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Instruments for high shares of renewables: An analysis of flexibility incentives

M. Pahle, W.-P. Schill (DIW),
C. Gambardella & O. Tietjen

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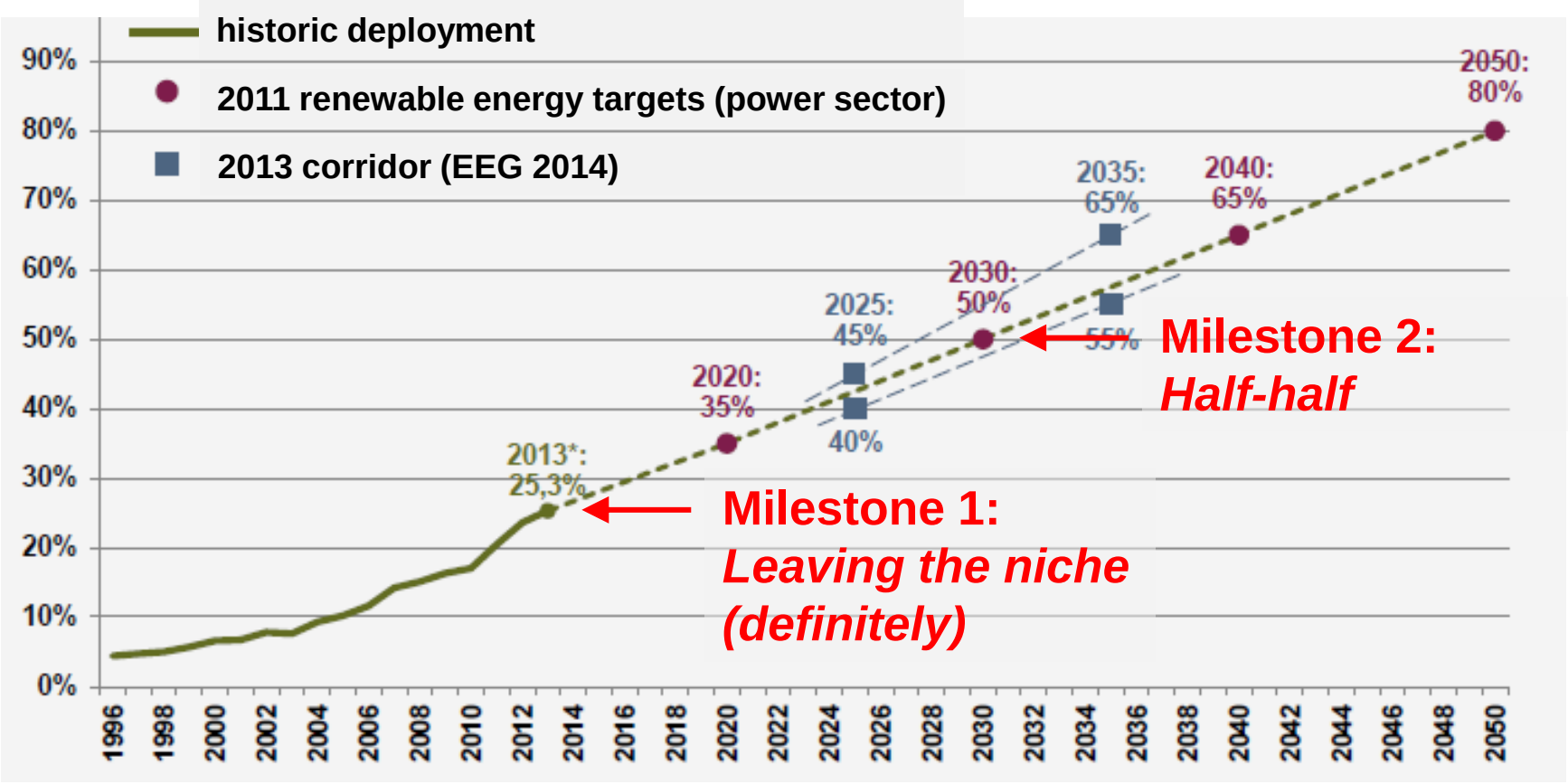
PROJECT

Power Market Design Project

- Project on “Power market design for high shares of renewables”
- Funded by Stiftung Mercator & Agora Energiewende
- Partners: PIK, DIW, BTU, Universities of Cologne & Maryland
- Approach: *Do not aim for fleshed out design, but give main issues more thinking (evolutionary perspective)*
- In this session three selected papers (focus on flexibility), but there are more!
- Final workshop in autumn 2015

INTRODUCTION

Energiewende renewables target



Adapted from BDEW (2014)

Which instrument for Milestone 2?

- **Requirements** (Coalition agreement 2013)
  - Increasingly **integrate RES into the market**
  - In the long-run **no additional payments**
- By and large **four instruments**:

	Market Integration	No additional payments
Market premium (Energy)	✓	✗
Market premium (Capacity)	✓	✗
~~Quota Scheme~~	~~✓~~	~~✗~~
Carbon price (indirect)	✓	✓

- **Justification aside**, how to **choose** among them?

