The European Market for Guarantees of Origin for Green Electricity

A Model-Based Evaluation of Future Price Scenarios

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FCN | Future Energy Consumer Needs and Behavior

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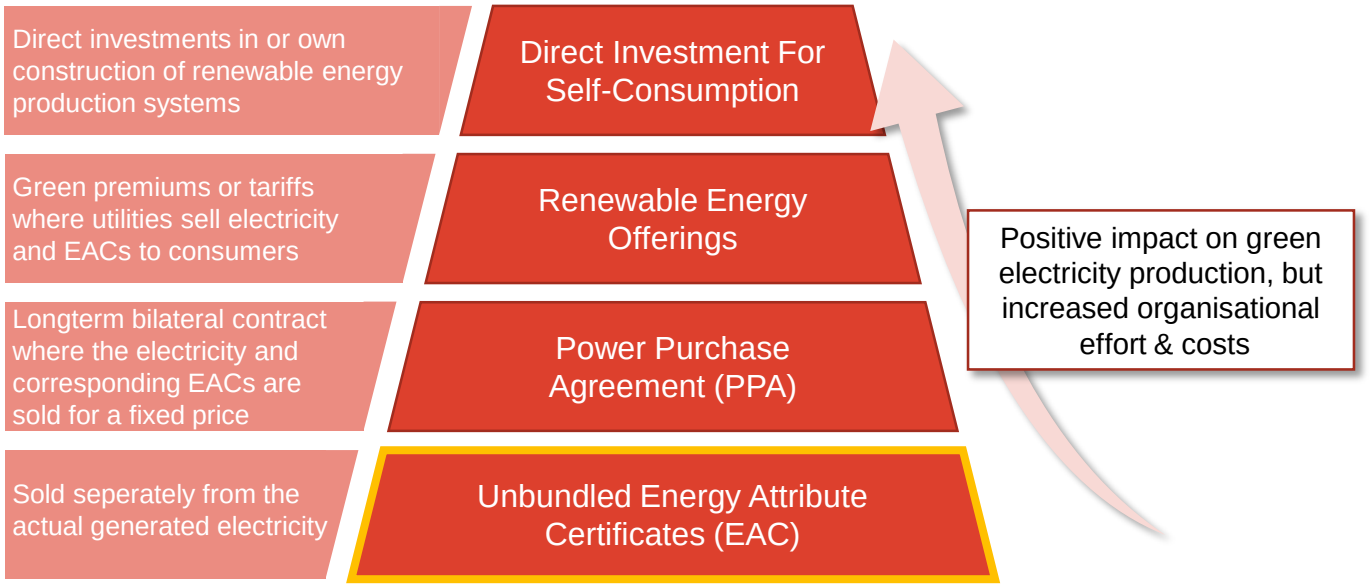
Agenda

1. Motivation
2. Theoretical Background
3. Model Design
4. Results
5. Conclusion and Future Outlook

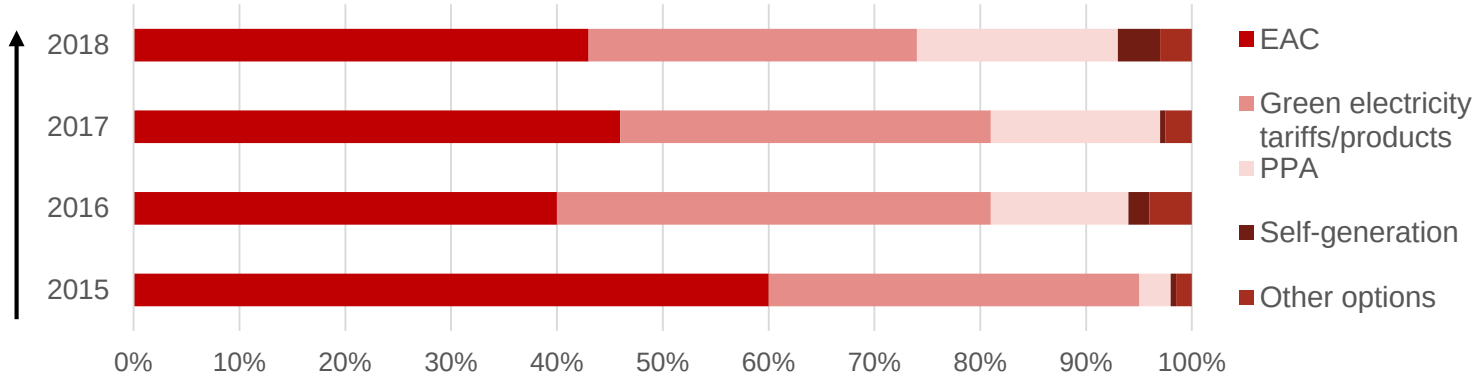
Agenda

Motivation | Approaches for Green Electricity Acquisition

Pyramid of Green Electricity Acquisition Approaches[1]



