

Seeing beyond total system cost

Welfare effects of technology-based climate policies in liberalized electricity markets

Frank Vöhringer

EPFL-LEURE
Econability

1st National Scenario Benchmarking Workshop
Joint Activity Scenarios & Modeling (JASM)

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Overview

- Changes in total electricity system cost do not tell us as much about the social desirability of scenarios as we might think
- Example: a “no gas” scenario in liberalized electricity markets
- What should we do?

Some developments on electricity markets

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- Liberalization for end users
 - demand > 0.1 MW: since 2009
 - demand < 0.1 MW: soon?

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**What will be the market structure of the future?
How are politics going to interfere?**

Three questions

worth asking after having minimized total system cost

- Is this really the total system cost that we are going to see?
 - dispatching under market conditions: wholesale and future markets, green certificates
 - international dimension of trade
 - impact of the system on market structure, market power and pricing
 - government regulation
 - reactions on the demand side

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 - central role of profits
 - pricing for end users

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 - central role of profits
 - pricing for end users
- Should we really endorse the “optimized” system?
 - Is the “optimized” system sustainable under marginal pricing?
 - If it leads to cutthroat competition or more emissions: How can we make it sustainable?
 - What is the current (and future) role of government intervention?
 - Will consumers profit from the “optimized” system?

The ELECTRA project

- ELECTRA : Electricity markets and trade in Switzerland and its neighboring countries
- Financed by the Swiss Federal Office of Energy
- Project partners:

EPFL, Ecole Polytechnique Fédérale de Lausanne

Sophie Maire, Philippe Thalmann, Marc Vielle,
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Top-down

PSI, Paul Scherrer Institute, Villigen

Rajesh Pattupara, Kannan Ramachandran, Hal Turton

Bottom-up

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- Top-down
- Bottom-up
- Objective: To build a coupled modeling framework
 - which represents all relevant links of the electricity sector with the economy,
 - which adequately takes into account the integration of Switzerland into the European electricity market,
 - and has sufficient technological detail.

The component models

CROSSTEM-CH (PSI)

- dynamic TIMES model
- electricity supply in Switzerland
- exogenous electricity demand
- exogenous trade prices
- 288 time-slices per year

GENESwIS (Econability, EPFL)

- dynamic computable general equilibrium
- Switzerland as a small open economy
- disaggregated energy demands
- 1 representative household
- annual periods