Considerations for instrument choice

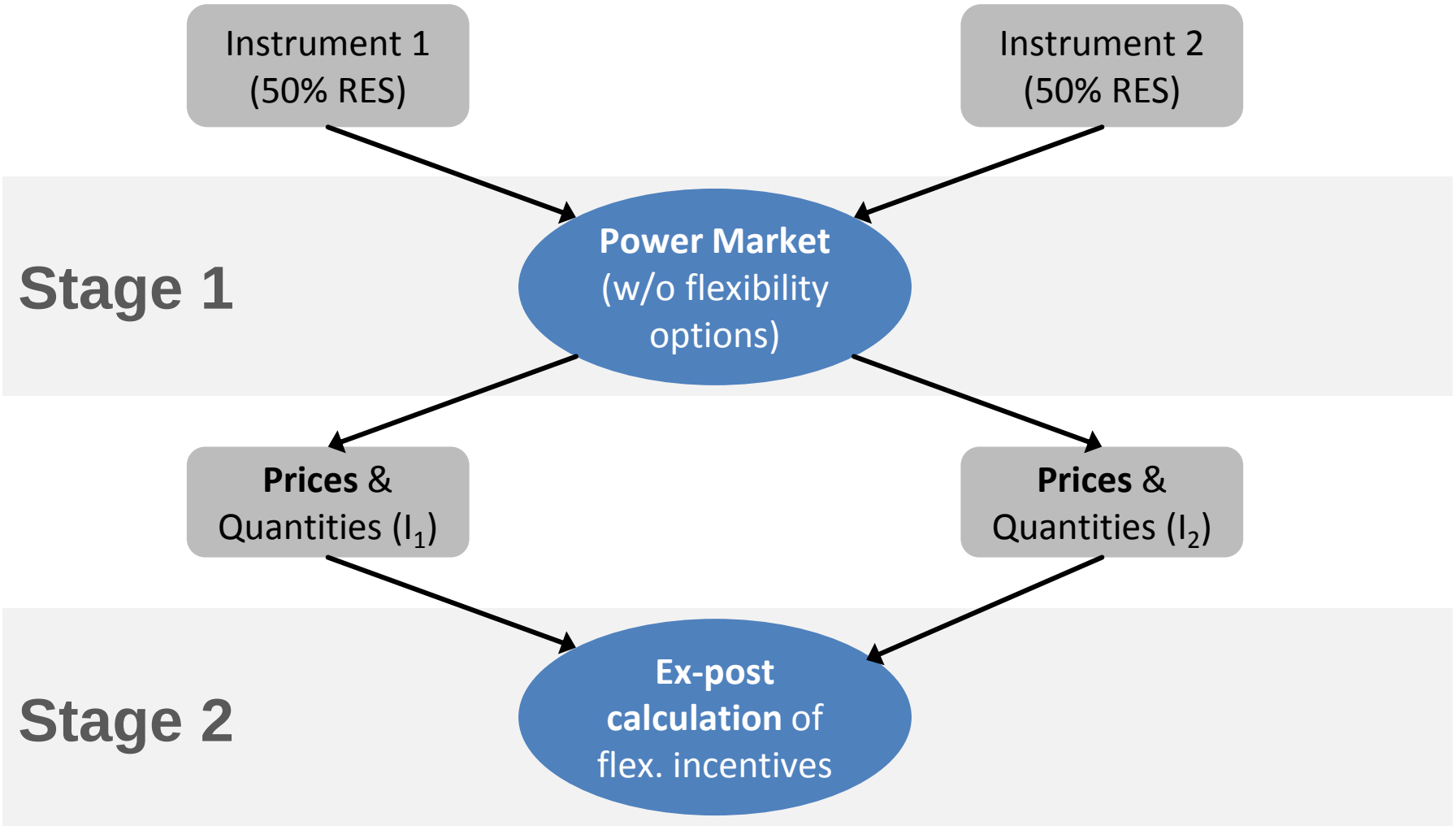
1. **Cost-effectiveness**
2. Effects related to **uncertainty & risk,** e.g. project finance
3. Creation of **incentives** to deploy **flexibility options** (storage & DSR) via price effects

→ This work **focuses on (3)**, complementary project work on (2) by Pahle & Schweizerhof (2015)

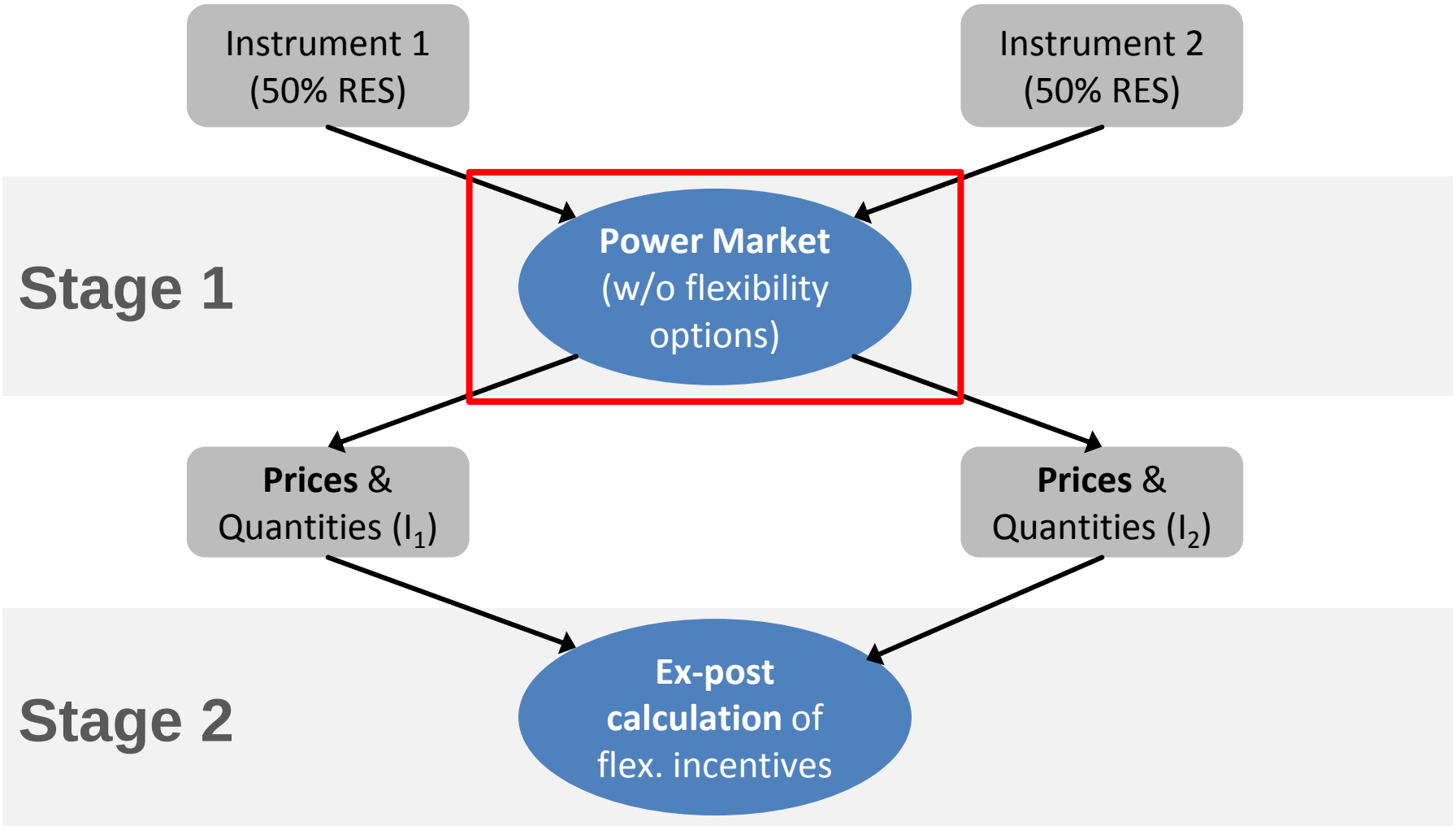
- But why bother? Flexibility options likely to be of **high value** for increasing RES shares
- But genuine incentive is power price, so it is more about **interaction**