Relative Shares of Acquisition Methods for Green Electricity Amongst RE100 Members[2]



Sources: [1] IRENA (2018), pp.41-51; [2] RE100 (2018), p.8

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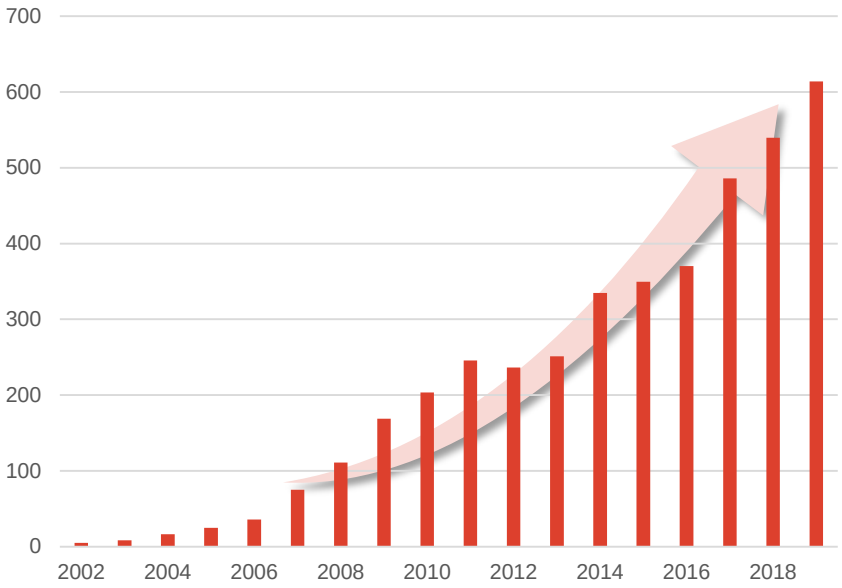
Motivation | Historical Volumes and Prices for European GoOs

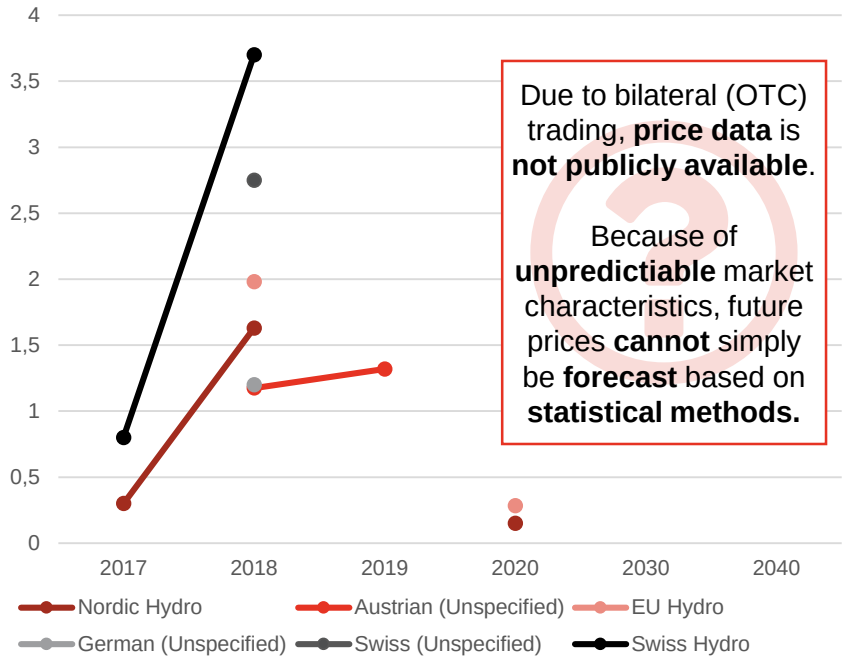
General Information

- **Guarantees of Origin** (GoOs) are used for electricity disclosure and can be traded on a separate market[1]
- The GoO market has been characterized by **non-transparency**, **volatility**, and **speculative** consumer behavior[2]

Cancellation of European GoOs [TWh][3]



Prices for Different European GoOs [€/MWh][4]



Due to bilateral (OTC) trading, **price data** is **not publicly available**.

Because of **unpredictable** market characteristics, future prices **cannot** simply be **forecast** based on **statistical methods.**

Question: How can future prices and volumes of European Guarantees of Origin for Green Electricity be predicted despite the lack of market transparency?

