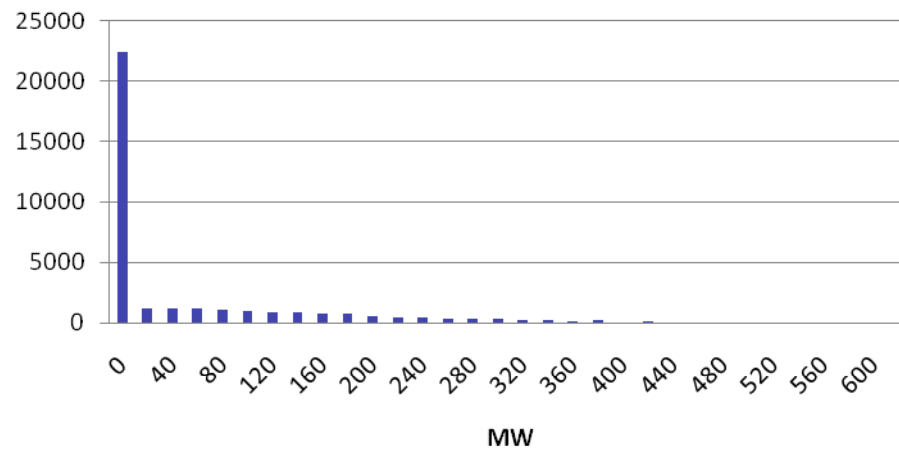
negative



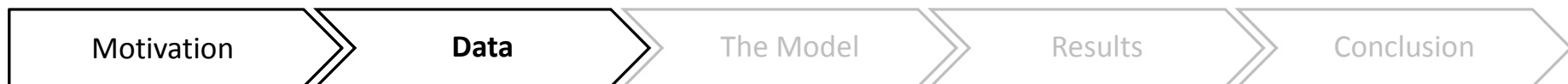
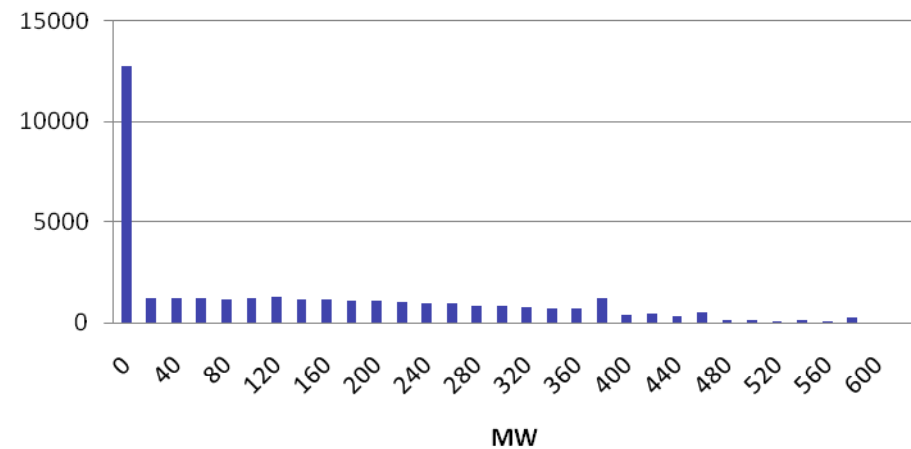


