
POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

# How do capacity markets affect demand flexibility: Welfare effects of dynamic capacity pricing

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# MOTIVATION

# Motivation
## Research Questions

- How to ensure both **resource adequacy** and dynamically efficient **deployment of flexibility options**?

- **Capacity Market Design:** *How* should consumers pay for adequate generation capacity? *What* is the welfare effect of **time-variable capacity pricing**?

- Are welfare effects of dynamic pricing pronounced in a system with **large capacities of fluctuating renewables**?

# METHOD

# Method: Model Basic Framework

## Borenstein & Holland (2005), Hunt Alcott (2012)

- **Two-Stage-Entry** model of a **perfectly competitive**
  1. Electricity wholesale market
  2. Retail market
  3. Forward capacity market
     - Exogenous reliability constraint = exogenous capacity **reserve margin (RM)**;
     - **Discriminatory** (only dispatchable generation technologies)

- **Total electricity demand** = Price-elastic + Price-inelastic demand

- **First Stage**: Capacity investment decisions
  - **Atomistic** generators maximize annual revenues from energy (and capacity) sales under **perfect foresight**

- **Second Stage:** Output, Pricing and consumption decisions

# Method: Model Setting Alcott (2012)

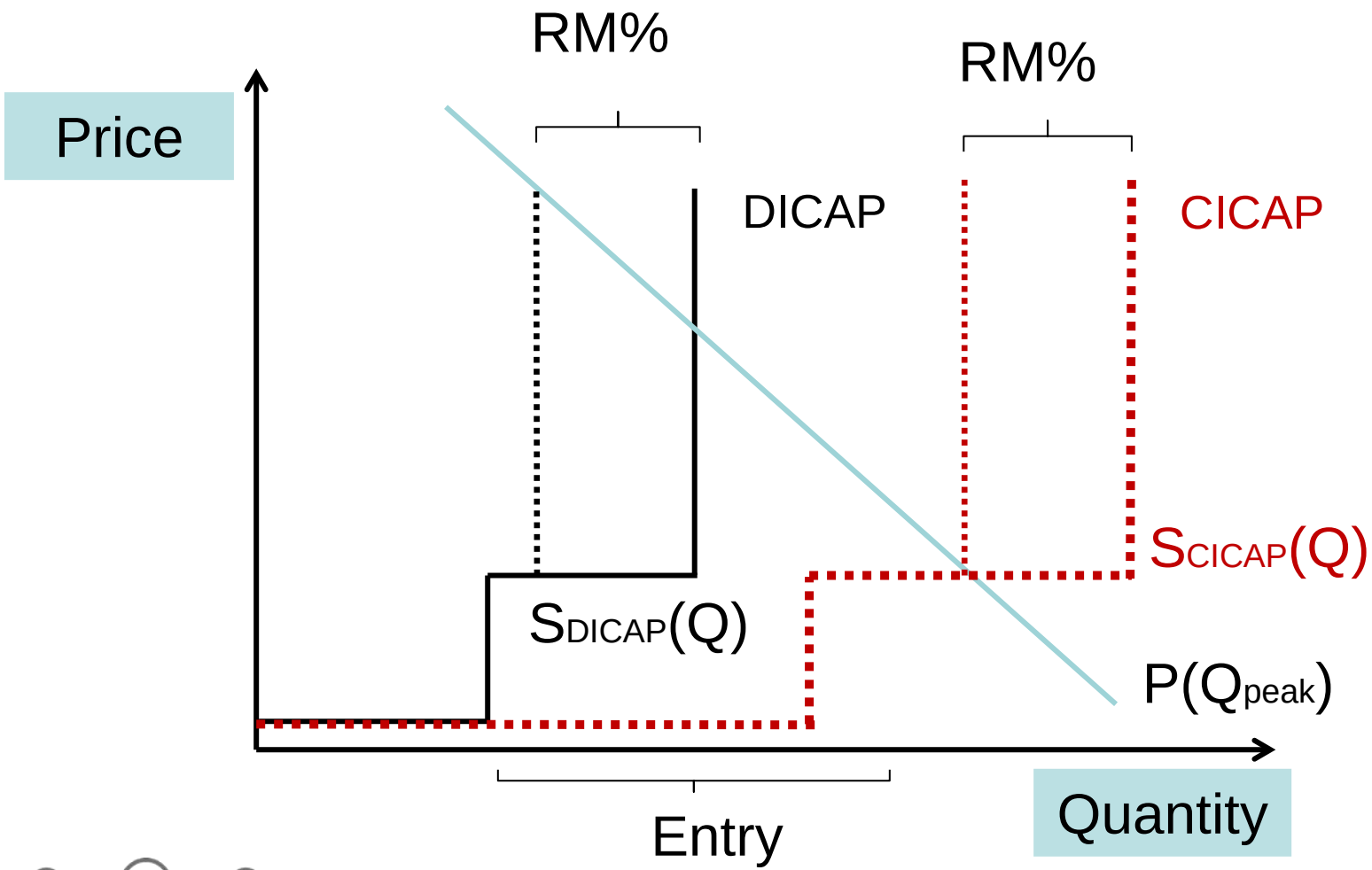
## Two capacity pricing regimes

1. **Time varying cost-pass-through** (DICAP):
   - In addition to their electricity bill, customers pay a dynamic tariff for capacity according to the time varying scarcity of capacity (Bindingness of RM-Constraint);

2. **Constant cost-pass-through** (CICAP): Customers face a flat tariff for capacity on top of each unit of electricity consumed.