Sources: [1] Langeraar & Devos (2003), p.63; [2] Hauser et al. (2019), p.209; [3] AIB (2020a); [4] Various sources, cf. Backup Slide 35

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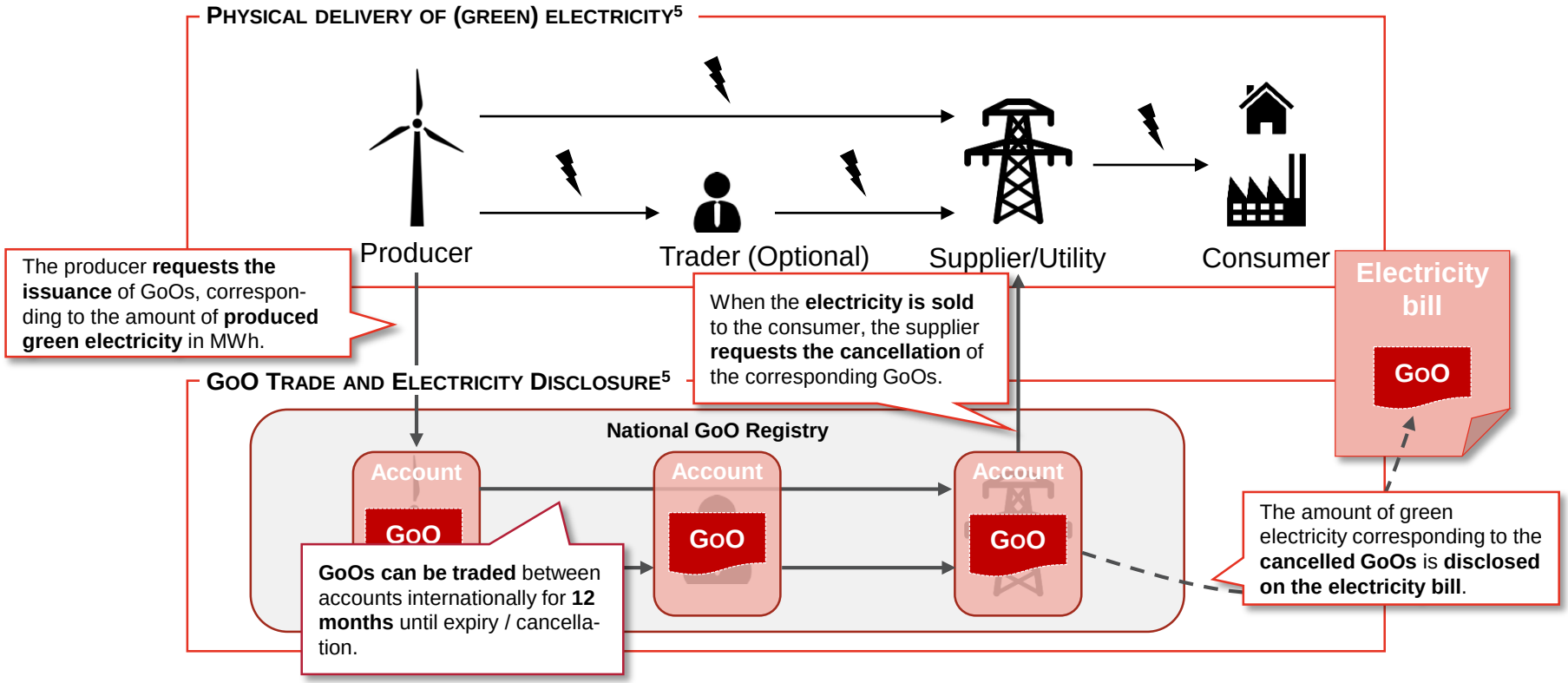
Theoretical Background | The Concept of Guarantees of Origin

What are Guarantees of Origin?

- Electricity is a homogenous good which makes it impossible to determine the origin of electricity once it is produced[1]
- Suppliers are required to **disclose** the origin of the **delivered electricity** to consumers[2]
- Definition of the European Union (2001): „*an electronic document which has the sole function of providing proof to a final customer that a given share or quantity of energy was produced from renewable sources*"[3]
- A **Guarantee of Origin** (GoO) contains all the information to identify **where**, **when** and **how one specific MWh** of **green electricity** was produced[4]



Sources: [1] Langeraar & Devos (2003), p.63; [2] Markard & Holt (2003), p.1472; [3] European Commission, Directive 2001/77/EC, § 5; [4] European Commission, Directive 2009/28/EC, § 16; [5] UBA (2020)

Theoretical Background | The European Energy Certificate System

Composition of the European Energy Certificate System (EECS)

- The EECS is governed by the **Association of Issuing Bodies** (AIB)[1]
- In total, **26 European states** are members in the AIB (23 EU + Norway, Switzerland & Iceland) and allow **international trade** of GoOs between their respective national registries[2]
- However, there is a lack of harmonization amongst AIB members concerning the issuance of GoOs, the handling of additional national support schemes and export rules[3]

Category 1

GoOs can be issued when support is received. However, this must be indicated on the GoO.

Category 2

Supported GoOs are auctioned in some form.