# Vattenfall

positive



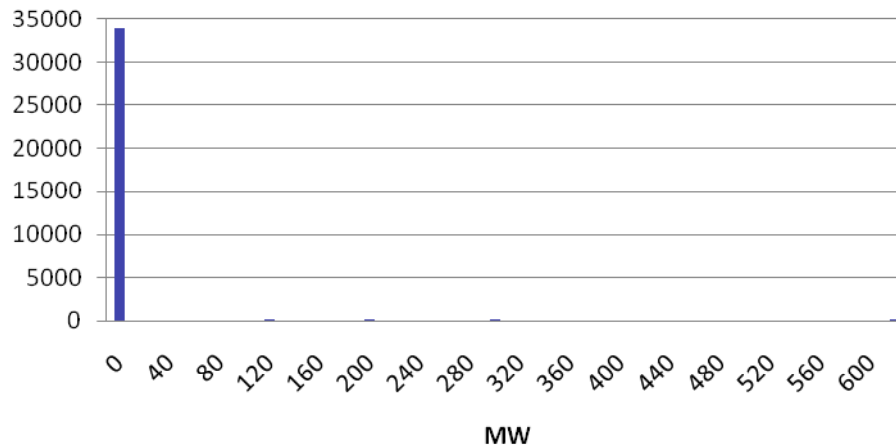
negative



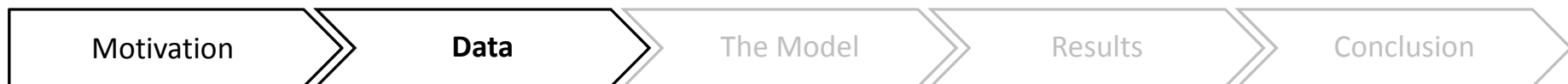
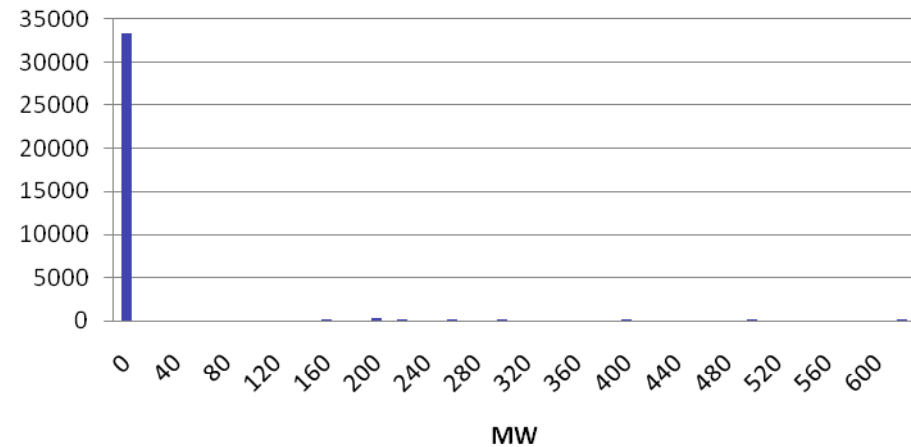
# Tertiary balancing power [MW]