APPROACH & METHODS

Overview of approach



Overview of approach



Stage 1: Power market model

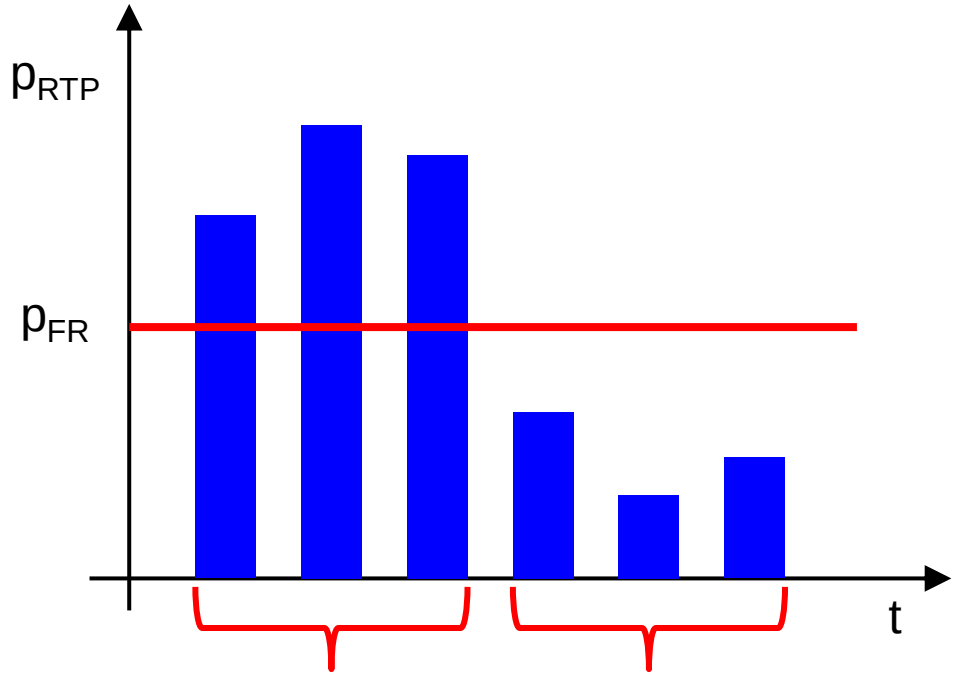
- Decentralized (MCP) long-term market model (*q*,*I*;*p*)
- **Greenfield approach** with no existing capacities
- **Semi-stylized** parametrization using **German** data
  - **Five technologies:** base, mid, peak & wind onshore, solar pv
  - **No** interconnected markets, start-up/ramping costs…

→ Focus is on "plausible" quantifications of **instrumental effects**, not on "realistic" optimal technology mix!

- But **realistic demand representation**: flat rate (FR) & real time pricing (RTP) consumers (Borenstein & Holland 2005)…