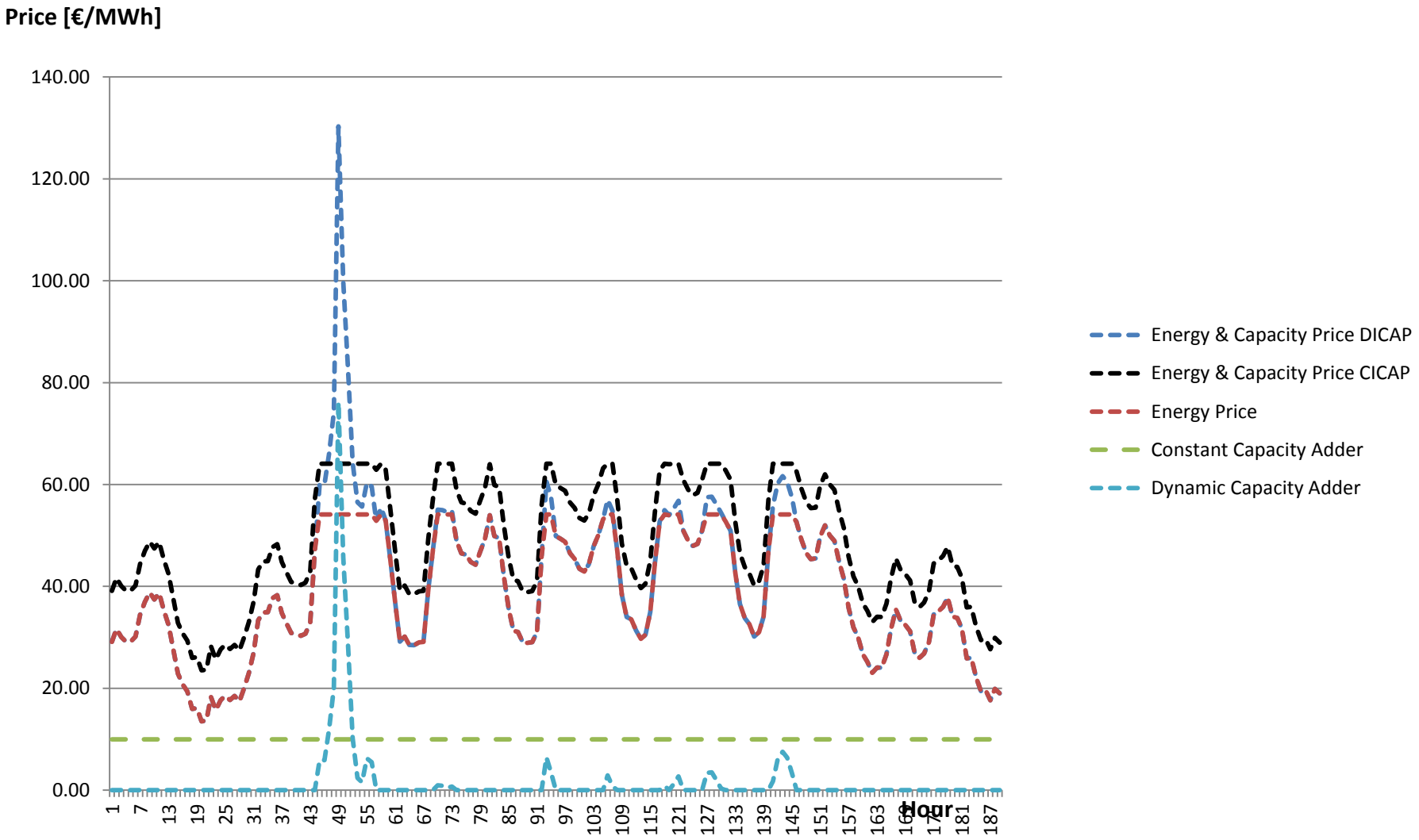
# Method: Main Mechanism

## "Excess" capacity entry under CICAP



# Method: Main Mechanism

## Effect of different capacity pricing regimes on retail prices



# Method: Numerical Analysis

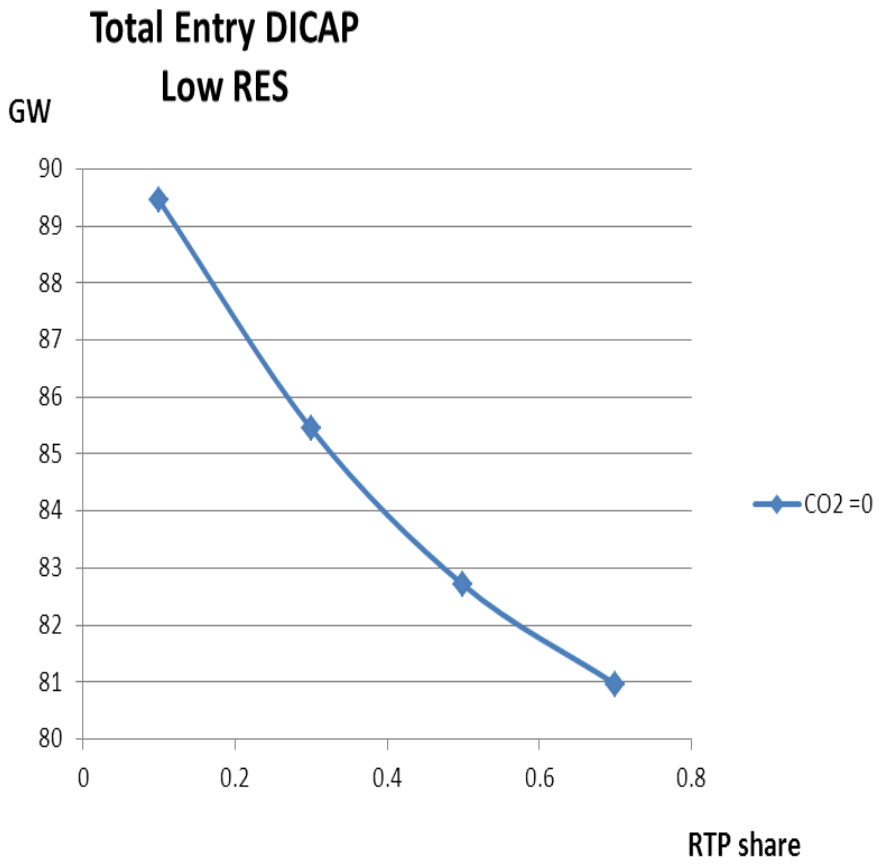
- Mixed Complementary Problem **(MCP)** in GAMS [NLP, work in progress];
- Model calibrated to **German**
  - clearing **price and load data (2010)**,
  - RES **infeeds/availability factors (2010)**;
- Time resolution: **6000 hours** [one full year, work in progress];
- **Scenarios (preliminary):**