Category 3

Supported GoOs are immediately cancelled after issuance.

Category 4

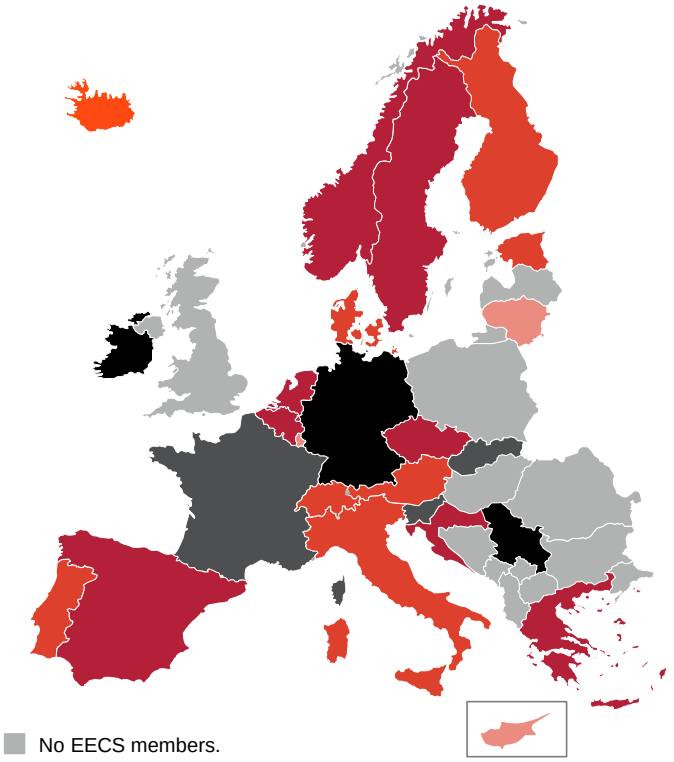
No GoOs may be issued for energy that has received governmental support.

Category 5

No regulations exist. This means that the same MWh may receive governmental support and a GoO.

Category 6

No governmental support scheme exists.



Sources: [1] Raadal et al. (2012), p.420; [2] AIB (2020); [3] AIB (2019)

Theoretical Background | Literature Review (Selection)

Literature on GoOs in general

- Velazquez Abad & Dodds (2020) *Green hydrogen characterisation initiatives* in Energy Policy
- Brander, Gillenwater & Ascui (2018) *Creative Accounting* in Energy Policy
- Nordenstam et al. (2018) *Corporate Greenhouse Gas Inventories* in Journal of Cleaner Production
- Carley et al. (2017) *Global Expansion of Renewable Energy Generation* in Environmental and Resource Economics
- Mulder & Zomer (2016) *Contribution of Green Labels* in Energy Policy
- Raadal et al. (2012) *Interaction between Electricity Disclosure and Tradable Green Certificates* in Energy Policy
- Ragwitz, del Rìo Gonzalez & Resch (2009) *Advantages and Drawbacks of Guarantees of Origin in Europe* in Energy Policy
- Langeraar & Devos (2003) *Guarantees of Origin* in Refocus

Commercial providers of GoO price & volume insight

- Advantag Services (Germany)
- Arcanum Energy Solutions (Germany)
- Argus Media (UK)
- Bischoff & Ditze Energy (Germany)
- Greenfact (Norway)
- Montel (Norway)
- Nvalue (Switzerland)
- Oslo Economics (Norway)

Future Traded Volumes and Prices in the European Market for Guarantees of Origin (GoO) for Green Electricity

Willingness-to-Pay for Green Electricity

- Yevdomikow et al. (2019) *Measuring Willingess to Pay for Electricity* in Energy & Environment
- Andor, Frondel & Vance (2017) *Germany's Energiewende* in The Energy Journal
- Grilli (2017) *Renewable Energy and Willingess to Pay* in Economics and Policy of Energy and the Environment
- Sundt & Rehdanz (2015) *Consumers' Willingness to Pay for Green Electricity* in Energy Economics
- Soon & Ahmad (2015) *Willingly or grudgingly?* in Renewable and Sustainable Energy Reviews
- OECD (2014) *Greening Household Behaviour*
- Winther & Ericson (2013) *Matching Policy and People?* in Energy Efficiency
- Diaz-Rainey & Ashton (2011) *Profiling Green Electricity Tariff Adopters* in Business Strategy and the Environment
- Borchers, Duke & Parsons (2007) *Does Willingness to Pay for Green Electricity Differ by Source?* in Energy Policy

(Historical) GoO Market Analyses, Misc. Sources

- Hauser et al. (2019) *Marktanalyse Ökostrom II* (In German) for UBA in Climate Change
- Dagoumas & Koltsaklis (2017) *Price Signal of Tradable Guarantees of Origins* in International Journal of Energy Economics and Policy
- Hufen (2017) *Cheat Electricity?* in Sustainability
- Kuronen & Lehtovaara (2017) *Development of the Guarantees of Origin Market* for Grexel Systems Ltd.
- Klimscheffskij et al. (2015) *Residual Mix Calculation* in Energies