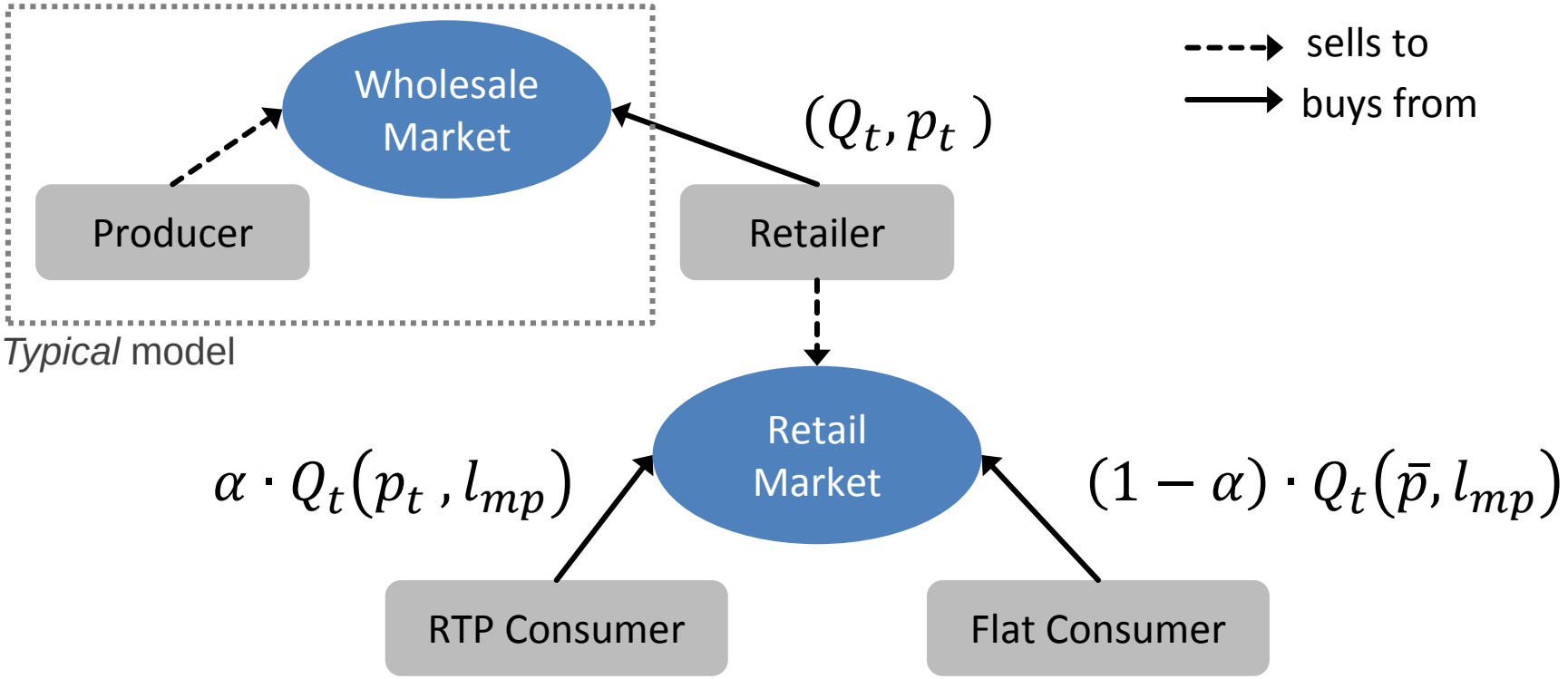
Stage 1: Flat vs. dynamic pricing

- RTP consumers have **advanced metering infrastructure** (AMI) and **dynamic tariffs**…
- …and thus **respond efficiently** to prices (DSR)



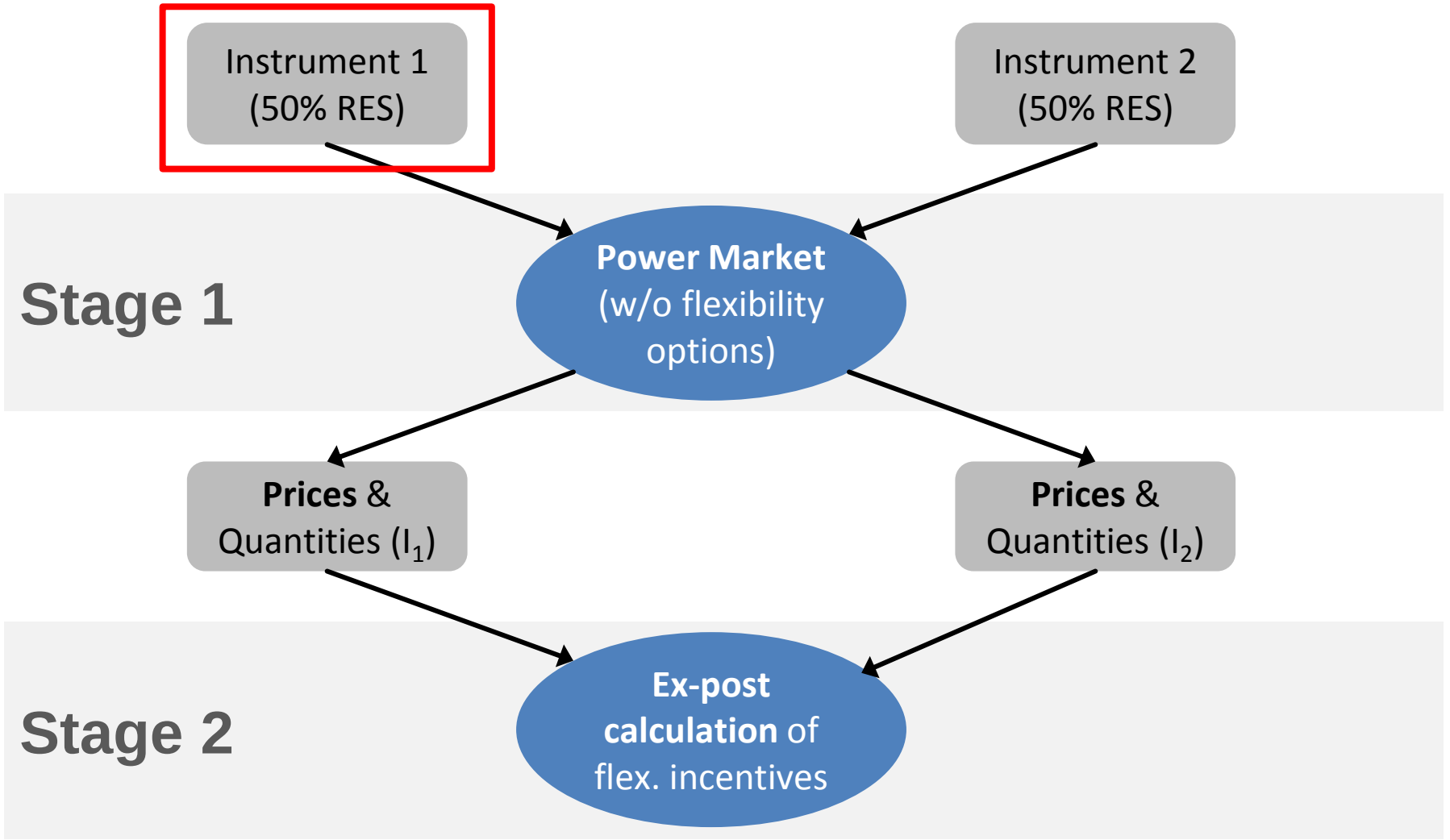
In contrast,
FR consumption… too high too low