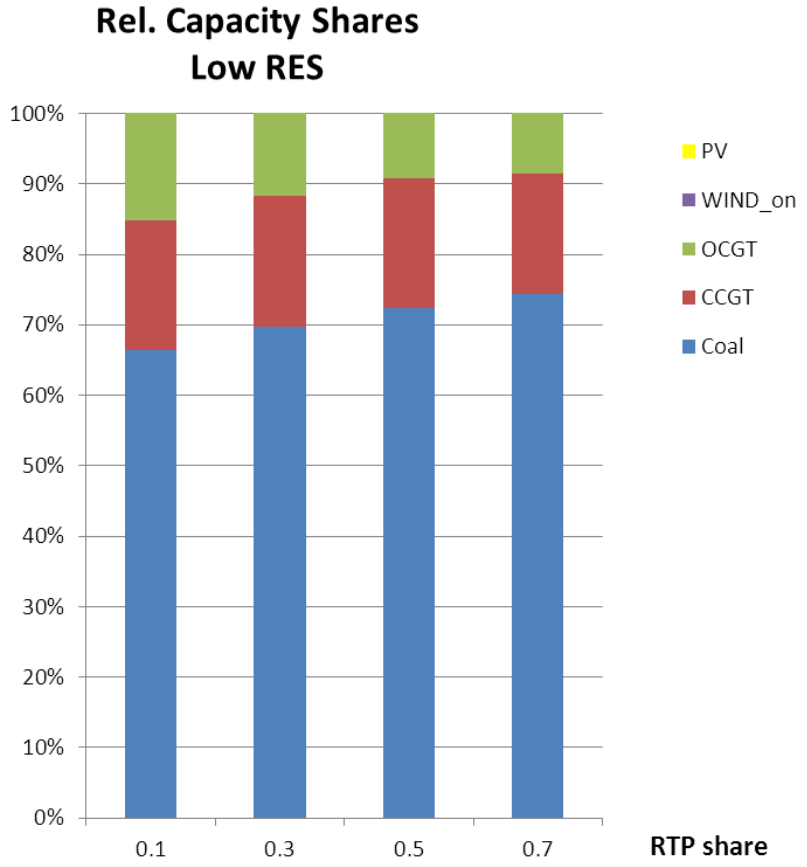
| **Comparative Statics (Welfare)** | | High RES share | No Res |
|---|---|---|---|
| | | High Cost DR | Low Cost DR |
| DICAP | RTP Share | | |
| CICAP | RTP share | | |

# PRELIMINARY RESULTS
## INCREASING RTP UNDER DICAP

# Preliminary Results: Increasing RTP Share under DICAP

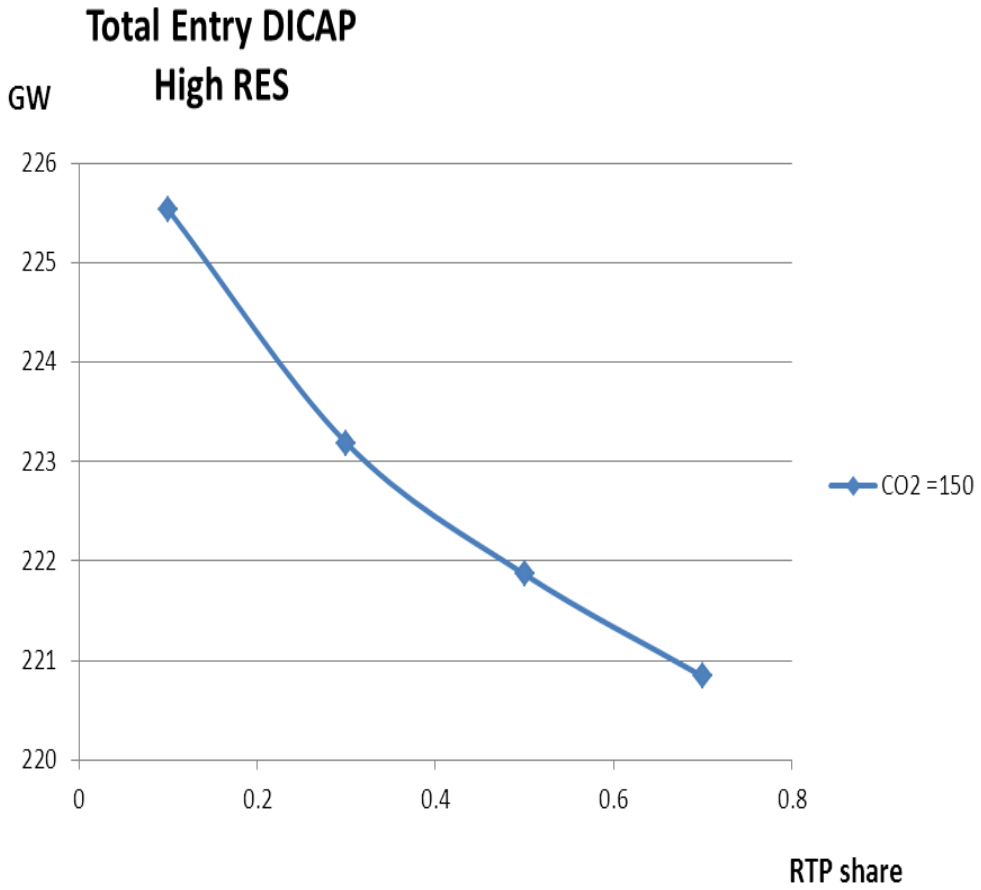
## Total Capacity Entry and Technology Portfolio