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Model Design | Calculation of prices

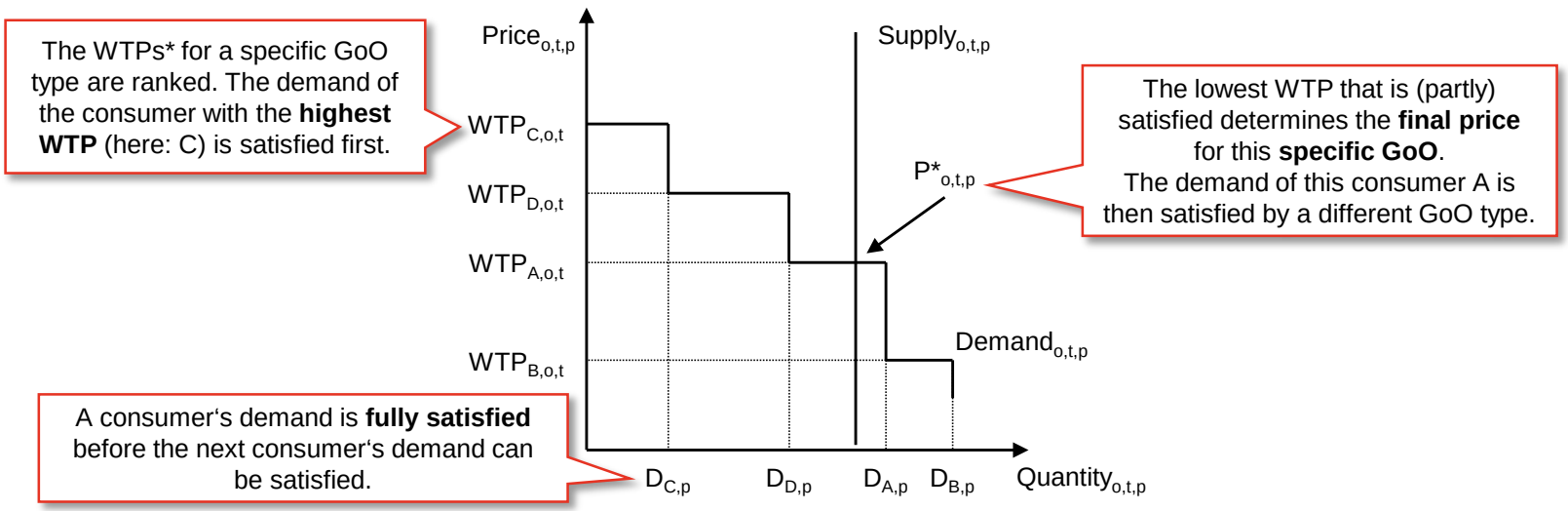
Fundamental approach

„The value of a GoO depends on the size of the market, the demand for green electricity or tariffs, the question if the disclosure scheme is mandatory and how it functions with complementary subsidy schemes.“ [1]

Key Assumptions

- The supply of GoOs is **perfectly inelastic**
- The current situation of over-supply in the market is eventually overcome and the **market becomes demand-driven**
- There is **no lower price boundary**
- Maximum prices are capped at the **lowest LCOE** of all RES technologies
- Prices are determined on a **yearly basis**