Stage 1: Model structure (demand side)



- Assumptions
  - Share of RTP consumers (α): 10% (no data available)
  - Linear demand with (point) price elasticity of -0.05, calibration according to Green & Vasilakos (2010)

Overview of approach



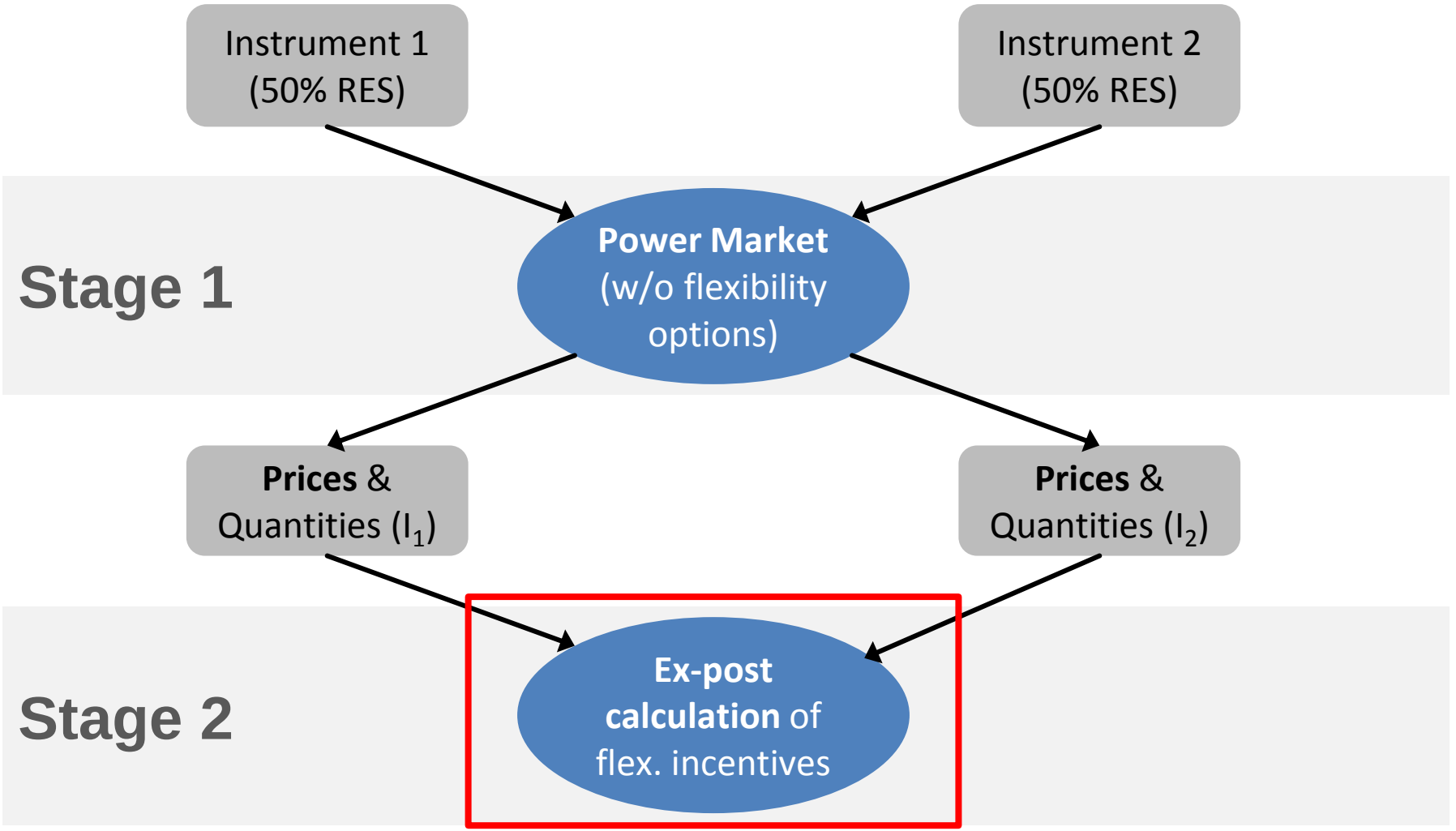
Stage 1: Instruments

- First order conditions (simplified):

	FOC
MP energy (mp_q)	q_i: $\mathrm{p} - \mathrm{c_v} + \mathbf{mp_q} = 0$
MP capacity (mp_c)	I: $\mathrm{c_f} - \mathbf{mp_{c,i}} = \sum r_t$
Carbon price (p_{co2})	q_i: $\mathrm{p} - \mathrm{c_v} - \mathbf{c_{CO2}} = 0$