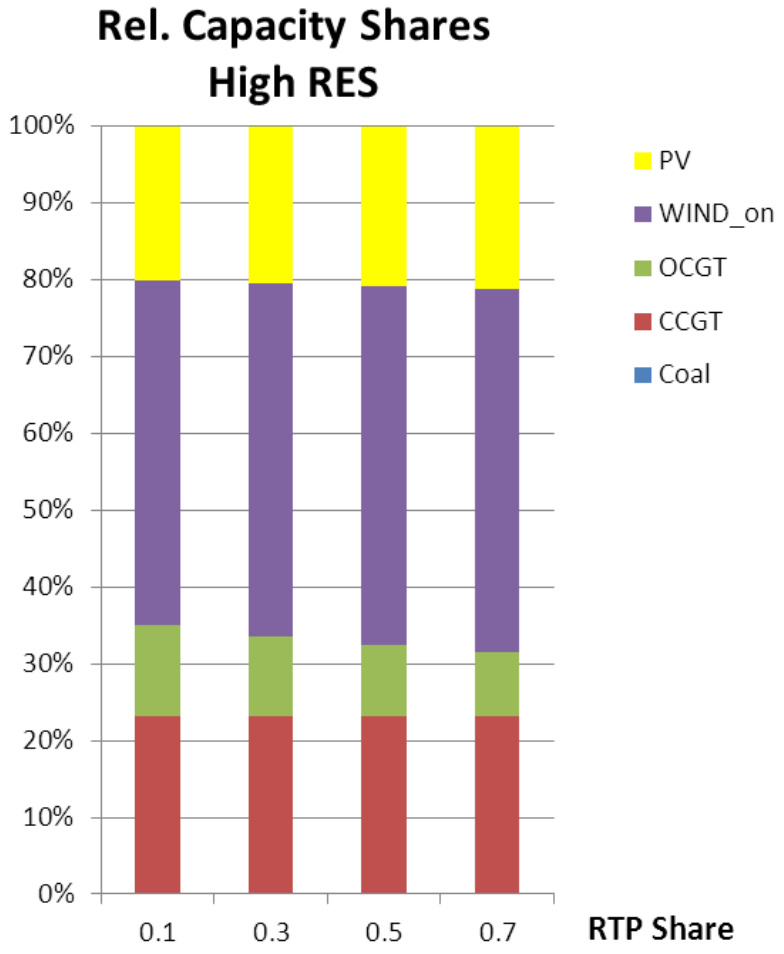


# Preliminary Results: Increasing RTP Share under DICAP

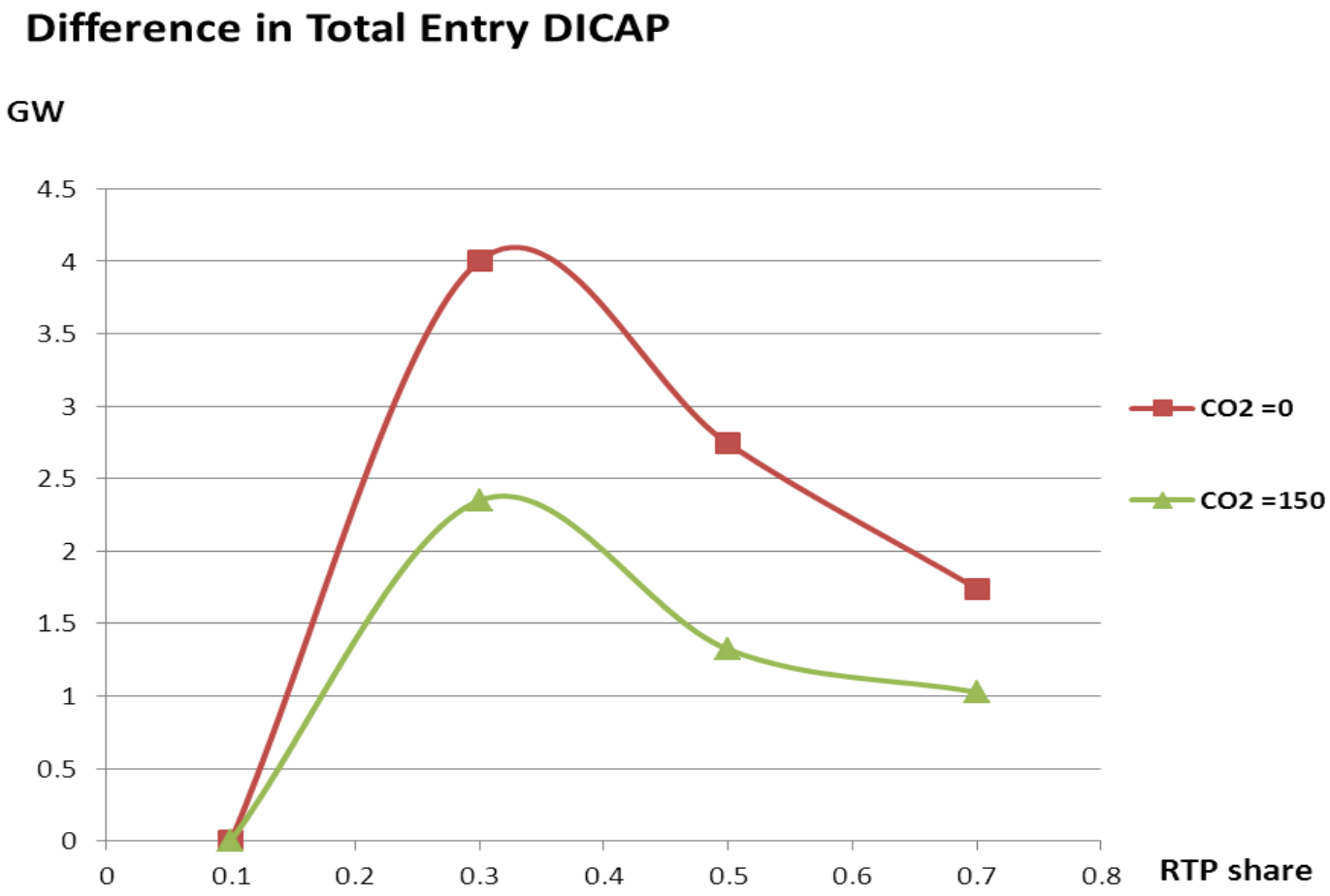
## Total Capacity Entry and Technology Portfolio