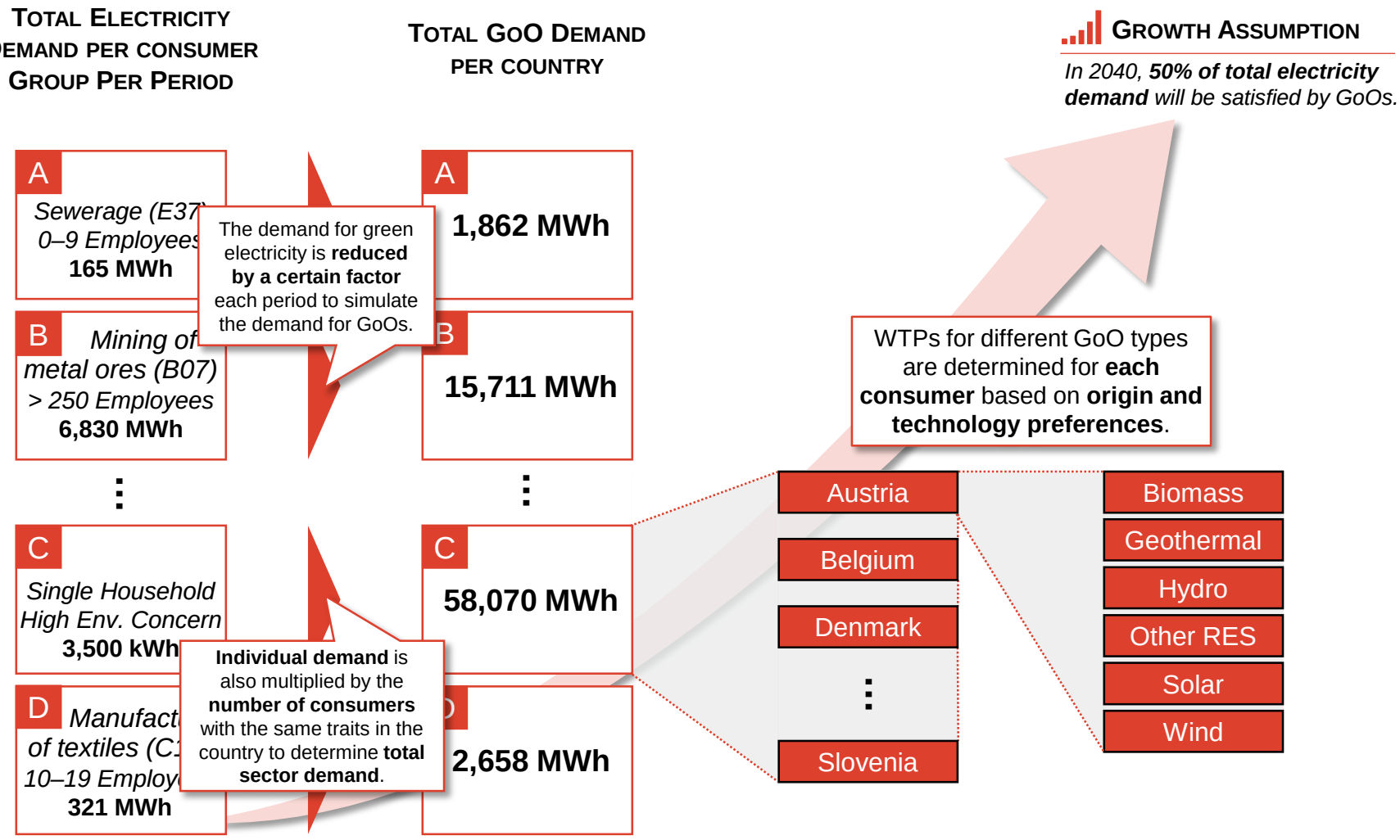
Exemplary price determination for GoOs of origin *o*, technology *t* in period *p* with consumers A, B, C and D



* WTP = Willingness-To-Pay

Source: [1] Velazques Abad & Dodds (2020), p.11

Model Design | Determination of Demand and Willingess-To-Pay



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Results | Scenario Presentation

Scenario 1: Status Quo

- Current harmonization situation in the AIB
- IEA's Stated Policy Scenario[1] for future development
- No RES technology portfolio diversification

Scenario 2: Sustainable Development

- Current harmonization situation in the AIB
- IEA's Sustainable Development Scenario[1] for future development
- Countries diversify their RES technology portfolios by beginning the production of previously unused technologies
- This leads to higher production of green electricity and GoOs

Scenario 3: Harmonization

- Harmonization policies have been implemented
- Members of Cat. 1, 2, 3 & 4 now have issue rates of those countries of Cat. 5
- This results in lower overall issue rates
- IEA's Stated Policy Scenario[1] for future development
- No RES technology portfolio diversification

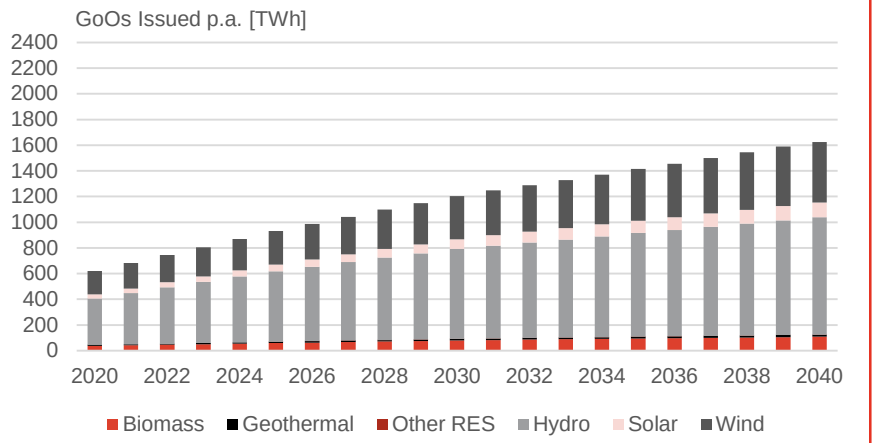
Scenario 4: Ideal Development

- Harmonization policies of Scenario 3 have been implemented
- IEA's Sustainable Development Scenario[1] for future development
- Countries diversify their RES technology portfolios by beginning the production of previously unused technologies