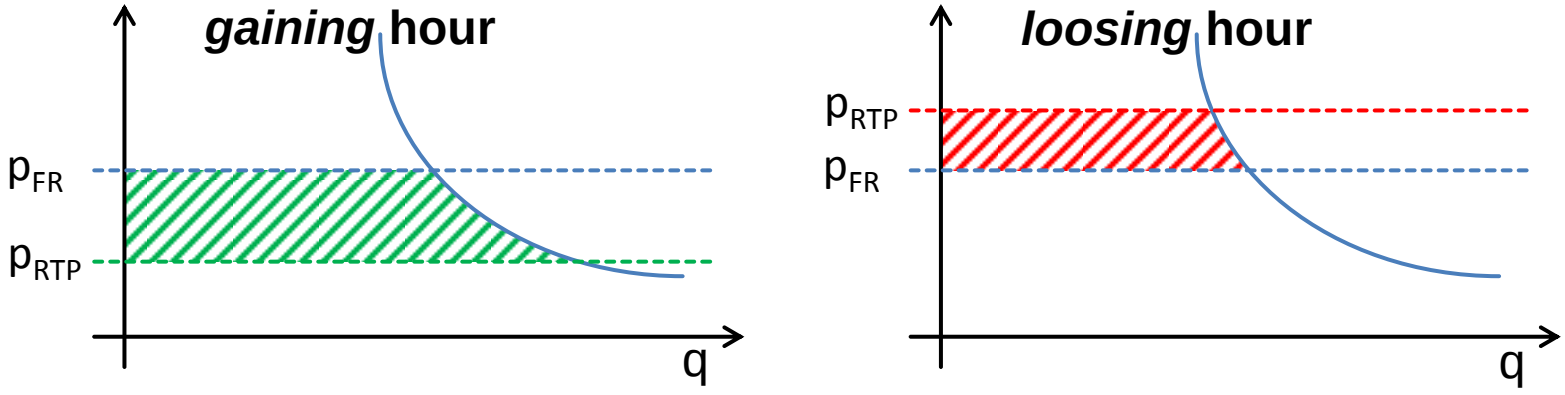
- Market premia in general **technology neutral**
- But capacity premium proportional to expected **full load hours:** $\boldsymbol{mp_{c,i} = mp'_c \cdot flh_i}$
- Premium **paid by consumers** (no exemptions)
- **Instrument level** to achieve 50% determined via **MPEC**

Overview of approach



Stage 2: Flexibility options & incentives

- **Two** flexibility options considered: (1) **storage**, (2) **DSR**
- **DSR** is **activated** through a shift from flat-rate pricing to dynamic pricing (**enabling** price responsiveness)
- Assumed **incentives** for deployment:
  - Storage: Intertemporal arbitrage
  - DSR: Consumer surplus gains…

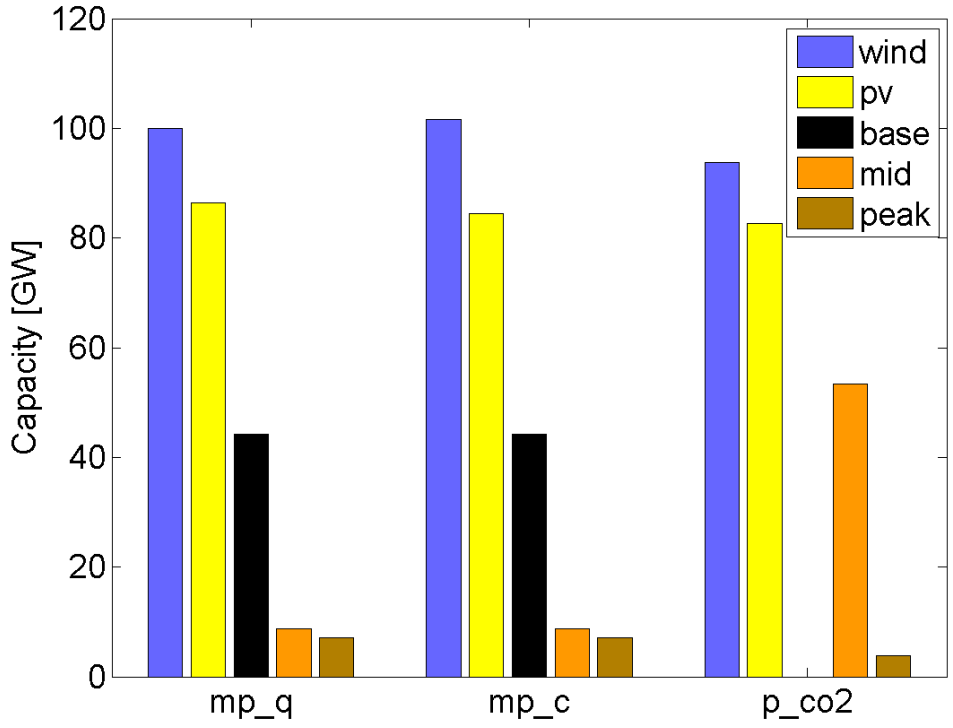


Stage 2: Ex-post calculation

- **Input:** Wholesale (storage) and retail (DSR) prices for each instrument (model output)
- Calculation of private return/gain for **one additional unit** of each option (cf. Mills & Wyser 2014)
  - Storage: typical pumped storage (8MW)
  - DSR: Consumer (1MWh/a)
- Indicative of **incentives to deploy** these options at some point in time (**no long-run equilibrium)**
- Why **not include** flexibility options in the power model?
  1. Isolate instrumental effects
  2. Market & instrument design is about (understanding & creating) incentives

