

REVISITING POLICY CONCERNS IN DECARBONIZED ENERGY SYSTEMS: PRICE VOLATILITY, SEASONAL STORAGE, AND SHOCKS

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# **KU LEUVEN**

## EUROPEAN COMMISSION **CLEAN PLANET FOR ALL IN-DEPTH ANALYSIS**









IN-DEPTH ANALYSIS IN SUPPORT OF THE COMMISSION COMMUNICATION COM(2018) 773

A Clean Planet for all A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy

## **POLICY CONCERN 1: PRICE VOLATILITY**





- Battery storage
- Demand side management
- Interconnections
- Curtailment bids
- Sector coupling

Large energy storage capacities

## **POLICY CONCERN 2: SEASONAL STORAGE**

#### Figure ES.1: Three groups of storage technologies based on powerand energy-capacity costs



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#### **POLICY CONCERN 3: SHOCKS**



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#### Table 1 Strategies.

| Strategy                        | Description                                  | Geographical scope*      |
|---------------------------------|--|--------------------------|
| Default                         | Pure cost-minimization                       | -                        |
| Diversity<br>(generation-based) | Diversified generation mix                   | National/regional/Europe |
| Diversity<br>(capacity-based)   | Ability of diversified<br>generation mix     | National/regional/Europe |
| Self-sufficiency                | Minimum constraint on<br>domestic generation | National/regional        |
| Redundancy                      | Excess generation capacities                 | National/regional/Europe |
| Interconnectivity               | Expansion of transmission<br>capacities      | (National)               |
| Flexibility                     | Expansion of storage capacities              | National/regional/Europe |

\* National – strategy valid for each country separately; regional – strategy valid for each regional group of countries separately; and Europe – European-wide strategy.

Nahmmacher, P., Schmid, E., Pahle, M., Knopf, B., 2016. Strategies against shocks in power systems – An analysis for the case of Europe. Energy Economics 59, 455–465. https://doi.org/10.1016/j.eneco.2016.09.002







#### WILL PRICE VOLATILITY IN DECARBONIZED ENERGY SYSTEMS BE GREATER THAN TODAY DUE TO VARIABLE RENEWABLE ENERGY (VRE)?

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"...there will likely not be too many zero or even negative price situations due to excess renewable production in the system since the additional cross sectoral consumers will, depending on their actual flexibility potential, use it to supply final heat, industry, and transport demands" (Härtel and Korpås, 2021).

|   | Energy Economics 93 (2021) 105051                |
|---|--|
| Ę | Contents lists available at ScienceDirect        |
| þ | Energy Economics                                 |
|   | journal homepage: www.elsevier.com/locate/eneeco |

Demystifying market clearing and price setting effects in low-carbon energy systems

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"We find that increasing VRE penetration leads to many hours of very low prices interspersed with a few periods when prices are very high (approaching the value of lost load...) owing to scarcity events" (MIT Energy Initiative, 2022).

![](_page_6_Figure_8.jpeg)

AN INTERDISCIPLINARY MIT STUDY

#### LONG-TERM EQUILIBRIUM WITH PERFECT FORESIGHT ENERGY PRICES

![](_page_7_Figure_1.jpeg)

![](_page_7_Figure_2.jpeg)

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#### EVEN IF BATTERY STORAGE IS CHEAP, WILL WE STILL NEED OTHER TYPES OF ENERGY STORAGE TO MEET CLIMATE-NEUTRALITY OBJECTIVES?

\*Among Long Duration Energy Storage technology options, we find that <u>hydrogen</u> (and other forms of derived chemical energy storage) offers a unique value proposition if it is produced with electricity and used <u>as a fuel to decarbonize</u> other end uses, thereby creating a large flexible load that supports VRE integration in the power sector" (MIT Energy Initiative, 2022).

![](_page_8_Figure_2.jpeg)

AN INTERDISCIPLINARY MIT STUDY

"Flexibility from electric batteries balances daily variation of solar and wind <u>whereas methane</u> and hydrogen storage mostly balances seasonal variation of demand and supply" (Koirala et al., 2021).

![](_page_8_Picture_5.jpeg)

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Integrated electricity, hydrogen and methane system modelling framework: Application to the Dutch Infrastructure Outlook 2050

Binod Koirala $^{a,*},$  Sebastiaan Hers $^a,$  Germán Morales-España $^a,$ Özge Özdemir $^b,$  Jos Sijm $^a,$  Marcel Weeda $^a$ 

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#### LONG-TERM EQUILIBRIUM WITH PERFECT FORESIGHT ROLE OF (SEASONAL) ENERGY STORAGE

![](_page_9_Figure_1.jpeg)

# IF WE DO NOT HAVE PERFECT FORESIGHT, WHICH SITUATION IS PREFERRED TO DEAL WITH SHOCKS: UNDERPREPARED OR OVERPREPARED?

- Will current electricity market designs give the right incentives for storage? The "European" paradigm of <u>an energy-only market relies on the</u> <u>prospect of high peak prices</u> ... "precautionary" <u>storage can be seen as arbitrage against the</u> <u>occasional risk of extreme prices when load</u> <u>might be lost</u>" (Geske and Green, 2020).
- "for the example of Germany, storage requirements are defined by a 12-week or longer period of intermittent scarcity, and <u>system planning based on average years</u> <u>significantly underestimates storage</u> <u>requirements</u>" (Ruhnau and Qvist, 2021).

![](_page_10_Picture_3.jpeg)

Optimal Storage, Investment and Management under Uncertainty: It is Costly to Avoid Outages!

Joachim Geske<sup>a</sup> and Richard Green<sup>a</sup>\*

Ruhnau, Oliver; Qvist, Staffan

#### Working Paper

Storage requirements in a 100% renewable electricity system: Extreme events and inter-annual variability

#### **SHORT-TERM EQUILIBRIUM WITH IMPERFECT FORESIGHT** -95% CO2 TARGET SCENARIO

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![](_page_11_Figure_1.jpeg)

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![](_page_12_Picture_0.jpeg)

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![](_page_12_Picture_2.jpeg)