## RWE

positive



negative





Market design is known

- Scoring Rule
- Settlement Rule
- Control Areas

Data is available

- Auction Data
- Activation Data

**Simulation of the market for balancing power with GAMS**

- **Scenario 1: Status quo**
- **Scenario 2: One united control area**

Motivation

Data

**The Model**

Results

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# Testing the model

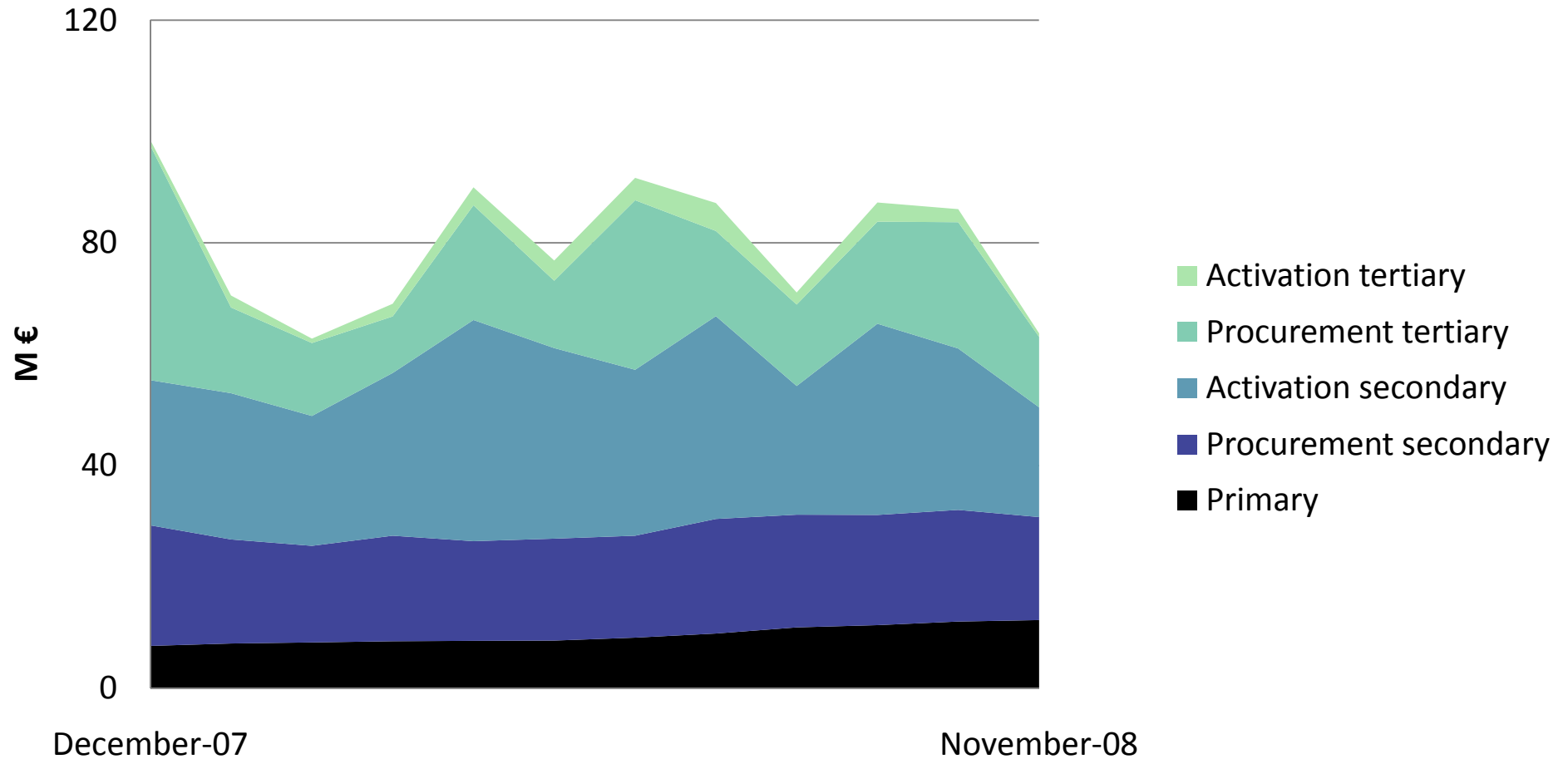
- Technical restrictions
- Data frequency
- Model specification

Average weighted energy rates:

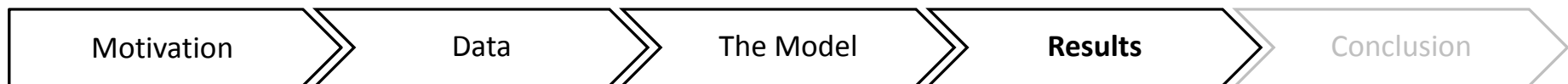
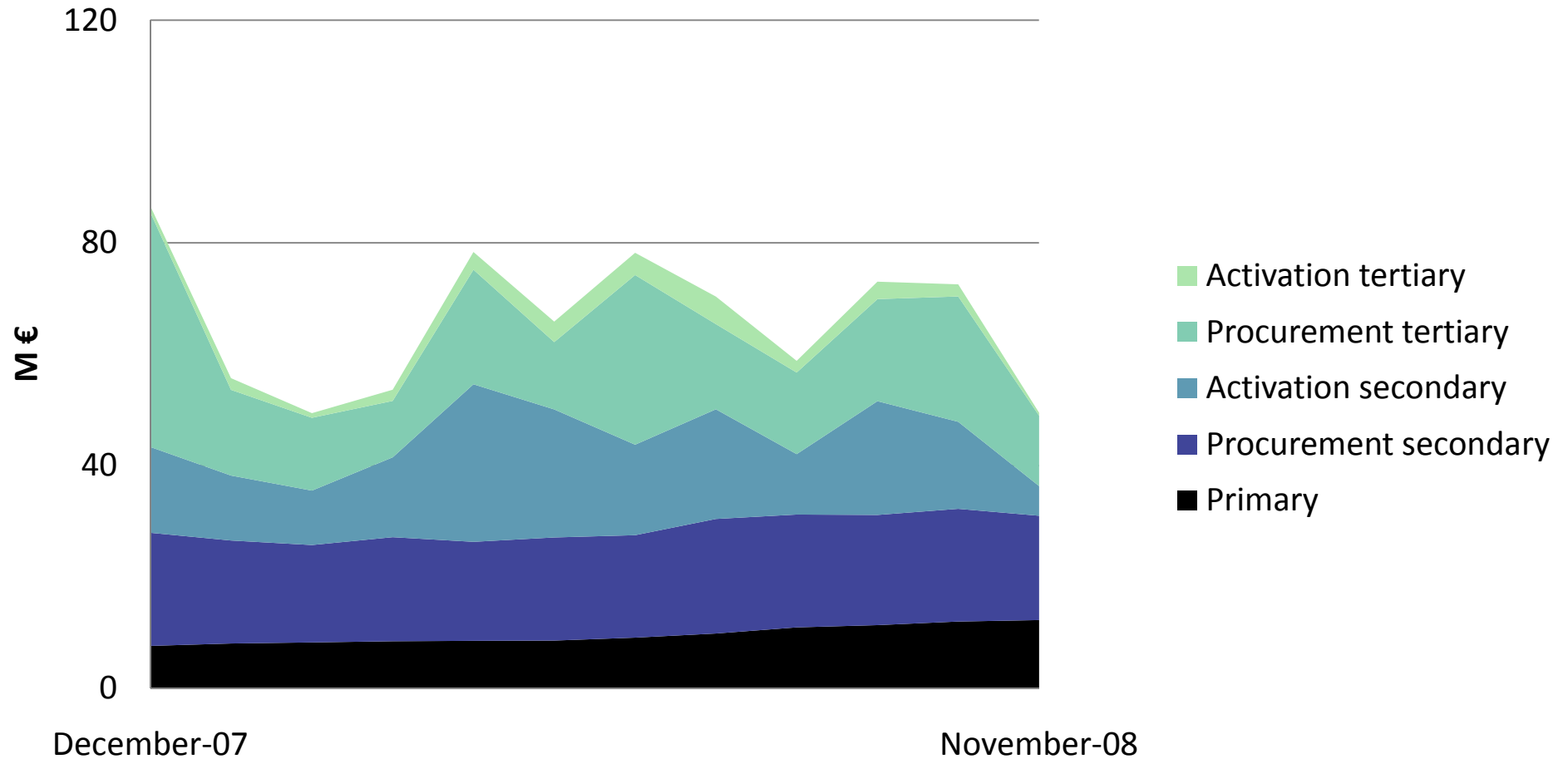
	AWER ENBW		AWER EON		AWER RWE		AWER Vattenfall	
	DATA	SIM	DATA	SIM	DATA	SIM	DATA	SIM
Mean	60.10	58.24	36.74	36.43	52.40	49.09	53.02	47.19
Median	61.00	61.00	0.00	0.00	2.00	2.00	3.00	2.75
Correlation	0.98		0.99		0.97		0.97	



### Scenario 1: "status quo"

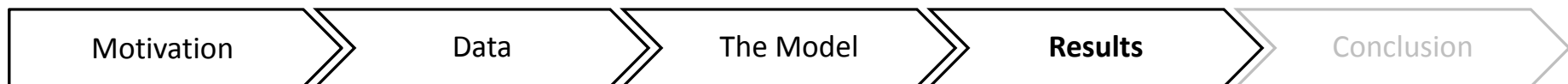


## Scenario 2: United control area



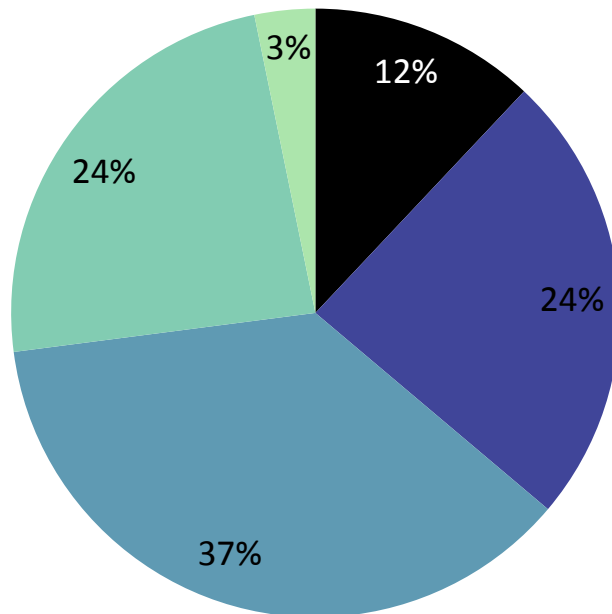
# Comparison of absolute levels

	Primary	Secondary		Tertiary		Sum
		Procurement	Activation	Procurement	Activation	
Scenario1 (M€)	114.8	230.4	351.3	227.5	30.7	<b>954.8</b>
Scenario2 (M€)	114.8	229.4	190.6	227.3	29.8	<b>792.1</b>
difference	0.00%	-0.43%	-45.72%	-0.07%	-3.06%	<b>-17.04%</b>