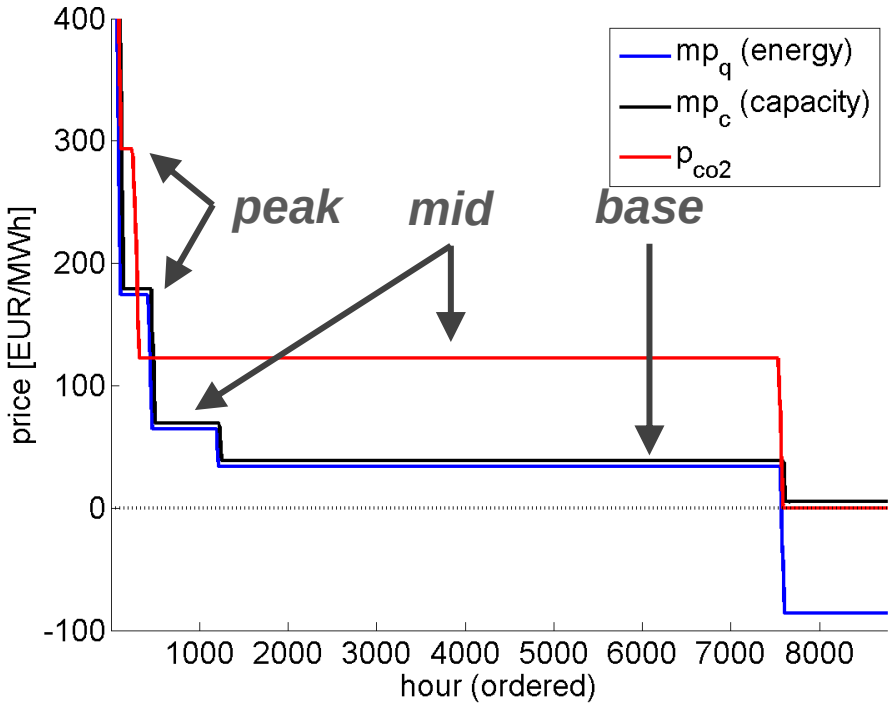
RESULTS

First for some similarities



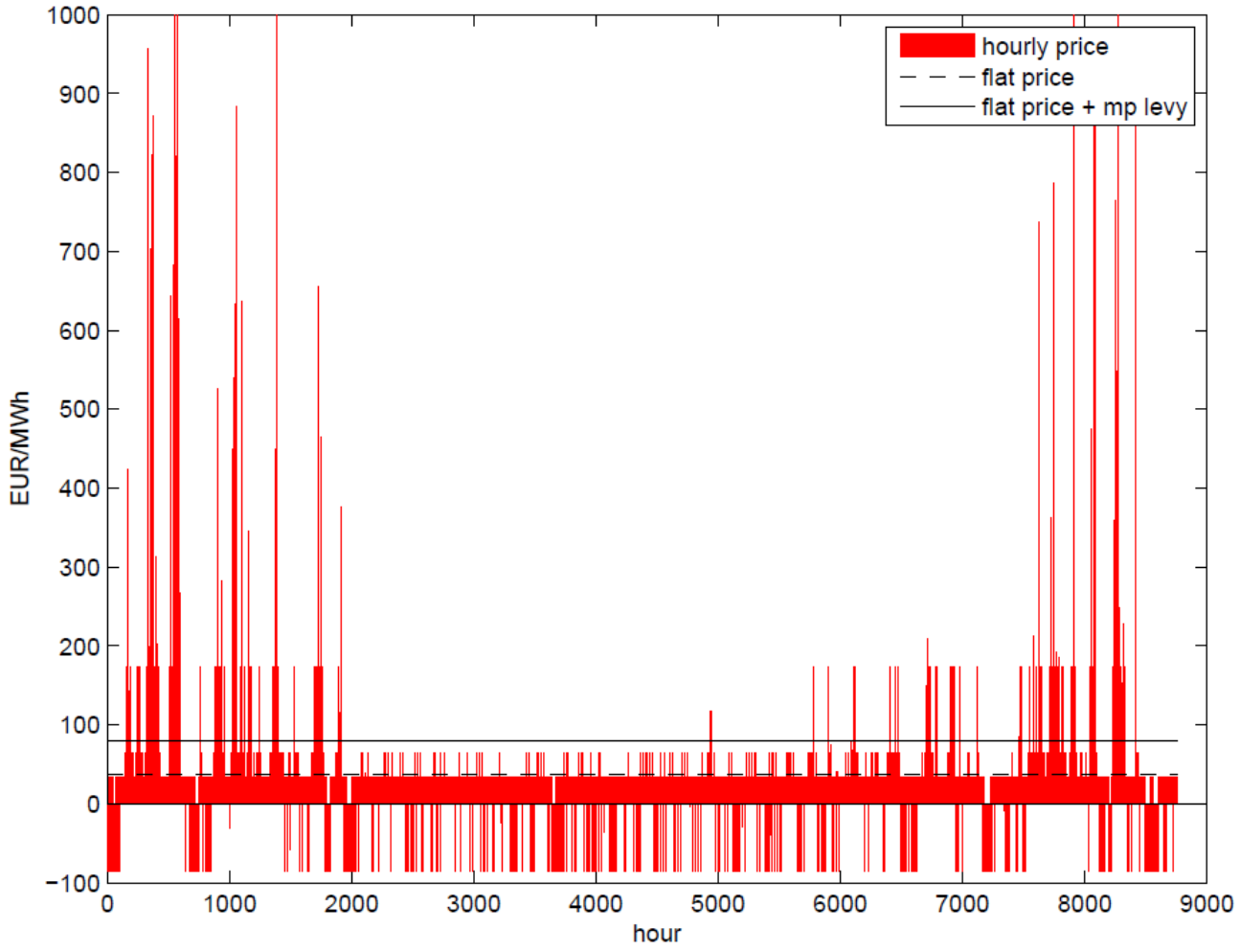
- More or less **equal RE capacities** in all cases
- **Carbon price:** no base capacity (lower emissions), less overall capacities (lower demand)

Now for the differences: prices



- In most hours prices set by marginal costs (**plateaus**)
- **Scarcity prices** in around 100 hours (up to ~1500 €/MWh)
- **Negative prices** for market premium on energy

Exemplary price time series (MP energy)