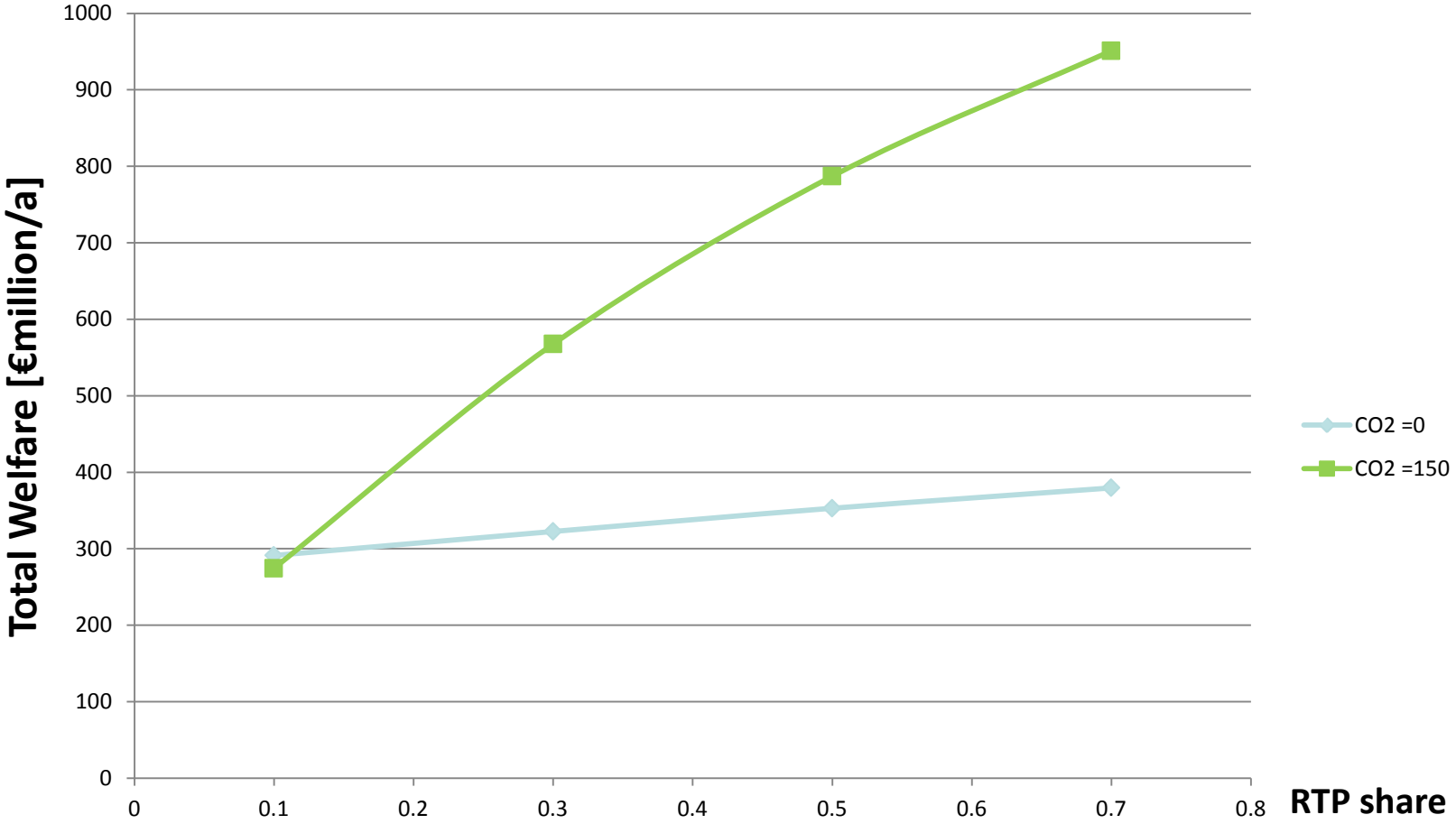
# Preliminary Results: Increasing RTP Share under DICAP