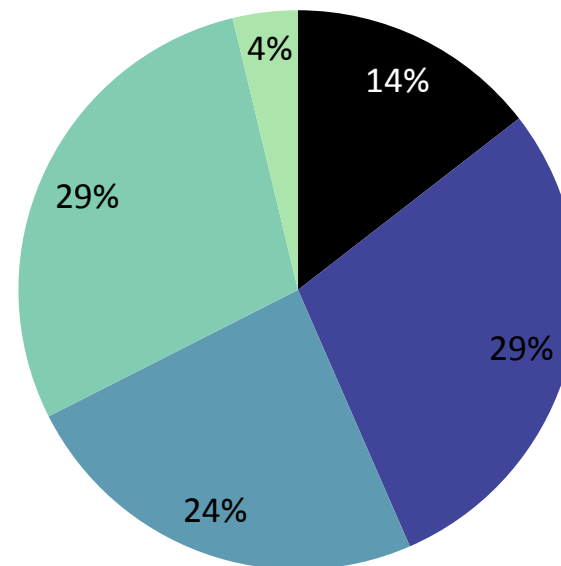


# Comparison of shares

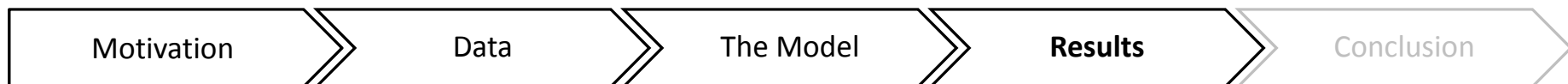
Scenario 1



Scenario 2



- Primary
- Procurement secondary
- Activation secondary
- Procurement tertiary
- Activation tertiary





### Conclusion

- When sufficient grid capacity is assumed, antipodal use of balancing power is inefficient
- Netting area imbalances → major cost reductions (160 M€)
- This is mostly on account of secondary balancing power

### Further research

- Co-operation of e.on, EnBW and Vattenfall
- Efficiency of scoring rule and settlement rule

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# Backup

# Model sequence

## Step 1: Procurement

- Scoring rule:  $PC = \min! \sum_b \sum_t \sum_c dr_{b,t,c} \cdot m_{b,t,c}$
- s.t.  $\sum_b m_{b,t,c} = \bar{m}_{t,c}$

## Step 2: Activation

- Settlement rule:  $AC = \min! \sum_b \sum_t \sum_c er_{b,t,c} \cdot x_{b,t,c}$
- s.t.  $\sum_c x_{b,t,c} \leq \sum_c m_{b,t,c}$
- and  $\sum_b x_{b,t,c} = CAI_{t,c}$



	AWER ENBW		AWER EON		AWER RWE		AWER VET	
	DATA	SIM	DATA	SIM	DATA	SIM	DATA	SIM
Mean	60.101	58.240	36.749	36.434	52.404	49.094	53.027	47.192
Median	61.000	61.000	0.000	0.000	2.000	2.000	3.000	2.750
Maximum	475.000	289.370	322.000	282.060	599.000	331.760	501.000	262.190
Minimum	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Correlation	0.984		0.993		0.977		0.975	
Obs.	35136	35136	35136	35136	35136	35136	35136	35136

Table 3: Descriptive statistics of average weighted energy rates

## Co-operation of EnBW, e.on and Vattenfall

- December 2008      Reduction of antipodal use
- May 2009            Reduction of procurement
- June 2009            Prequalification for united control area
- October 2009        Joint merit order

# Literature Review

Haubrich (2008): Gutachten zur Höhe des Regelenergiebedarfs

- Computation of the potential economies of scope of a united control area
- Result: Provision of balancing power could be reduced by 400 MW (positive) and 1000 MW (negative)
- Effect not included in our article

LBD-Beratungsgesellschaft (2008): Untersuchung des Einsparpotentials bei der regelzonenübergreifenden Saldierung

- Computation of the netting-effect in a united control area
- Result: Cost reductions of 314 million euros are possible
- Results are based on average weighted energy rates

Motivation

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