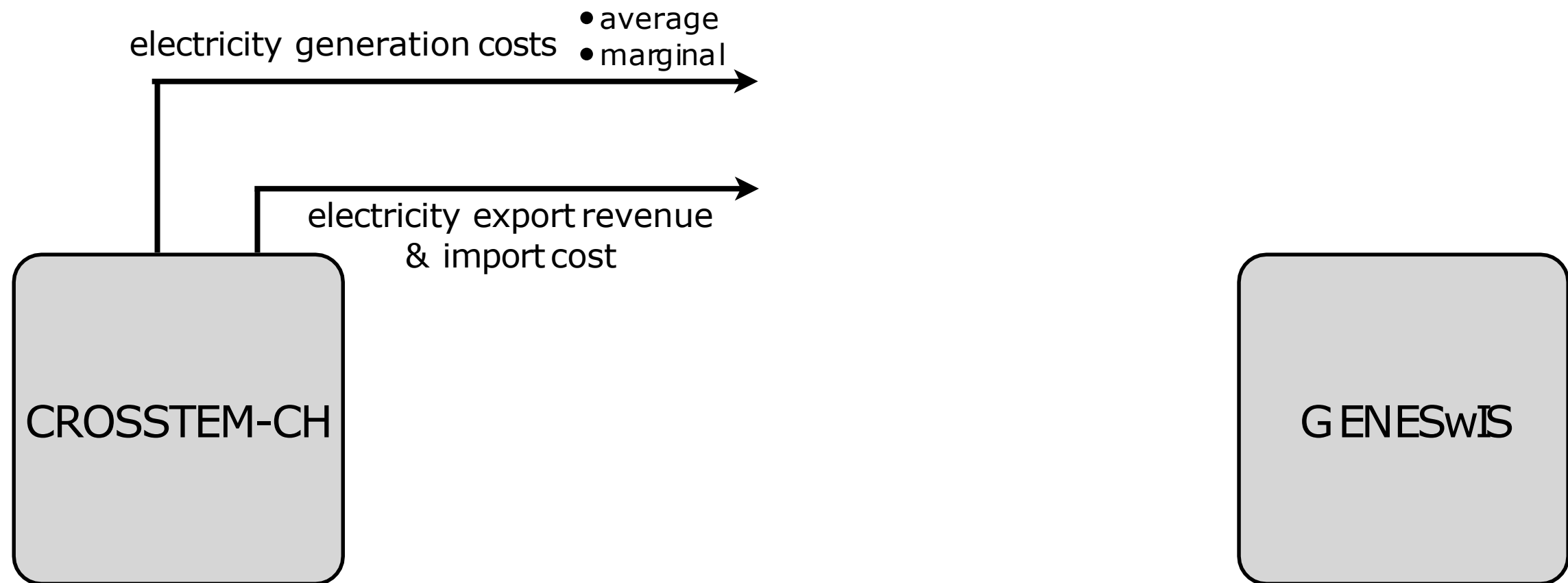
Modeling horizon: 2050

Coupling

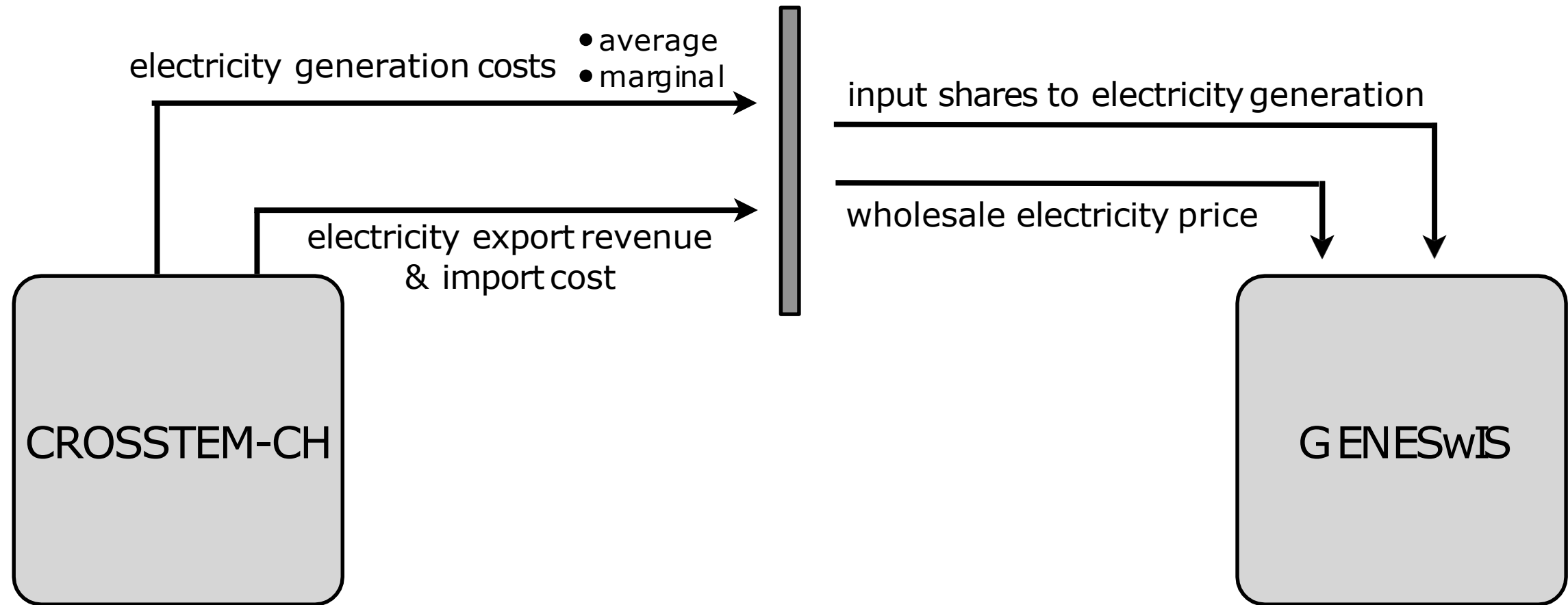
CROSSTEM-CH

GENESwIS

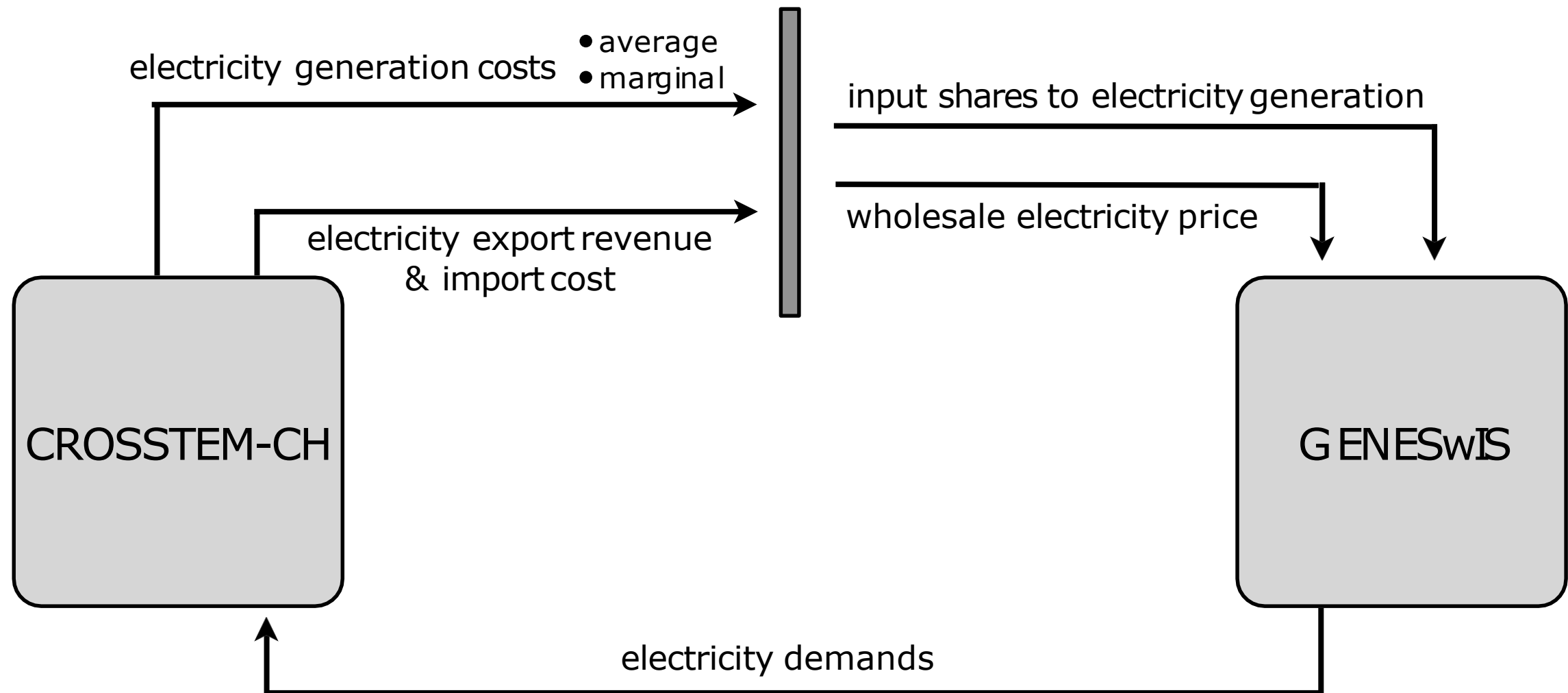
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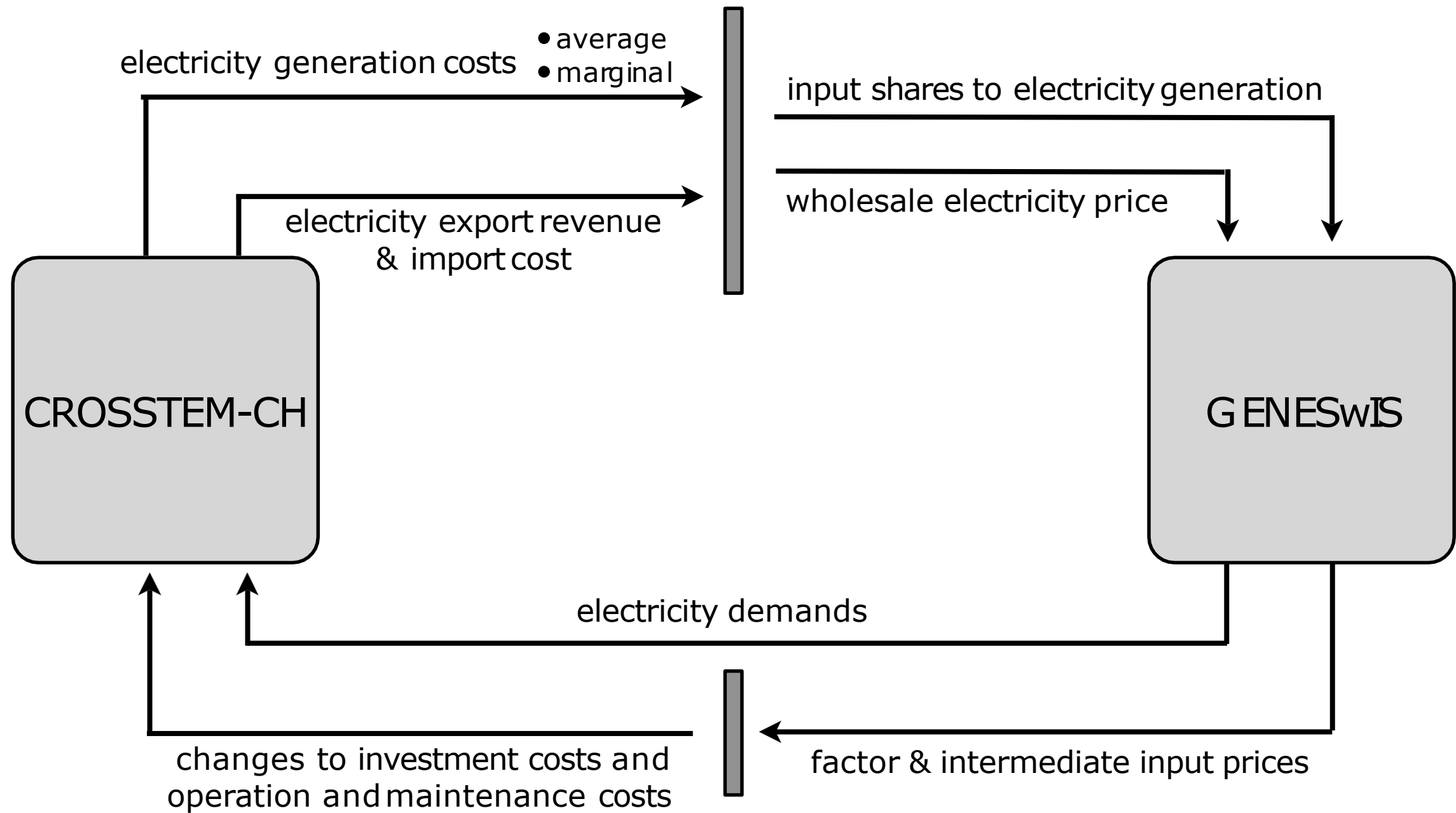
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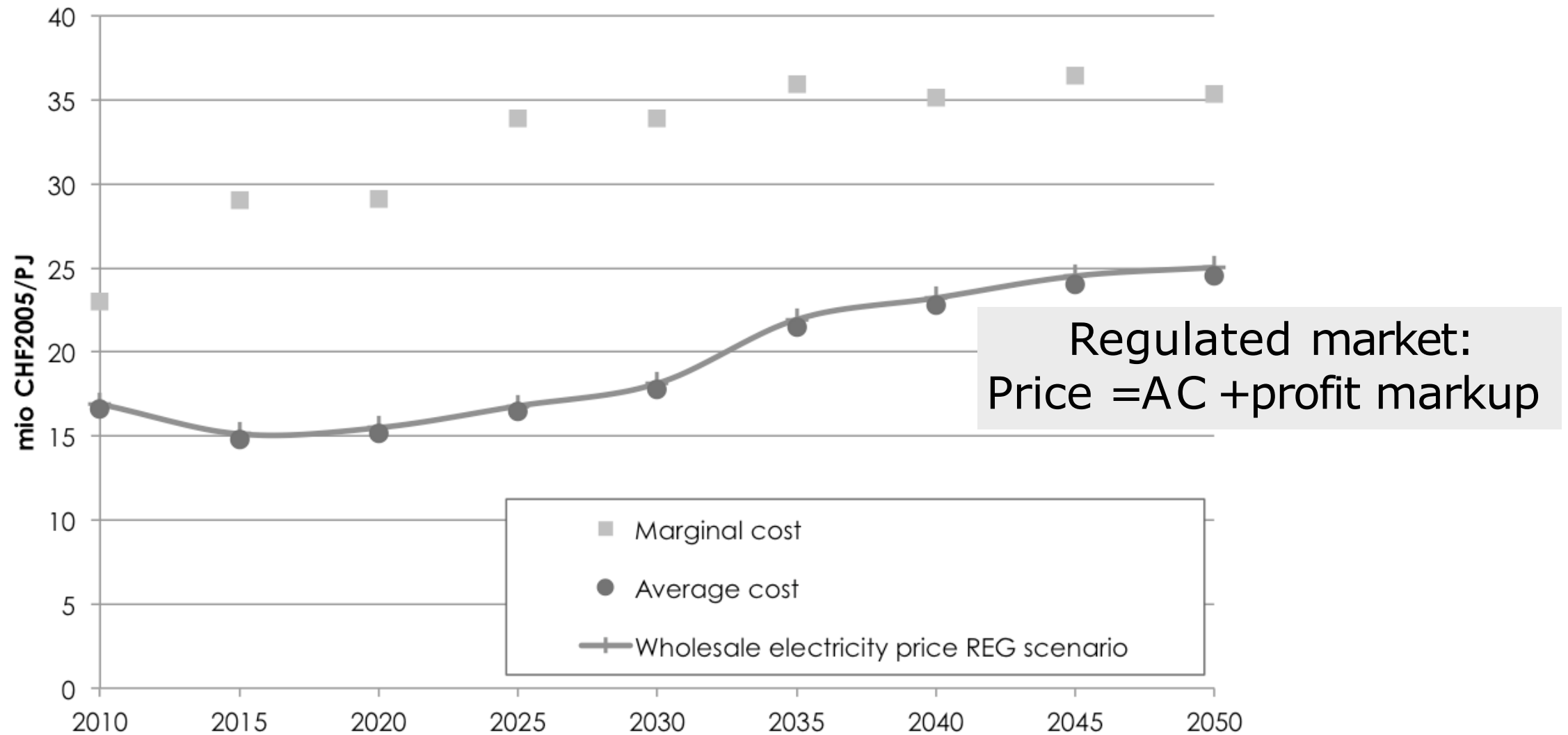
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Coupling



Costs and prices

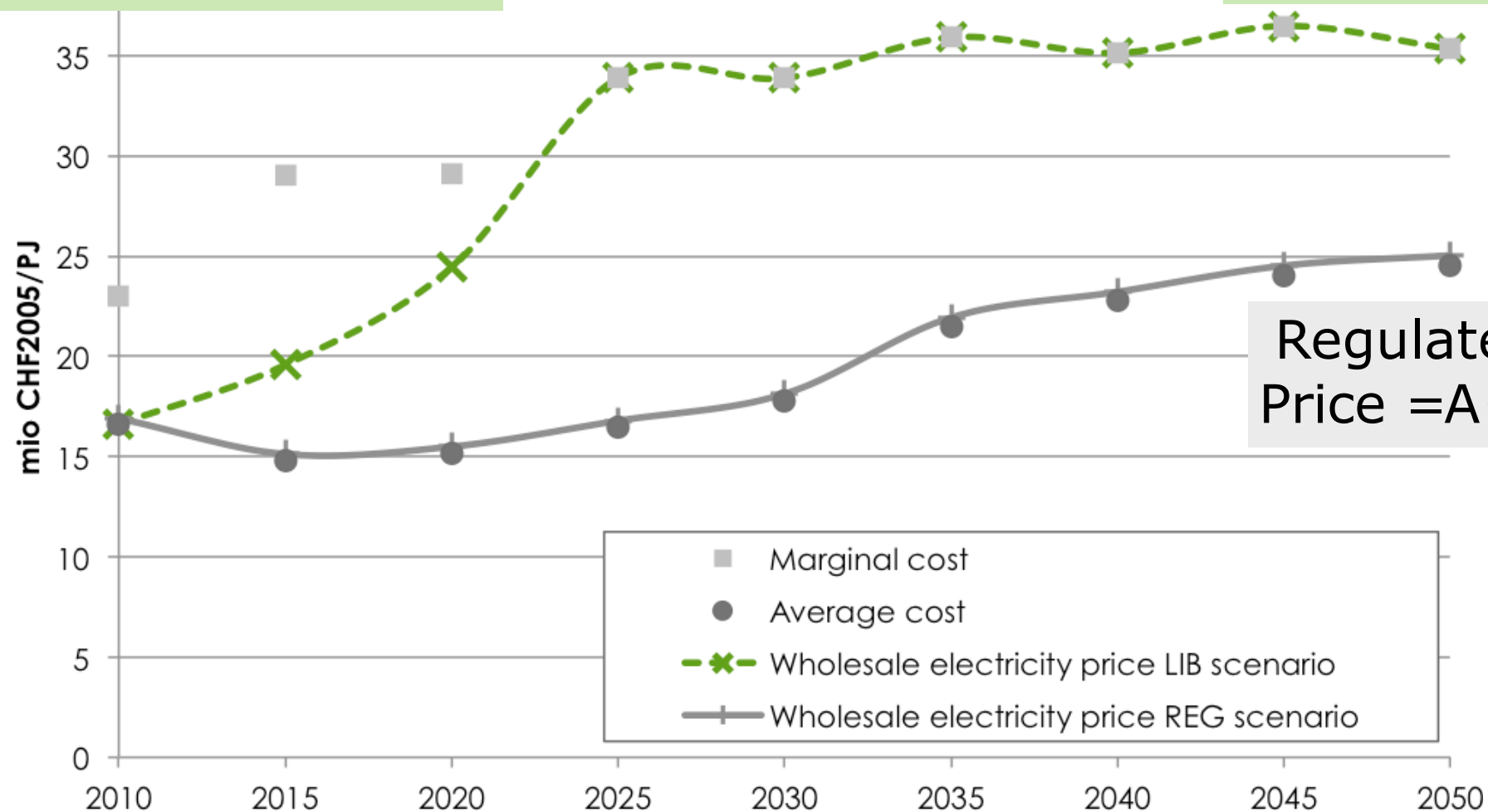


Wholesale electricity price assumptions with regards to average and marginal cost from the CROSSTEM-CH model.