Flexibility incentives

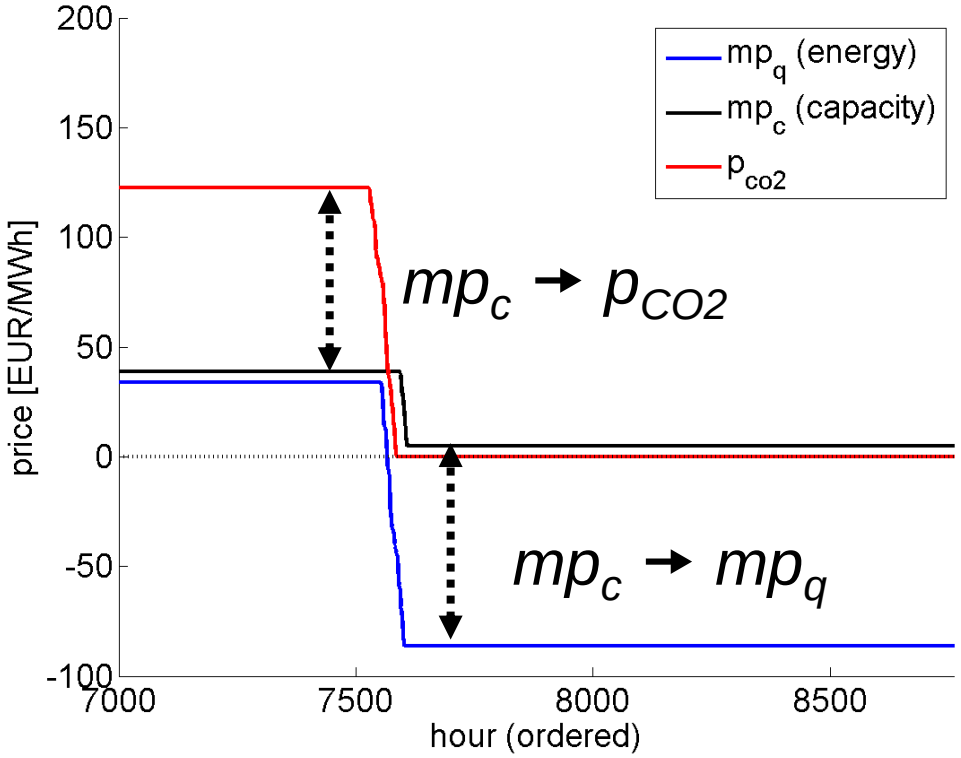
- Due to prices very **different flexibility incentives**

	Storage revenues [k€]	Switching surplus [k€]
MP capacity (mp_c)	116	64
MP energy (mp_q)	193	82
Carbon price (p_{co2})	156	81

- Incentives provided by mp_c are **lowest**
- In comparison incentives provided by mp_q are 66% (storage) and 28% (switching) **higher**
- ***Moreover*** p_{co2} also provides higher incentives, but less so for storage (~34%)

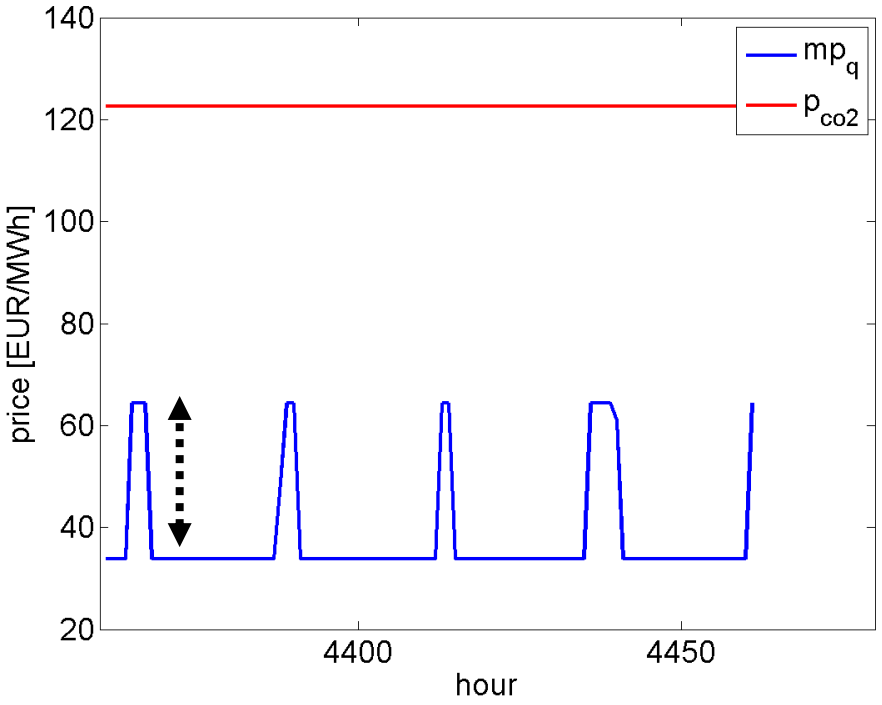
Differences explained (1)

- **Plateau effects** correspond to increasing price spreads
  - Higher arbitrage opportunities for storage
  - More to gain from switching



Differences explained (2)

- Lower storage revenues for carbon price likely explained by lower **“fossil diversity”**
- Little relevance for DSR because of **flat price**



Discussion & Conclusion

- Main finding: Different instruments provide **different (incremental) flexibility incentives**
- Incentives are **highest** for a **market premium on energy**
- Main reason are ***plateau effects*** (increasing price spreads)
- Should be considered when choosing the **milestone 2 instrument**

- Crucial for the effects are the **demand side**, e.g. different picture when demand is **isoleastic** (negative price, switching surplus, etc.)
- But demand side is essentially a **big known unknown**
  - What is a suitable functional form?
  - What is the share of RTP consumers, what are their tariffs?
  - Are surplus gains really switching incentives (consumer preferences)?
- More **research & data collection** needed on demand side

BACKUP

Data assumptions

	Annuitized fixed costs [€/kW*a]	Variable costs [€/MWh]
Wind	136	0
PV	76	0
Base (hard coal)	125	34
Mid (CCGT)	89	64
Peak (OCGT oil)	40	174

Source: DIW review