## Decreasing Reduction of Total Capacity Entry



# Preliminary Results: Increasing RTP Share under DICAP

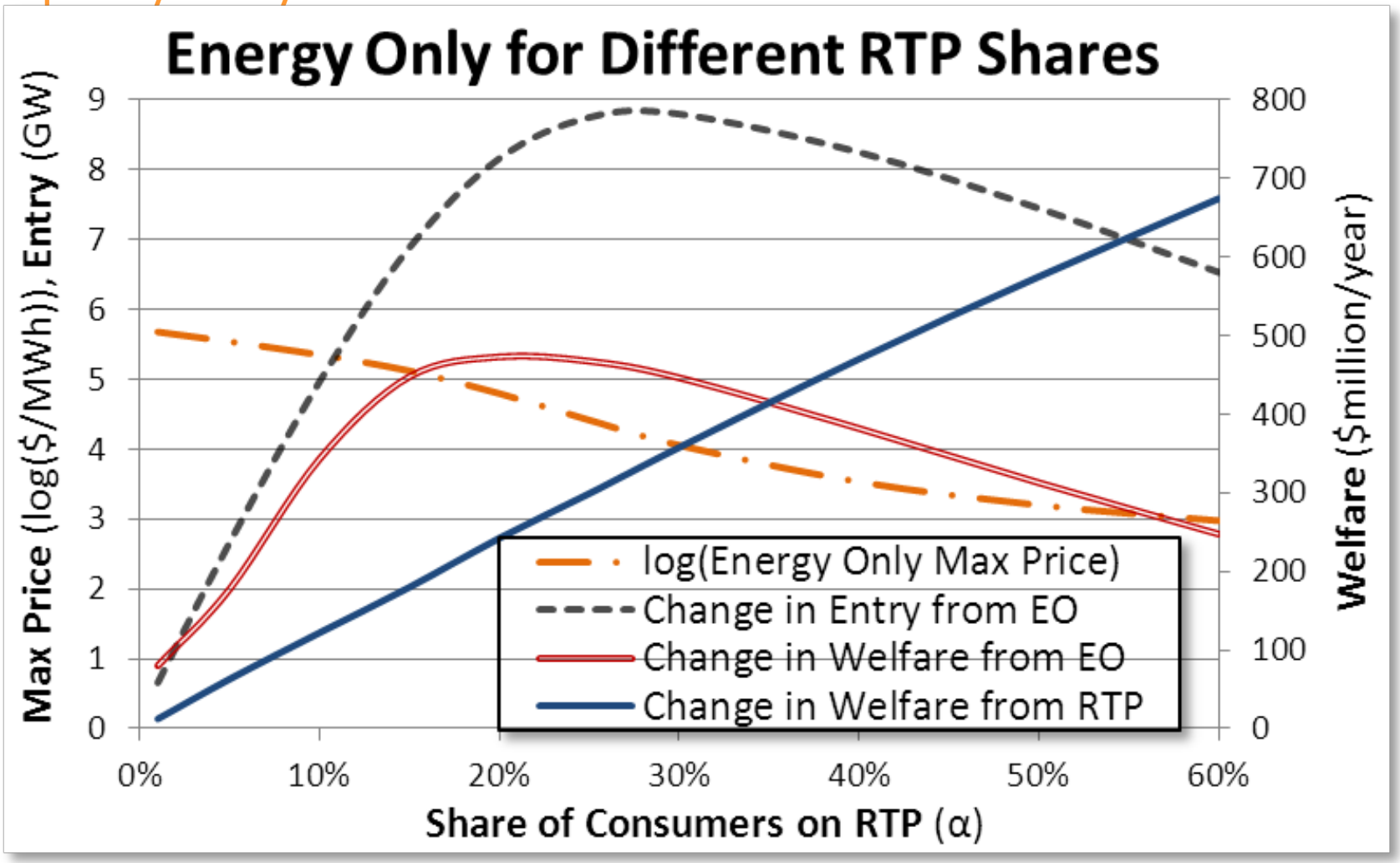
## Increasing Total Welfare (decreasingly)



# PRELIMINARY RESULTS
## CHANGING FROM CICAP TO DICAP

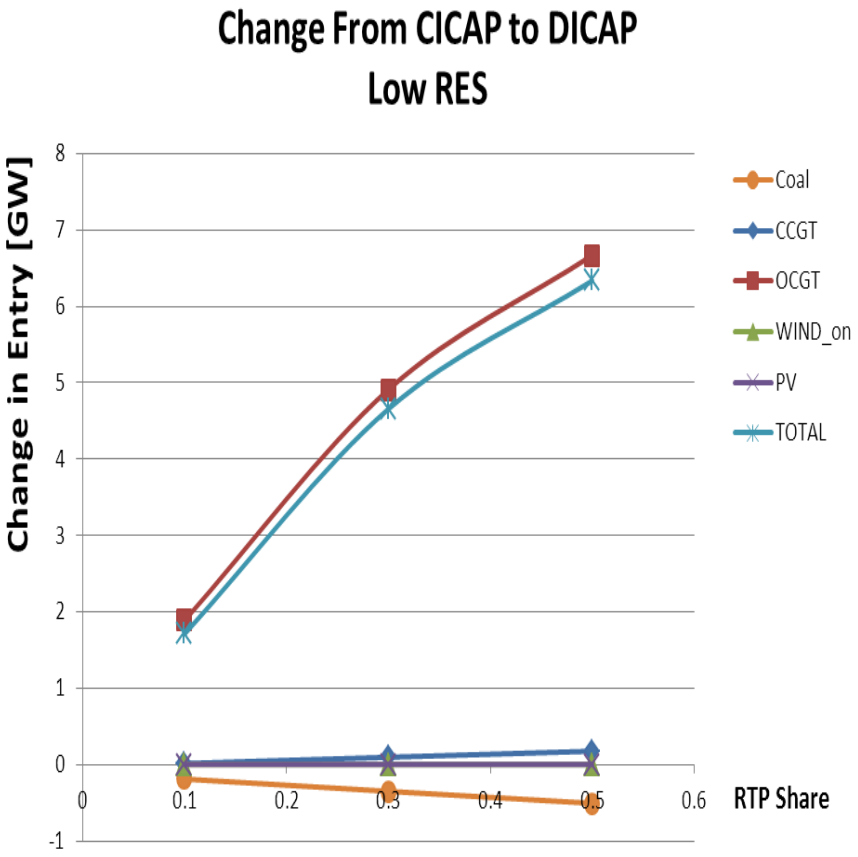
# Preliminary Results: (Alcott 2012)