Costs and prices

Liberalized market
 $\text{Price}_{(<2025)} = f(\text{AC}, \text{MC})$

Liberalized market
 $\text{Price}_{(>2025)} = \text{MC}$



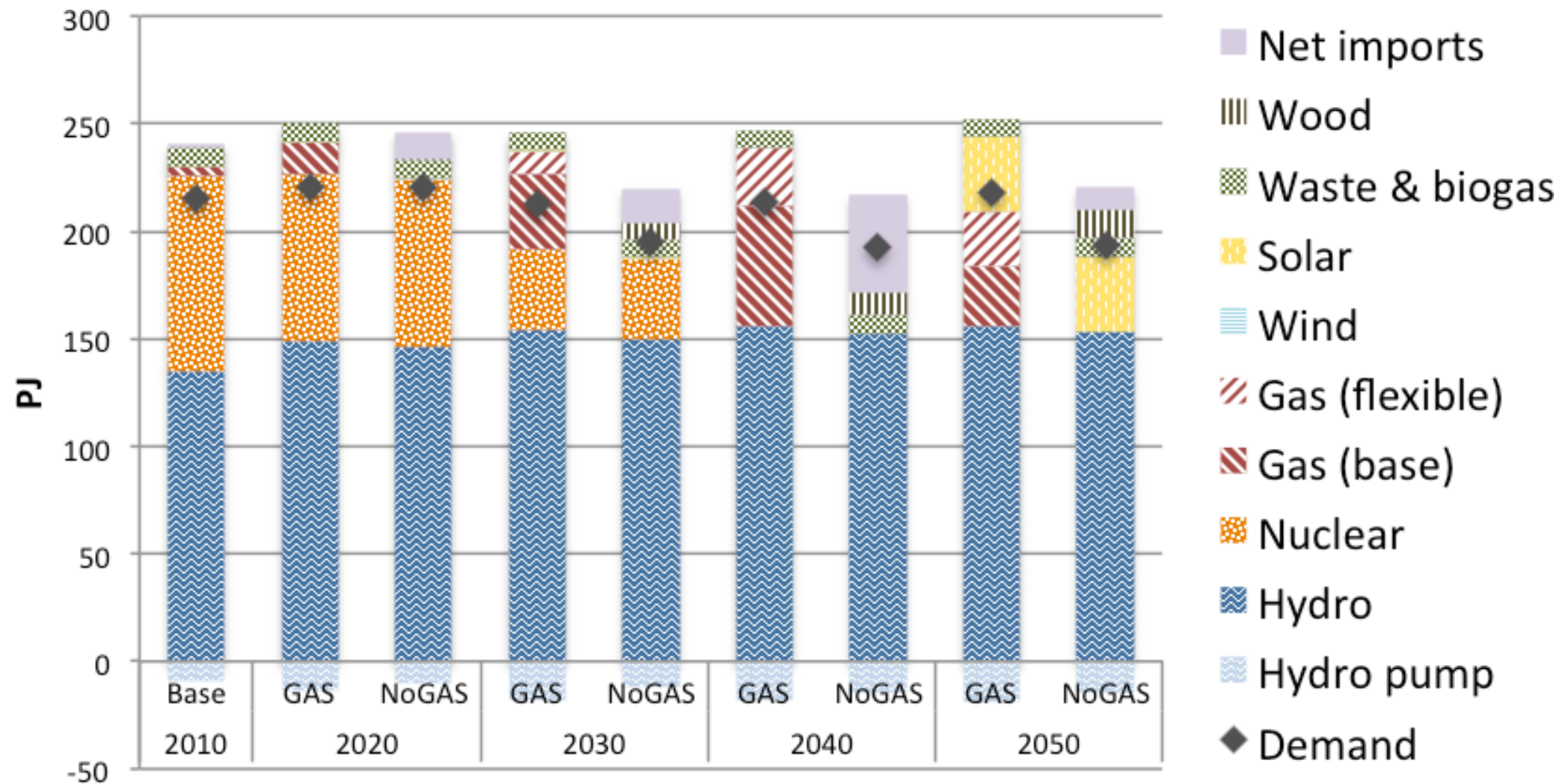
Regulated market:
 $\text{Price} = \text{AC} + \text{margin}$

Wholesale electricity price assumptions with regards to average and marginal cost from the CROSSTEM-CH model.

Scenarios

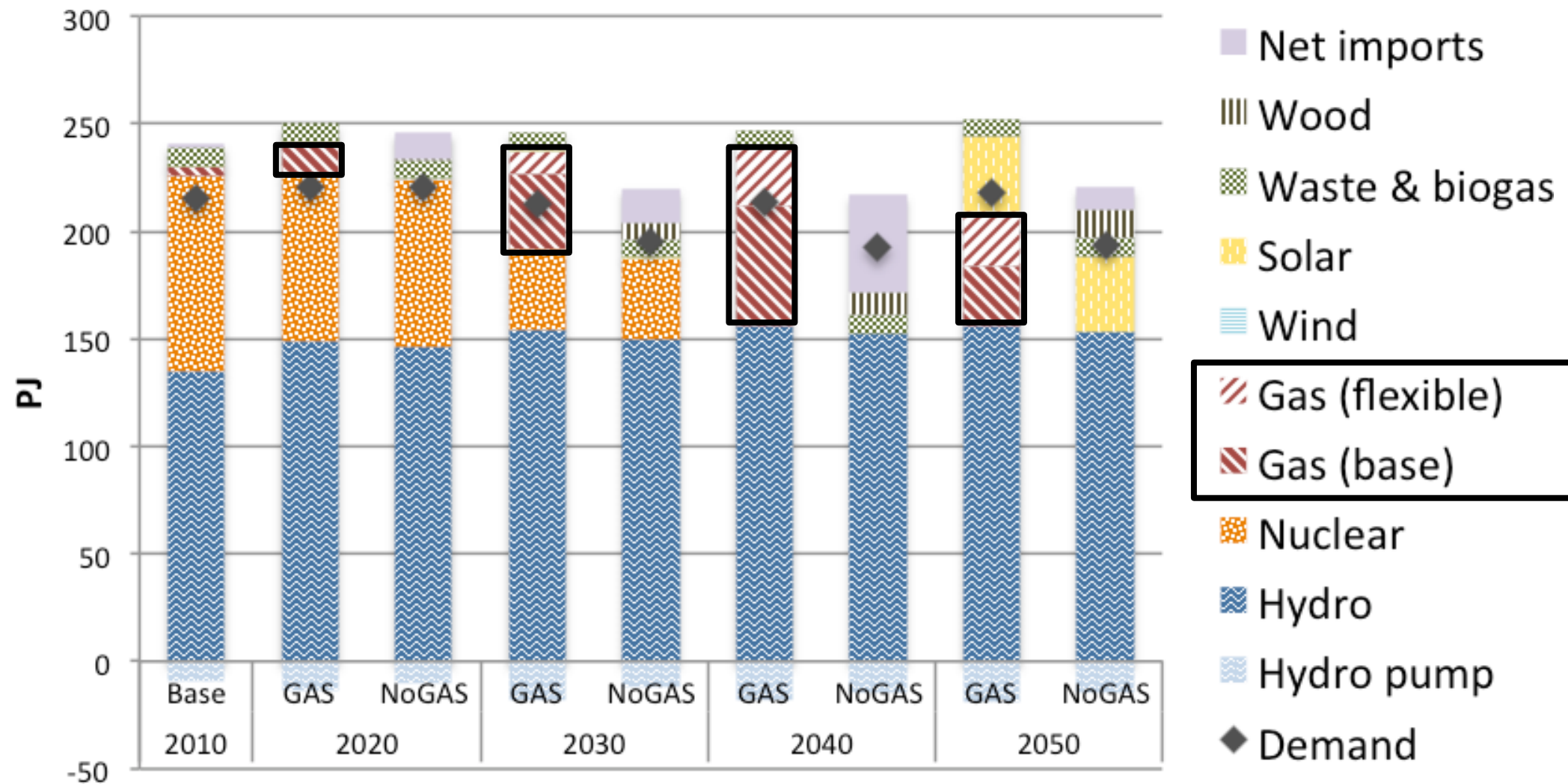
| | Reference GAS | NoGAS |
|------------------------------------|--|---|
| Market instruments | ETS scheme CO ₂ tax Electricity tax | same |
| Technology and import restrictions | Nuclear phase-out - No net electricity imports (annually) | same No gas-fired power plants Net electricity imports allowed |

Electricity generation mix



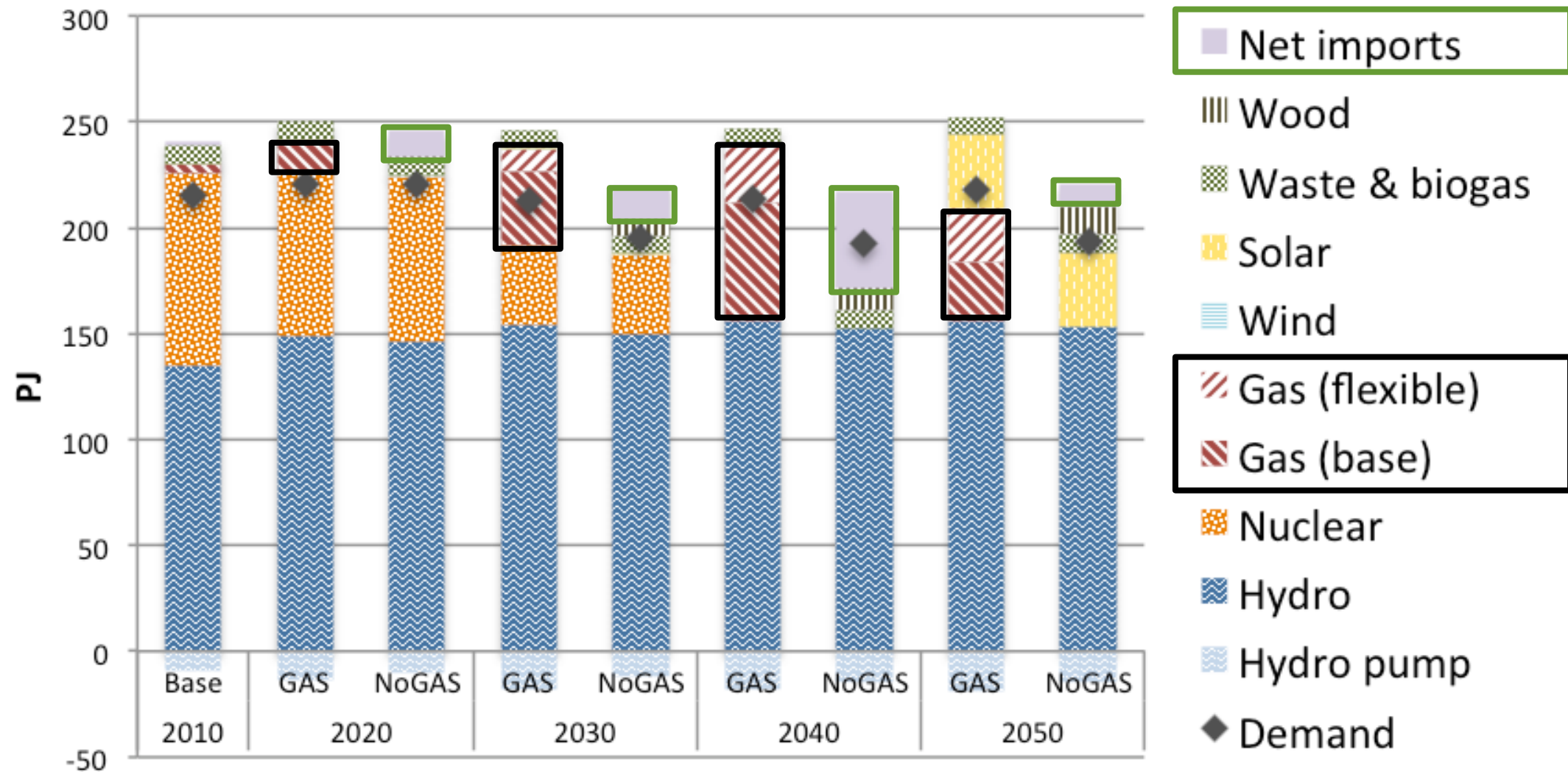
Electricity generation mix for the GAS and NoGAS scenarios