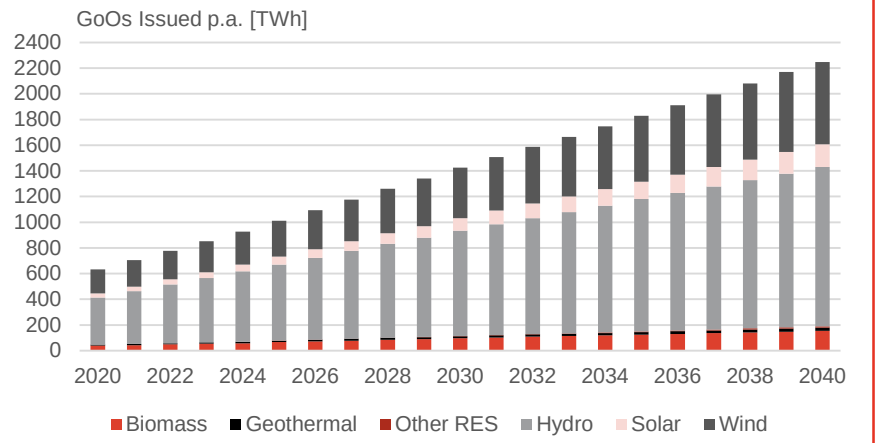
Source: [1] IEA (2020)