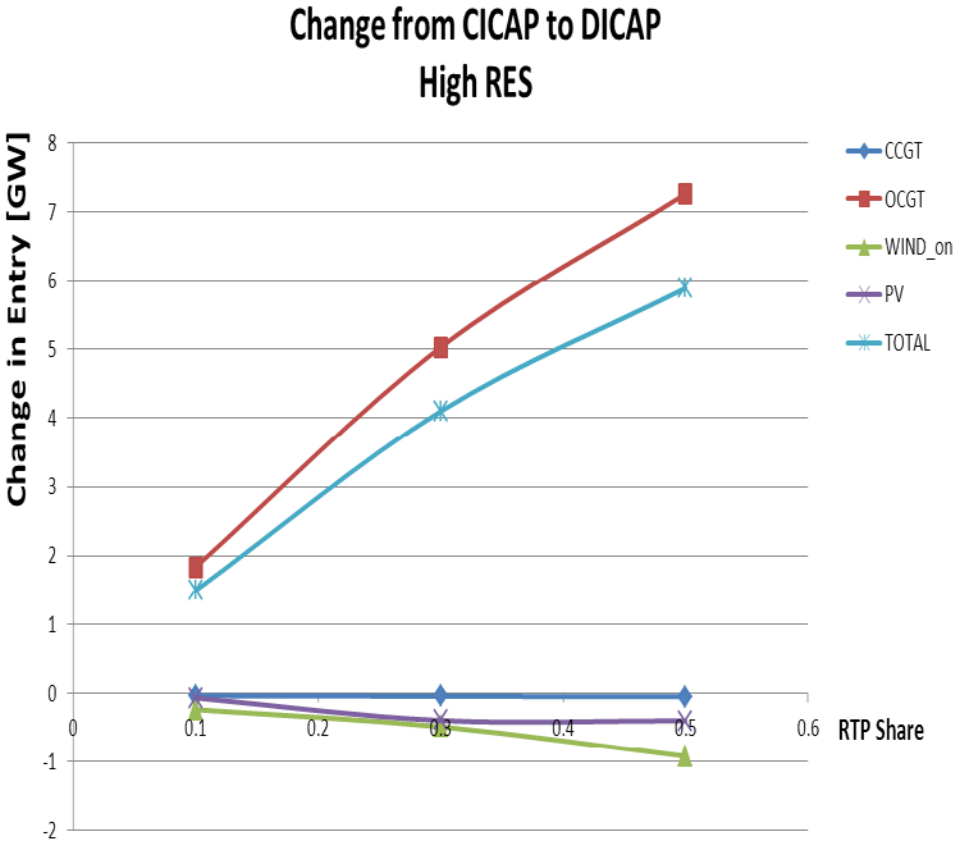
## Capacity Entry



# Preliminary Results: Change from CICAP to DICAP

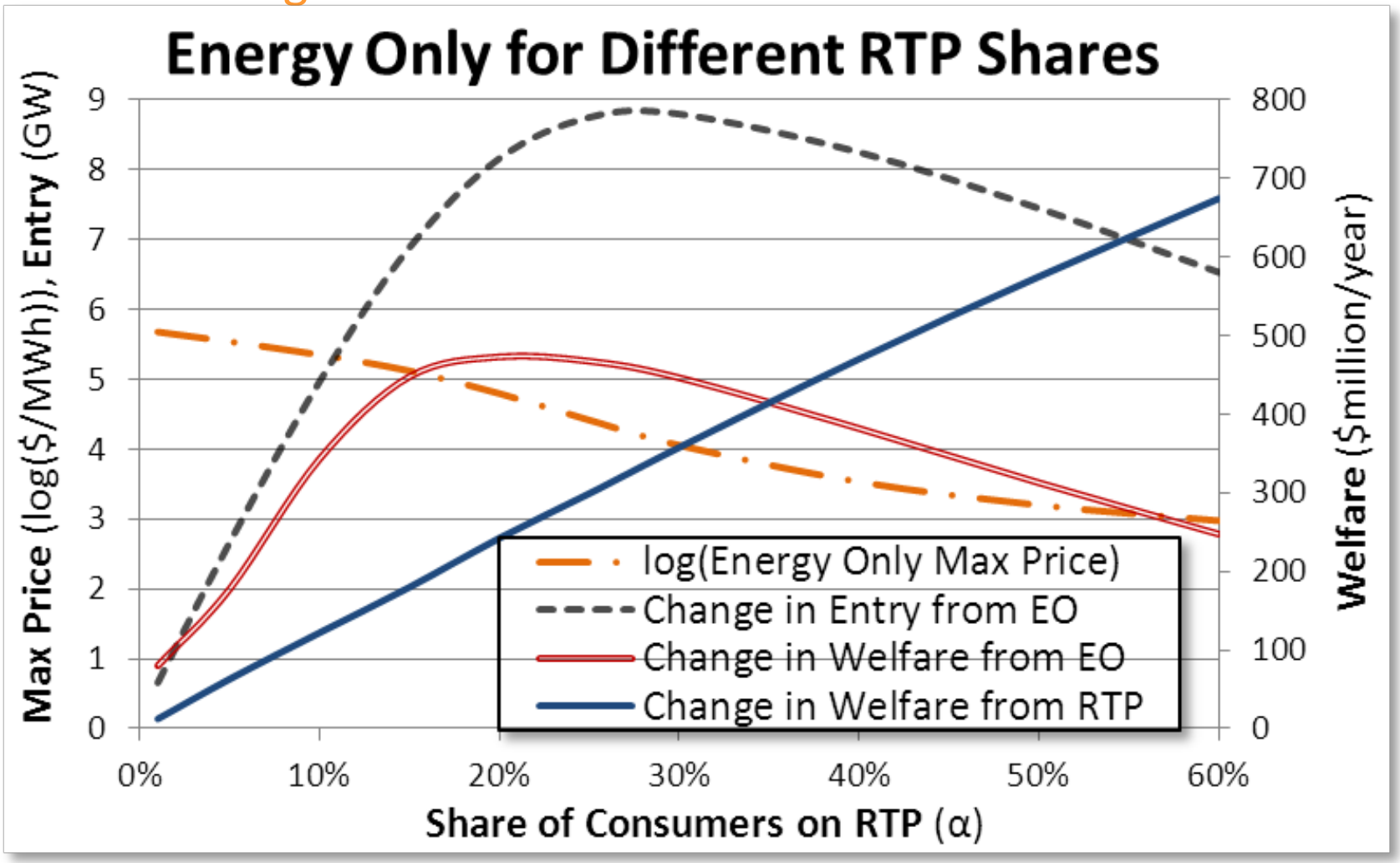
## Change in Total Capacity Entry/Differed by Technology