Electricity generation mix



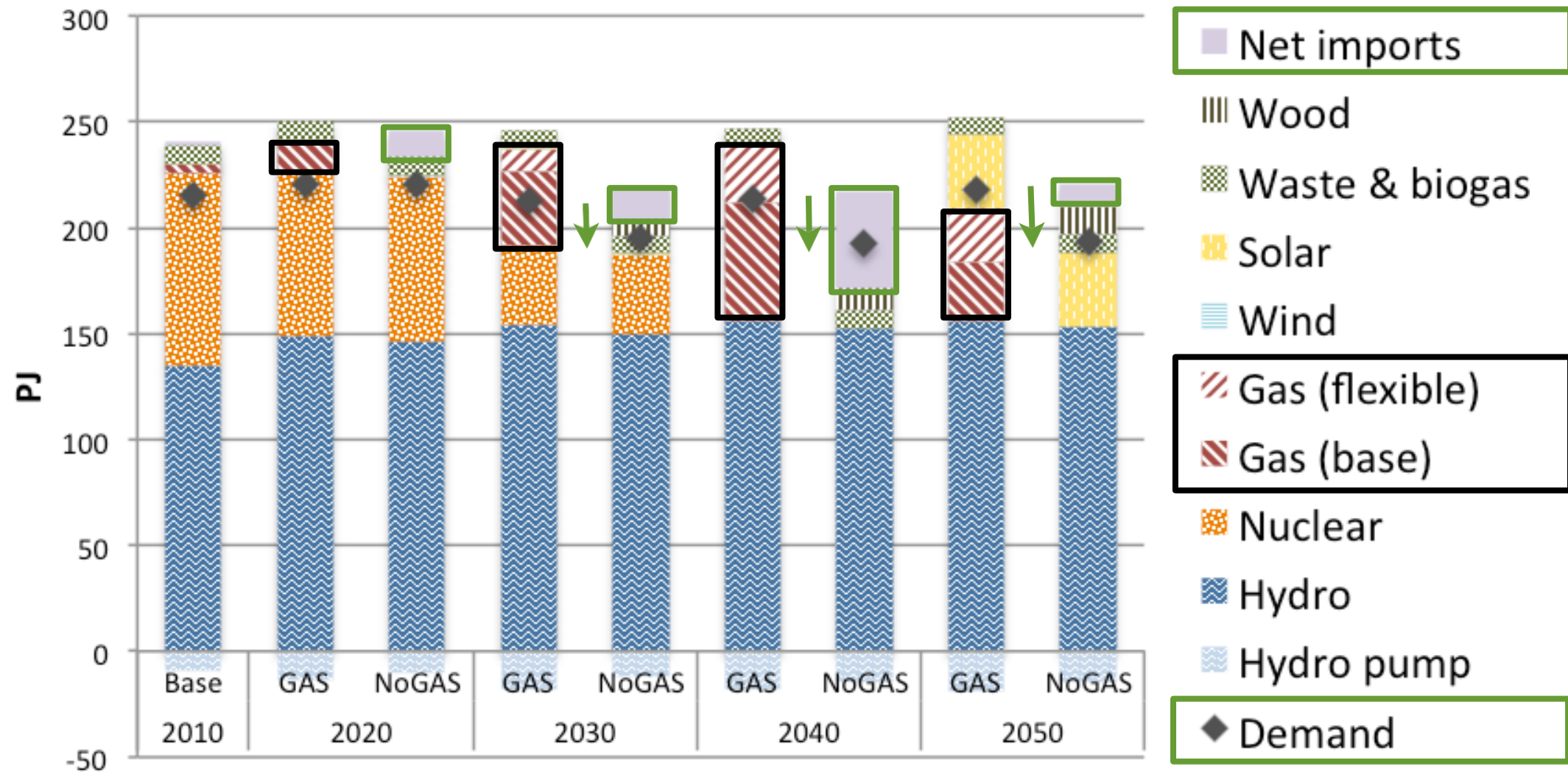
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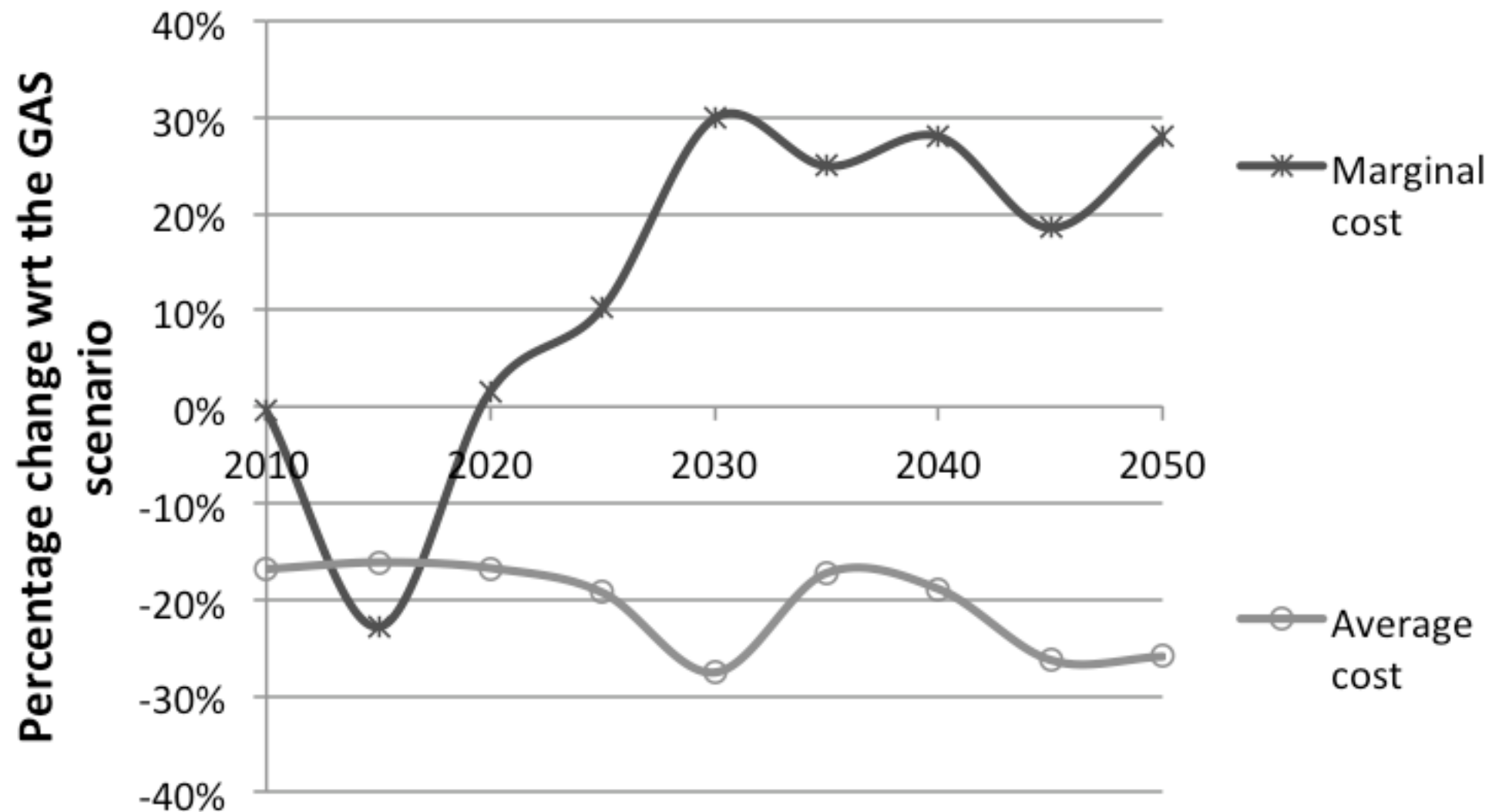
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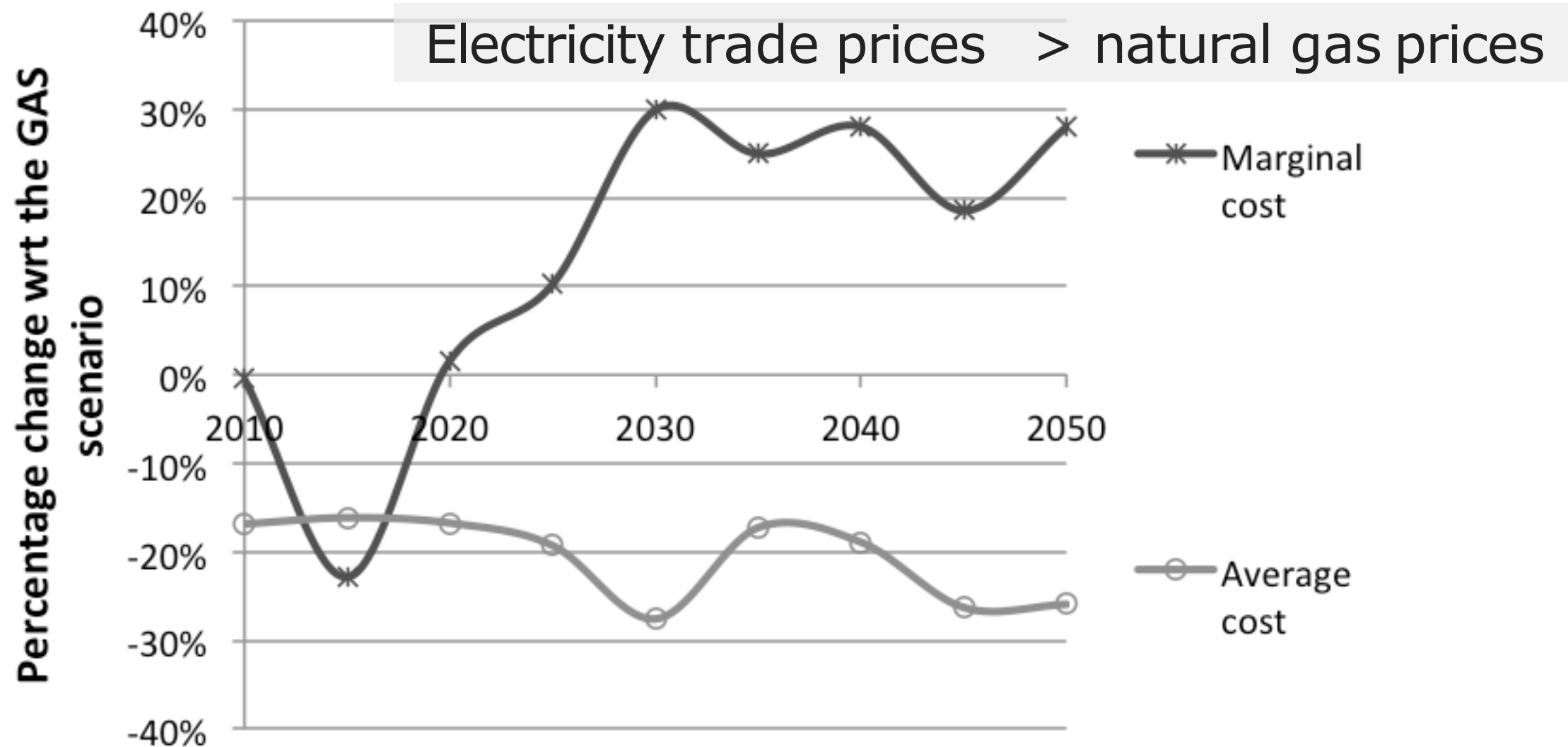
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Electricity costs



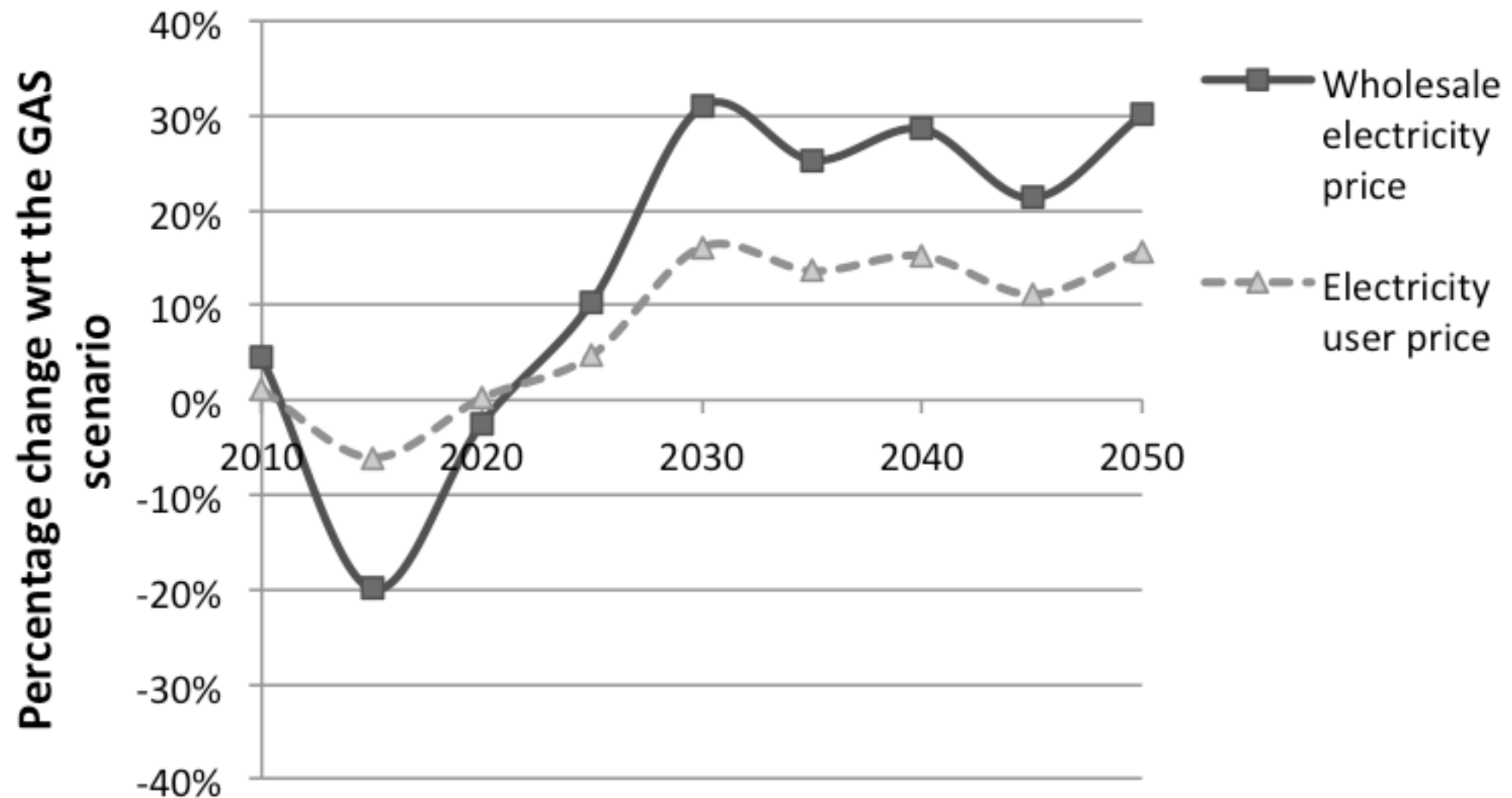
Variations of marginal and average costs of electricity in the NoGAS scenario compared to the GAS scenario.