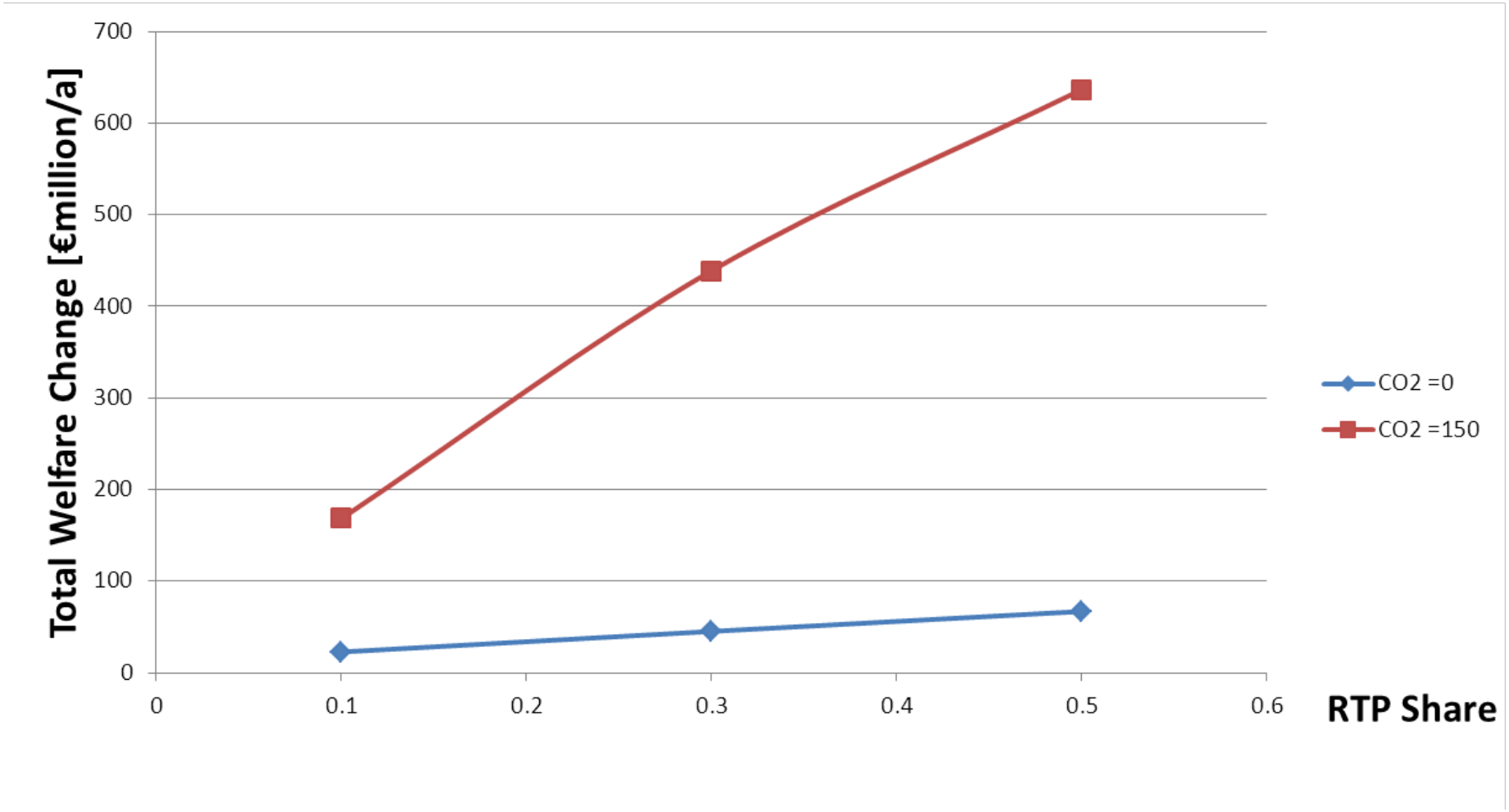
# Preliminary Results: (Alcott 2012)

## Welfare Change



# Preliminary Results: Change from CICAP to DICAP

## Change in Total Welfare



# CONCLUSION

# Conclusion

- **Replication** of previous model results (Alcott 2012):
  1. Increasing RTP share decreases total (peaker) capacity entry;
  2. Increasing RTP share increases total welfare;
  3. *Welfare gains from changing to DICAP much higher than from increasing RTP share (not shown here!);*

- *New* Results w.r.t. Low/High RES-System Comparison **for DICAP**:
  1. **Higher decrease in total capacity entry** from increasing RTP shares in low RES-Market;
  2. ***But,*** (dispatchable) **peaker-capacity-exit** is almost the same; RES entry partially compensates exit more than coal entry in low RES-market;
  3. **Welfare/Welfare gains from RTP** much higher in High RES-market;
  4. **Changing from CICAP to DICAP reduces total & peaker capacity entry** approximately by the same amount for each RTP share;
  5. ***But*, Welfare gains from changing from CICAP to DICAP** much higher in High RES-market; ***Higher surplus change for RTP consumers???***

# References

**Alcott, H., 2012.** *Real-Time Pricing and Electricity Market Design*. Working Paper, NYU (March). Available at: https://files.nyu.edu/ha32/public/research/Allcott%20-%20Real-Time%20Pricing%20and%20Electricity%20Market%20Design.pdf

**Borenstein, S., Holland, S., 2005.** *On the Efficiency of Competitive Electricity Markets with Time-Invariant Retail Prices*. RAND Journal of Economics, Vol. 36, No. 3, pages 469-493.

**Borenstein, S., 2005.** T*he Long-Run Efficiency of Real-Time Electricity Pricing*. The Energy Journal, Vol. 26., No. 3 (April), pages 93-116.