Electricity costs



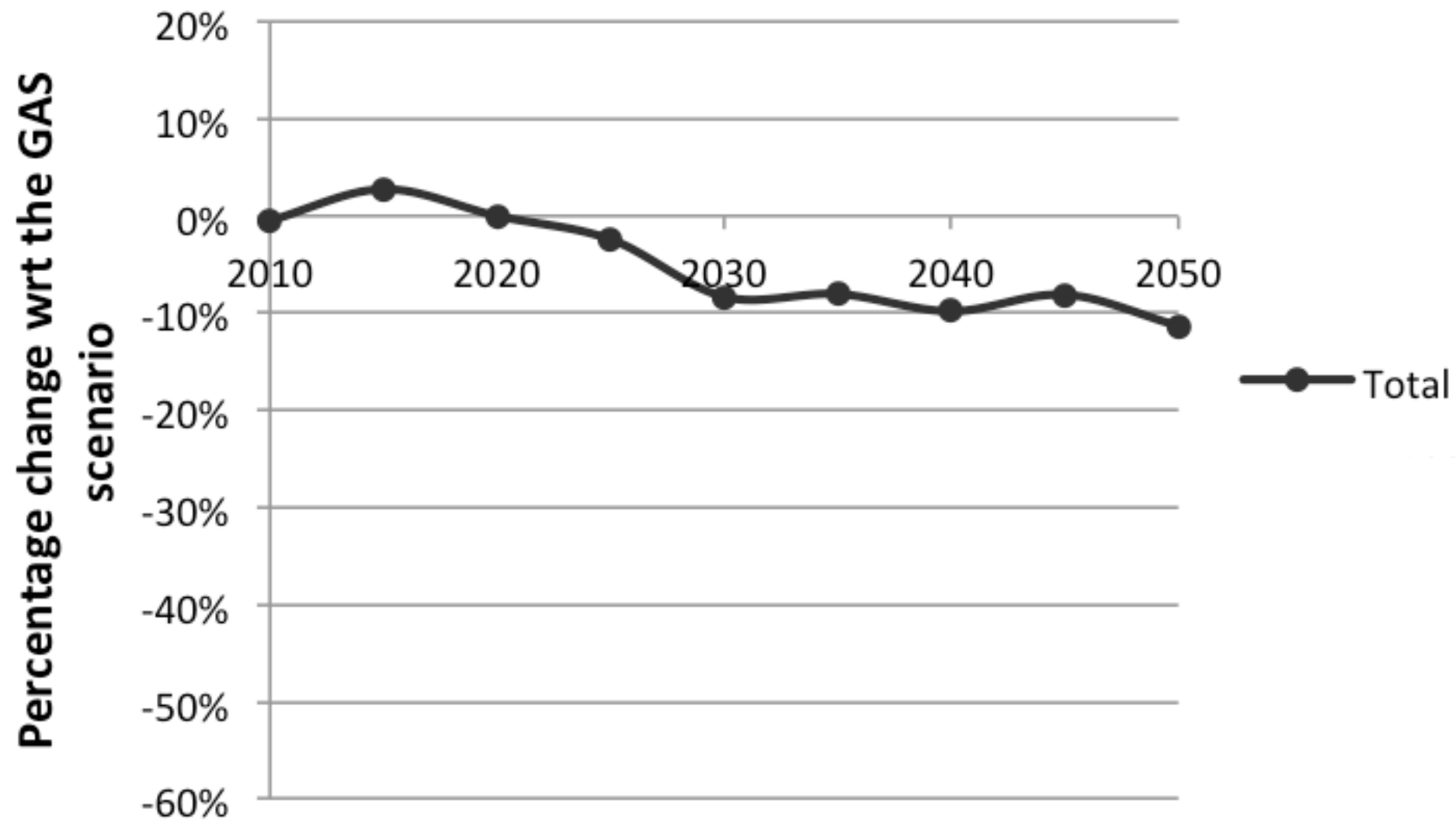
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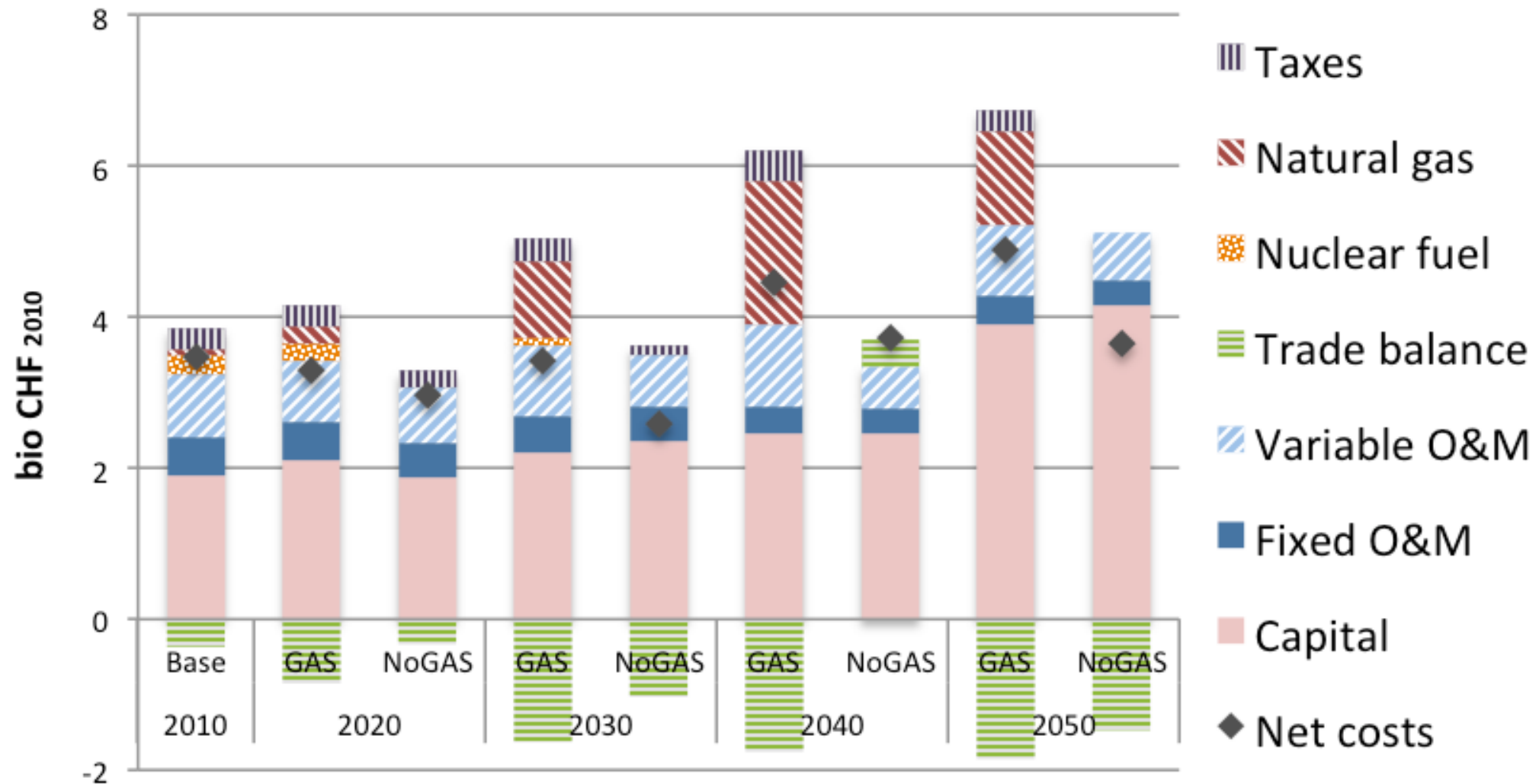
Variations of wholesale electricity price and electricity price for users (incl. distribution costs and tax) in the NoGAS scenario compared to the GAS scenario.

Electricity demands



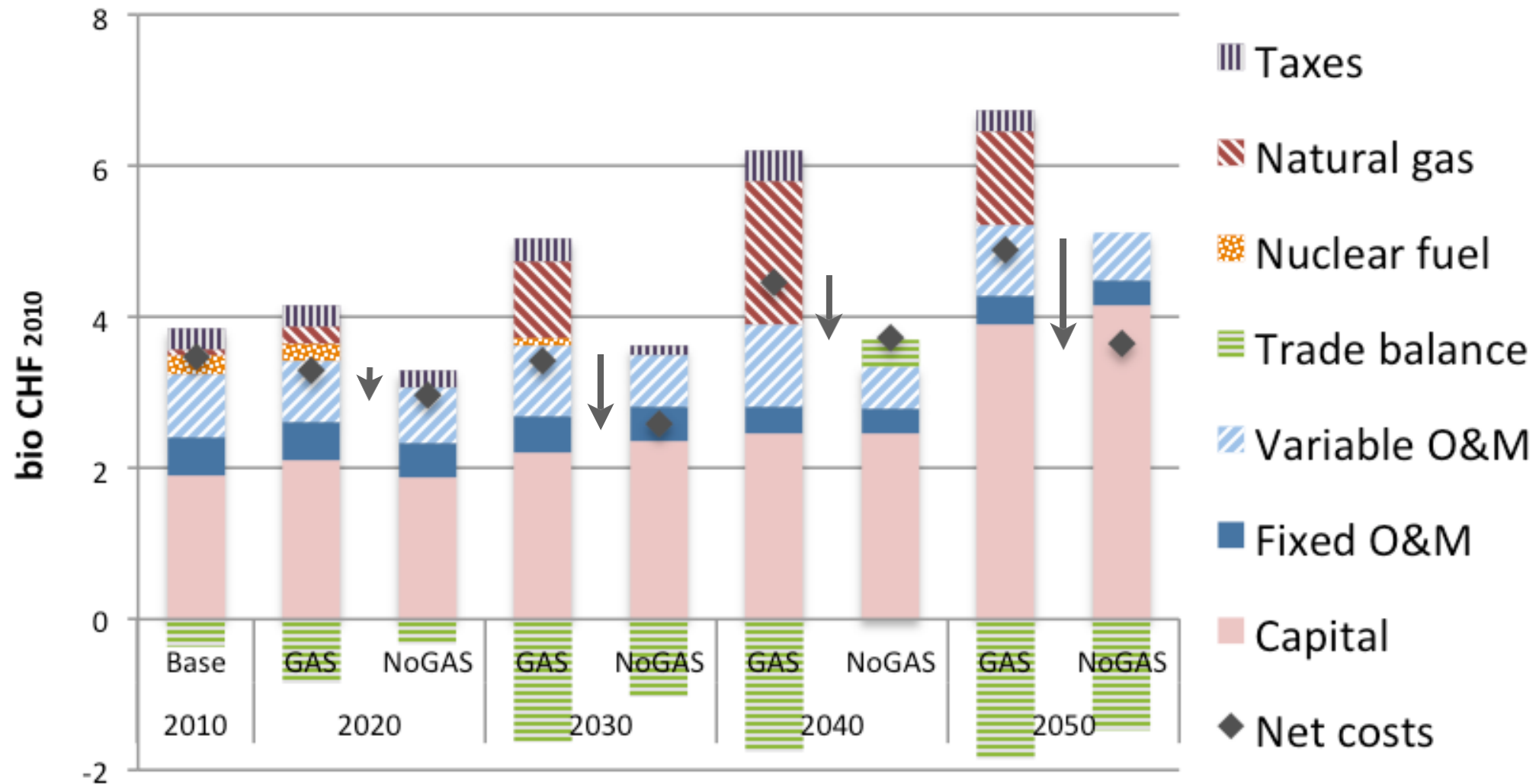
Variations of wholesale electricity demands in the NoGAS scenario compared to the GAS scenario.

Electricity total system cost



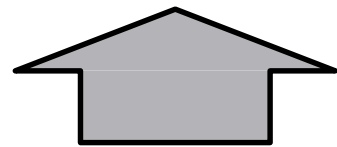
Total system cost of electricity generation for the GAS and NoGAS scenarios

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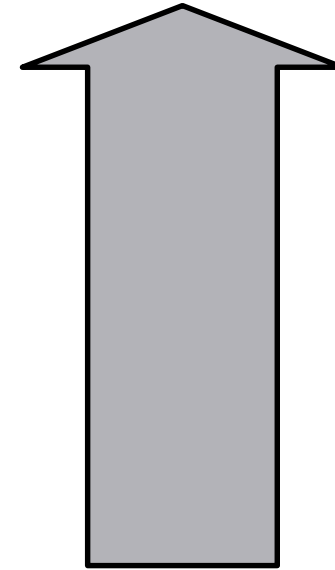
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Welfare (HEV) vs total system cost



welfare increase

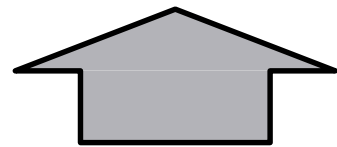
1 bio CHF



total system cost decrease

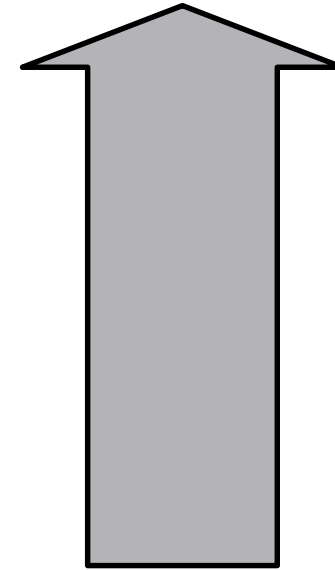
4.2 bio CHF

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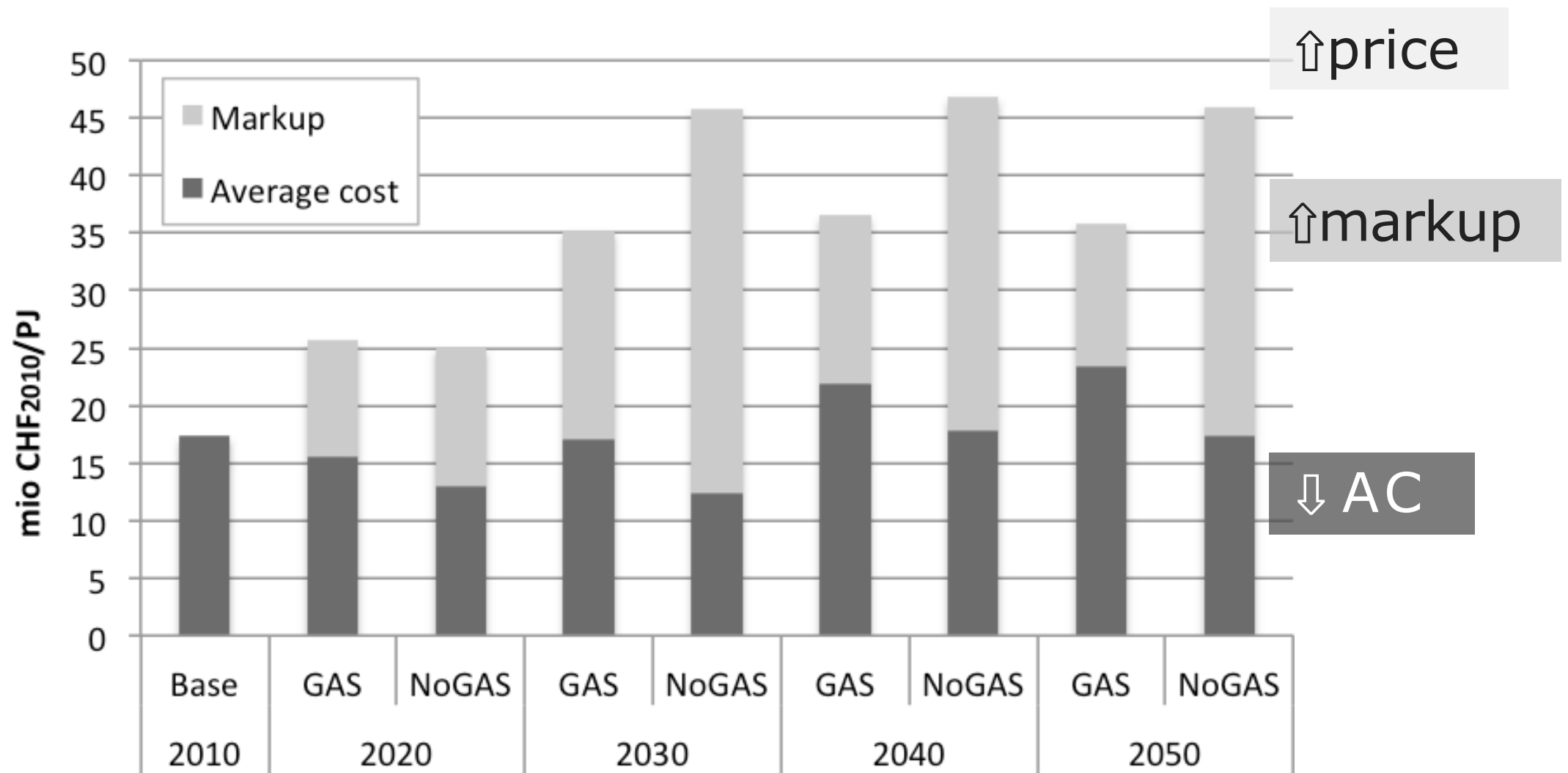


total system cost decrease

4.2 bio CHF

Why the difference?

Electricity prices



Wholesale electricity price and its components for the GAS and the NoGAS scenarios.

Effects on welfare (HEV)

↓ AC

Cost saving (on total system cost)

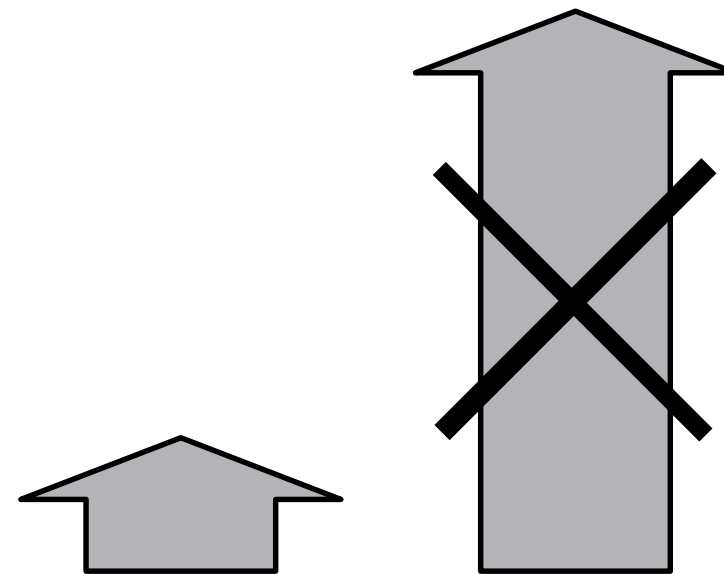
* increase in welfare

↑ price

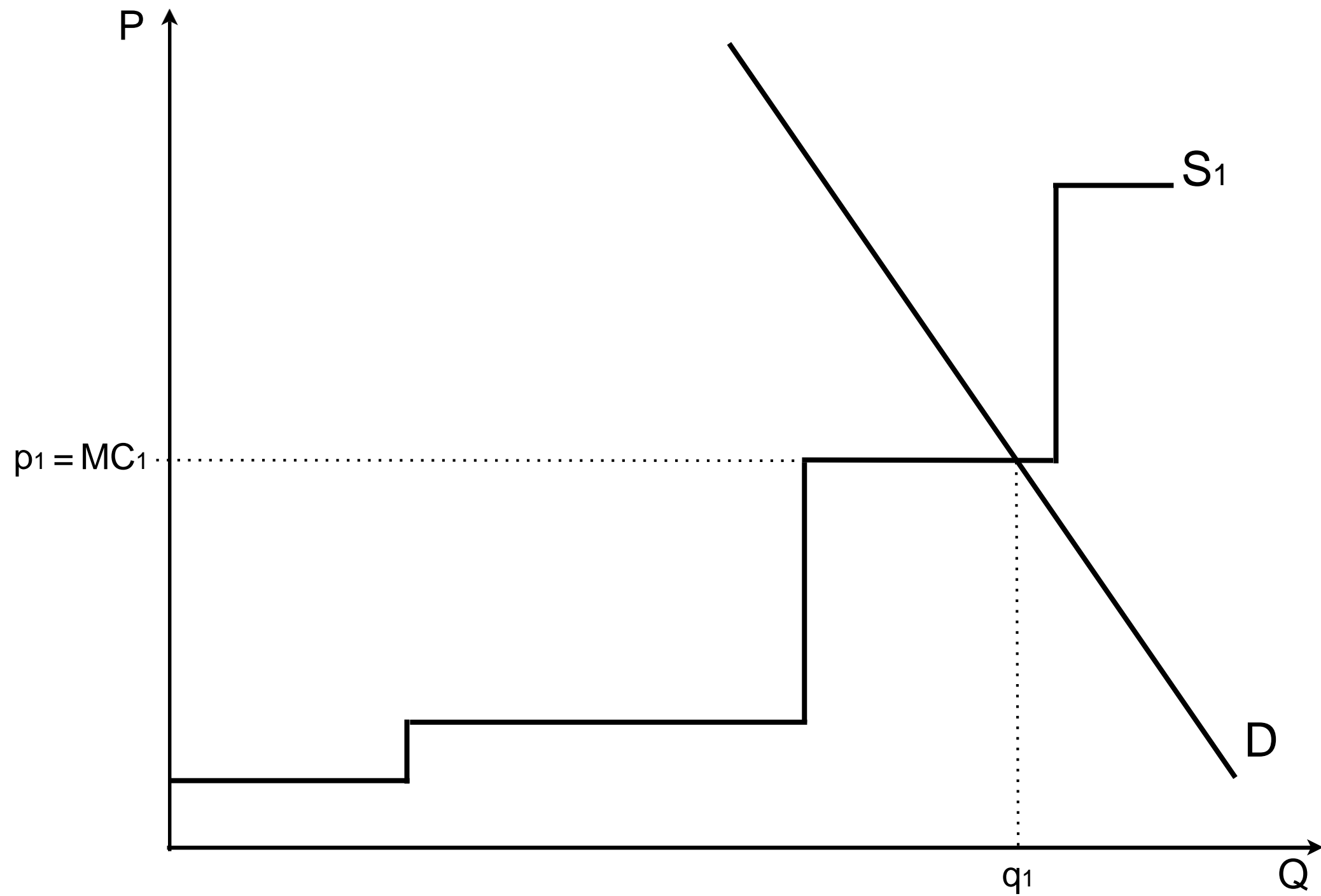
Increase in marginal cost (wholesale price)

* decrease in welfare

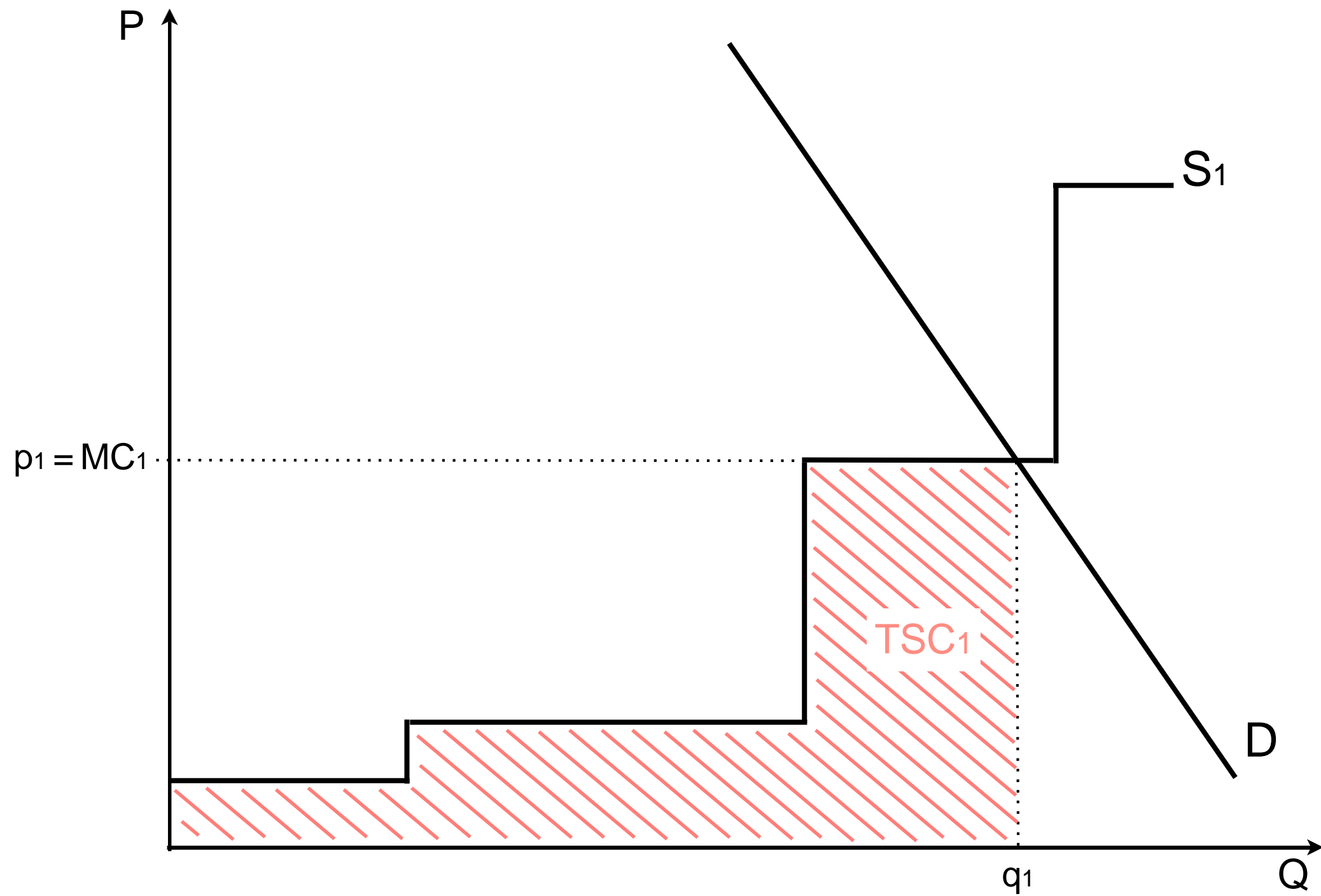
* total welfare variation:



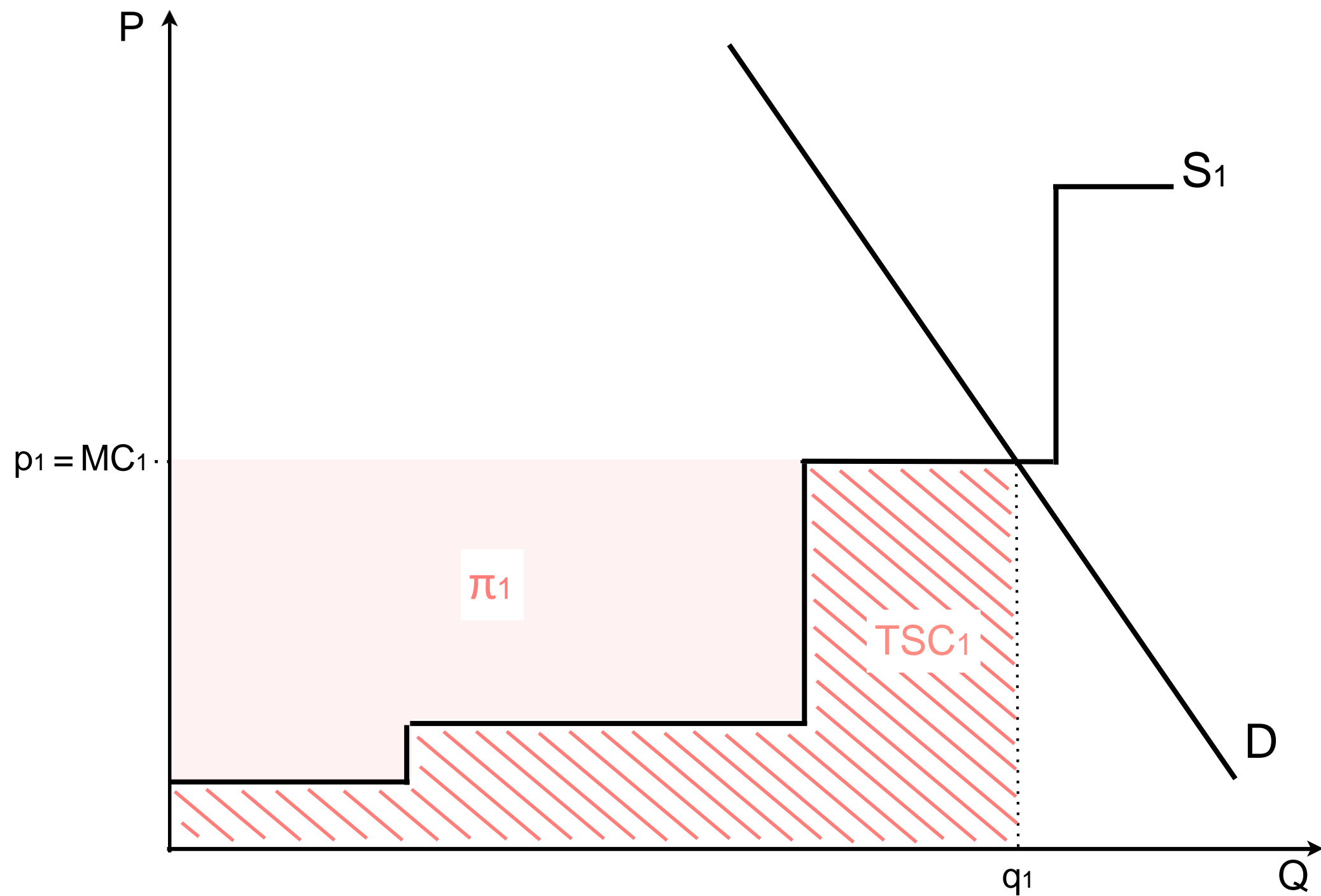
Partial-equilibrium illustration



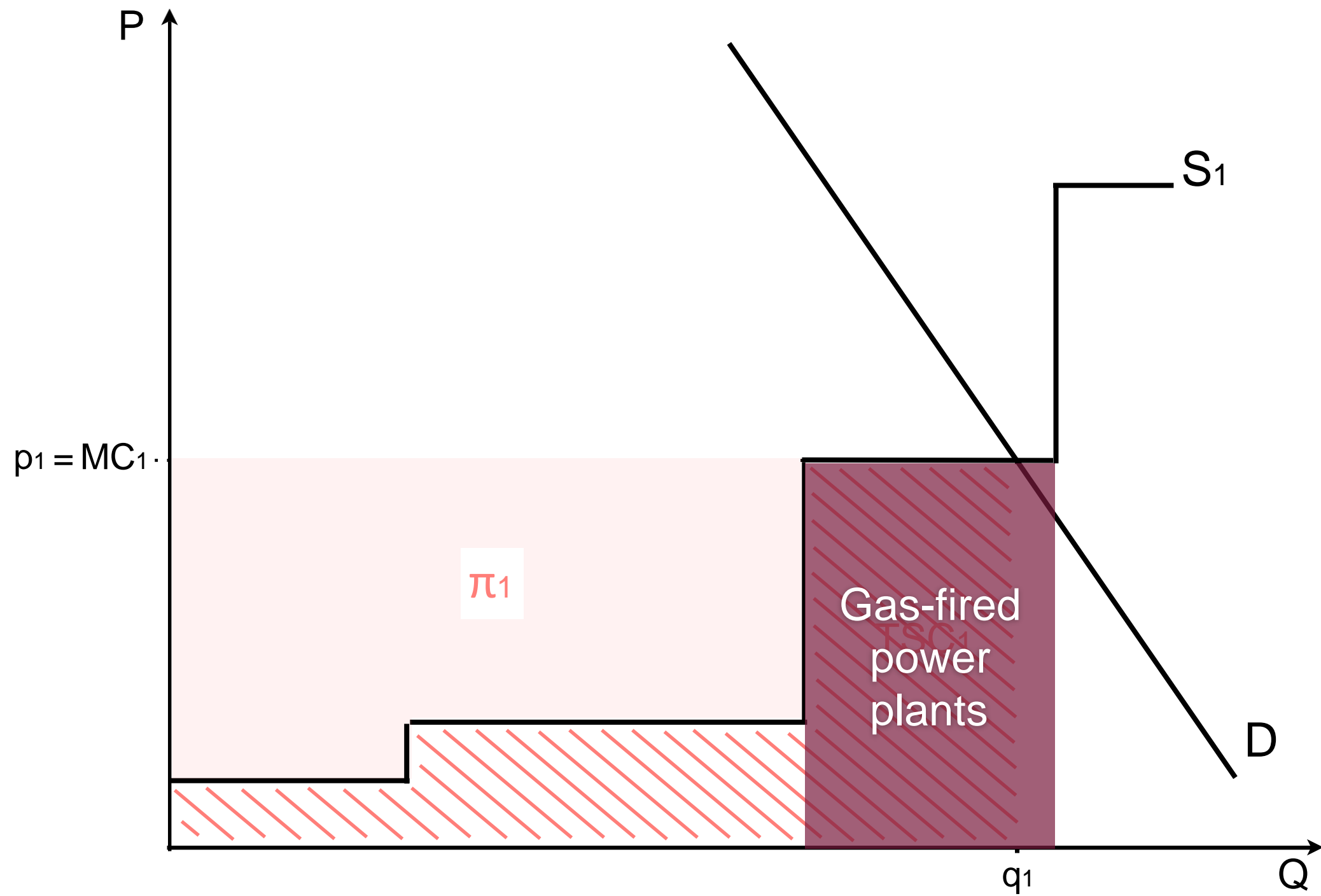
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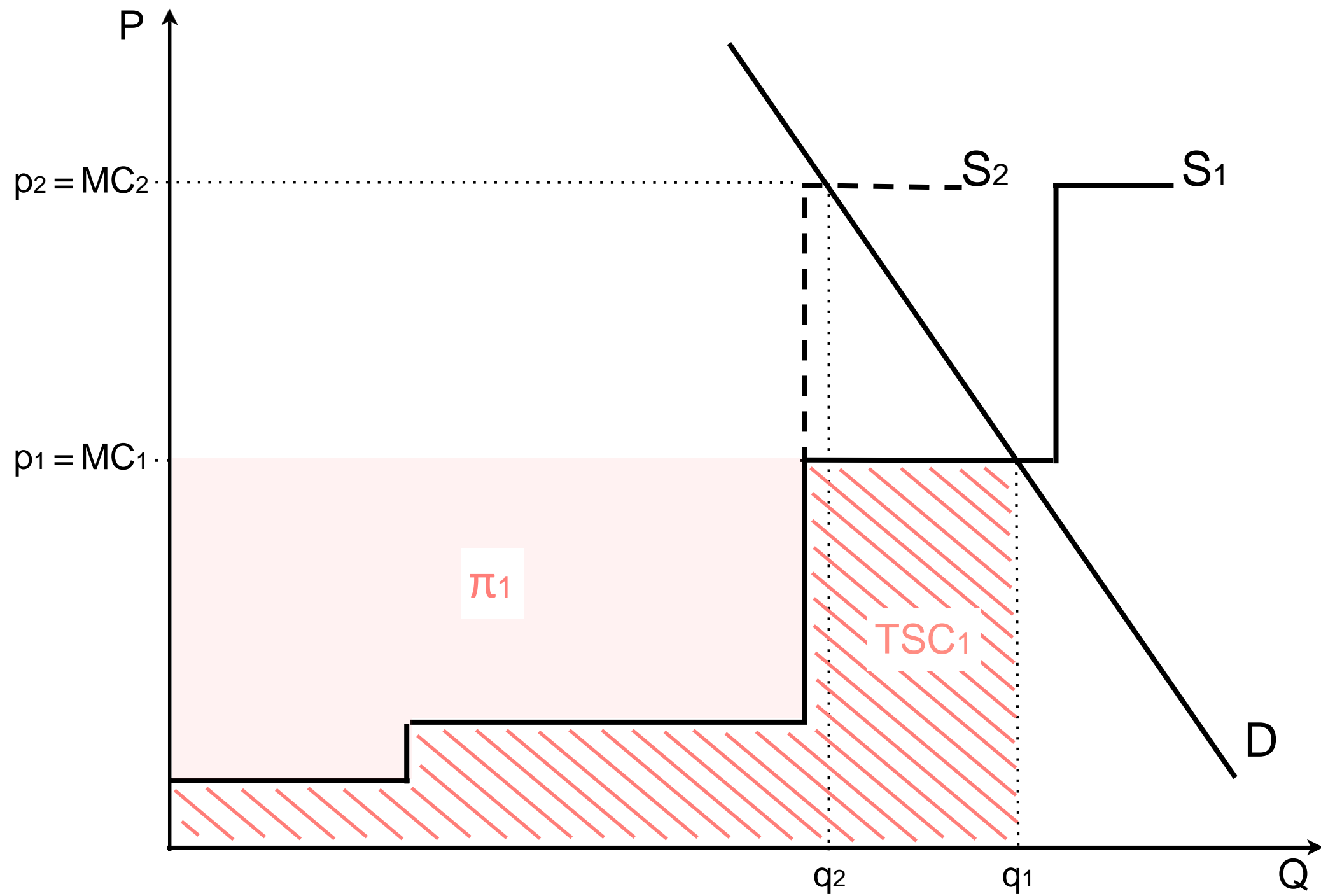
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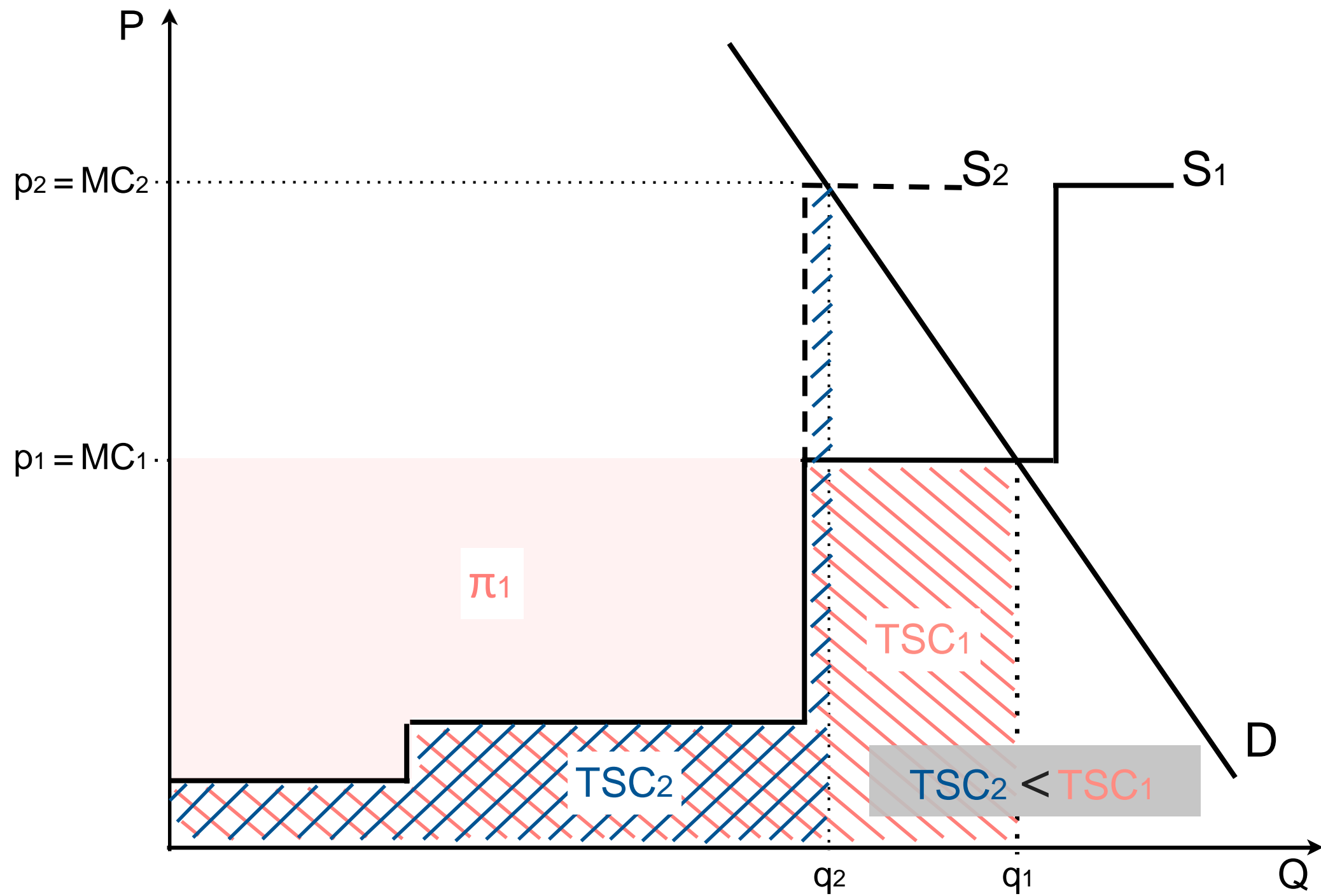
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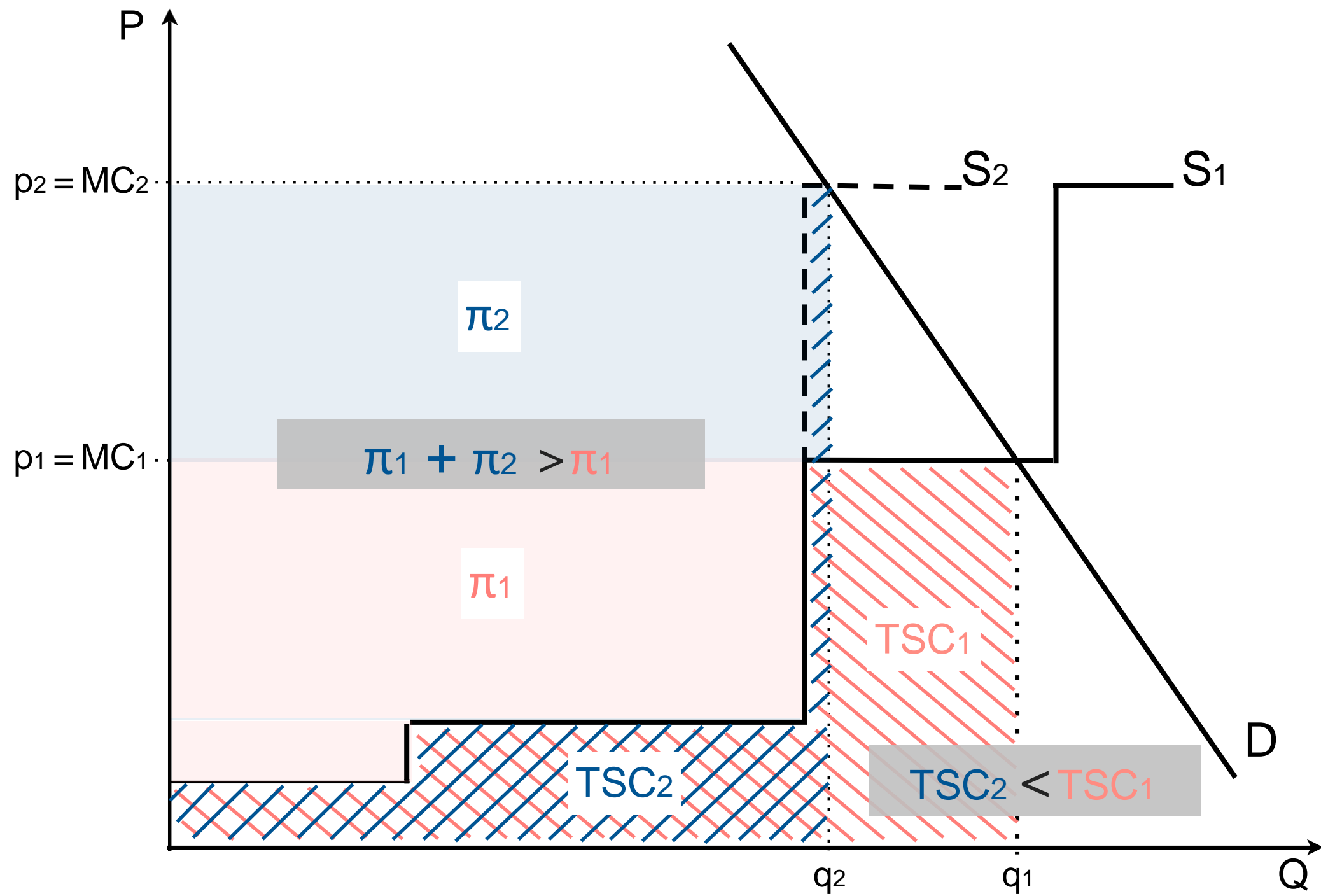
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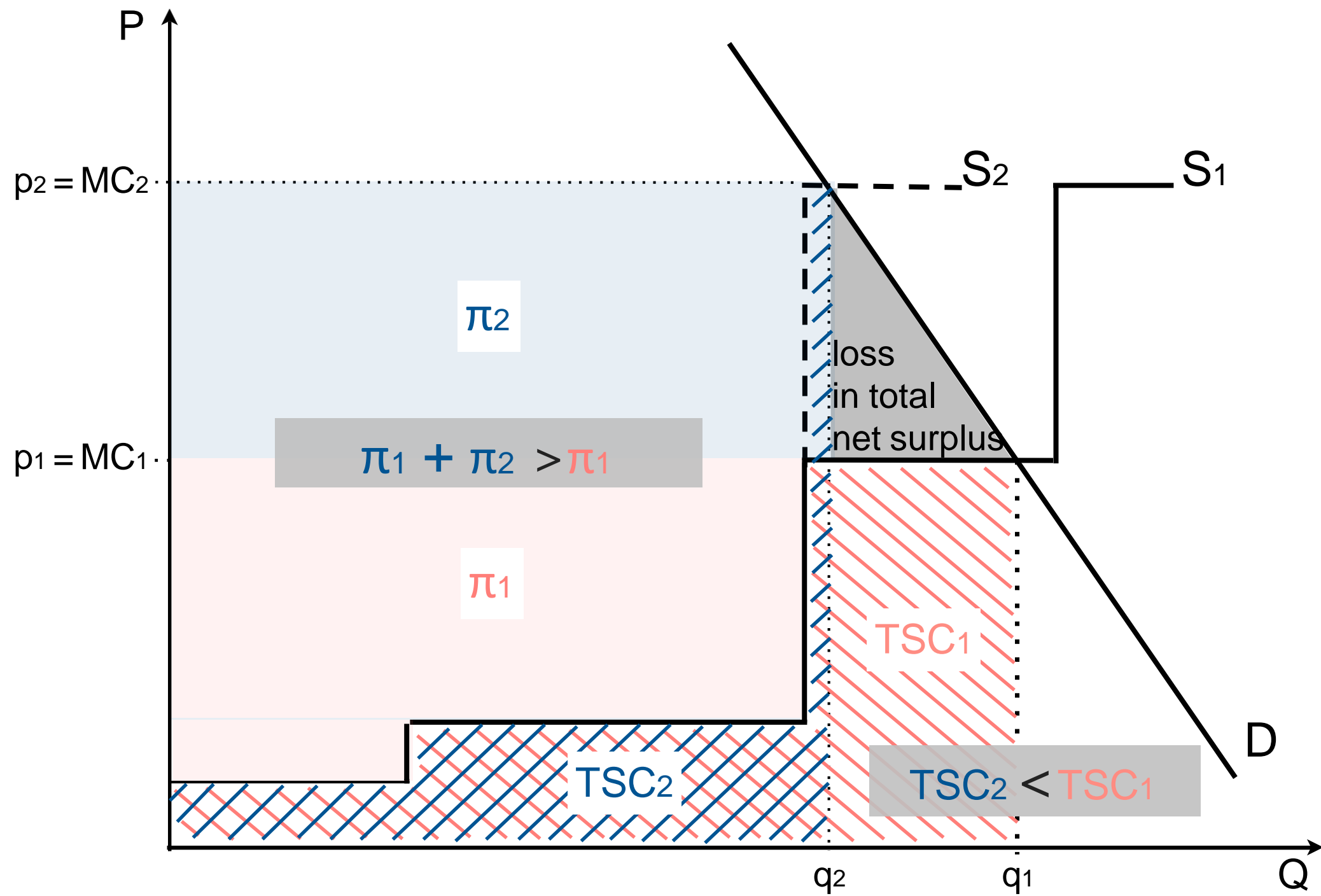
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- Liberalized market: price = MC
- MC and AC do not react the same way to a policy shock
- Results are specific to each system/country and scenario

- our scenario is quite particular:

↑ MC (=price)

↓ AC

↑ profit

- depends on relative import prices for electricity and gas
- the opposite constellation can be even more problematic
- changes in profit are generally relevant for the system and welfare

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- What are the consequences of technology choices on the functioning of the system, including markets and regulation?
- Pricing changes (average cost pricing not a valid assumption anymore)
 - > profits -> investment incentives
 - > user prices and demand reactions
 - > feedbacks on the system (technology choices)

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 - distinguishing wholesale (peak/off-peak/base load) & retail markets
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 - technology-induced dynamics of the market structure
- the minimum:
 - Let's not design projects as if Switzerland were an island.
 - Regard central planning as a serious model caveat.
 - Conclude carefully from indicators (total system cost, or even total surplus).
 - Provide recommendations with lots of caution and the full complexity in mind.