Results | Future GoO Volumes per Technology

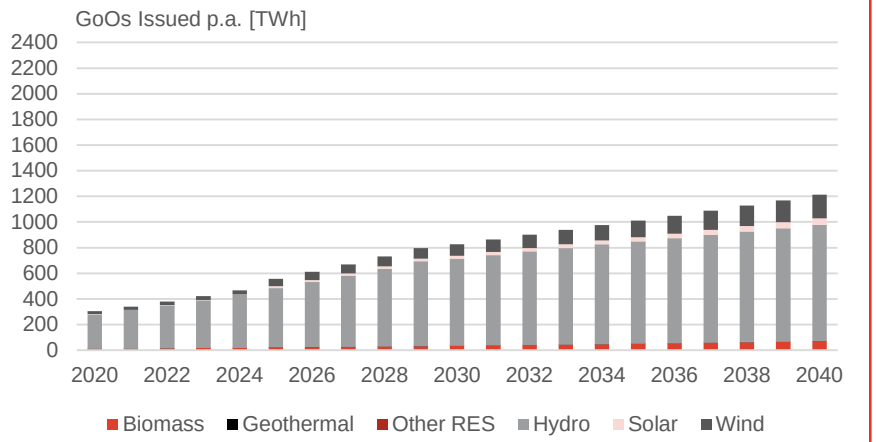
Scenario 1: Status Quo



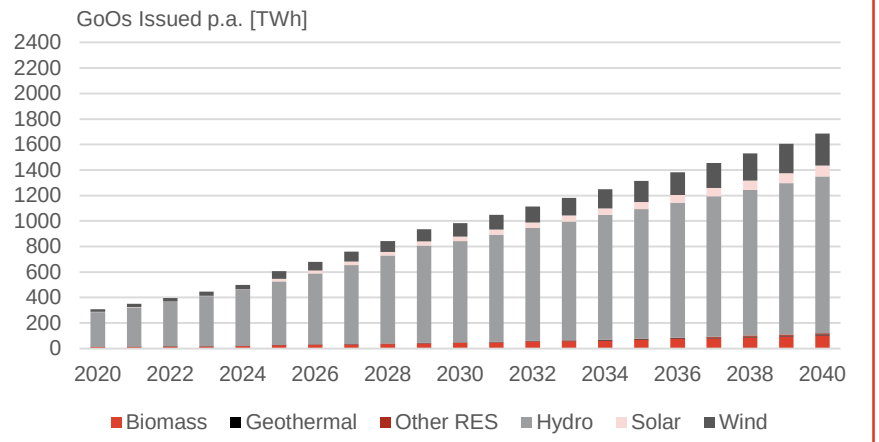
Scenario 2: Sustainable Development



Scenario 3: Harmonization



Scenario 4: Ideal Development



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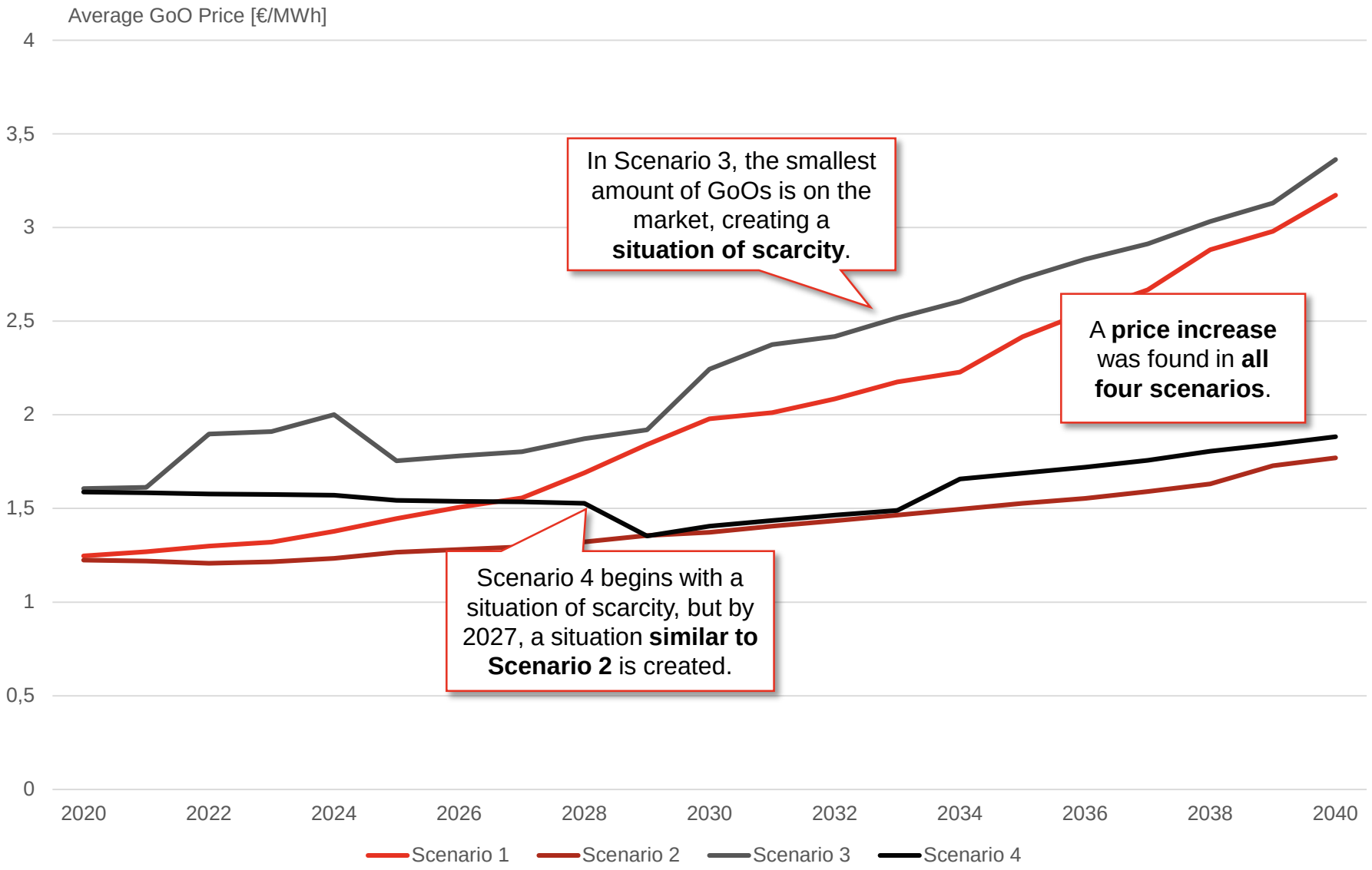
Results | Comparison of Average Prices over Technologies and Countries per Scenario



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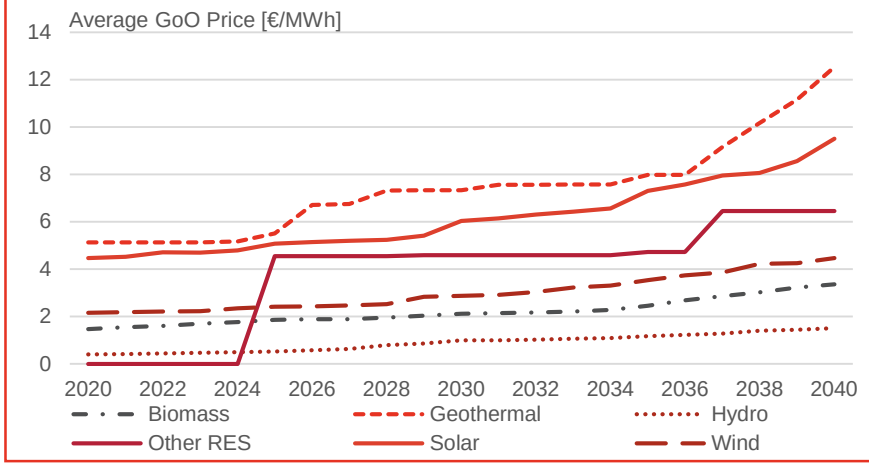
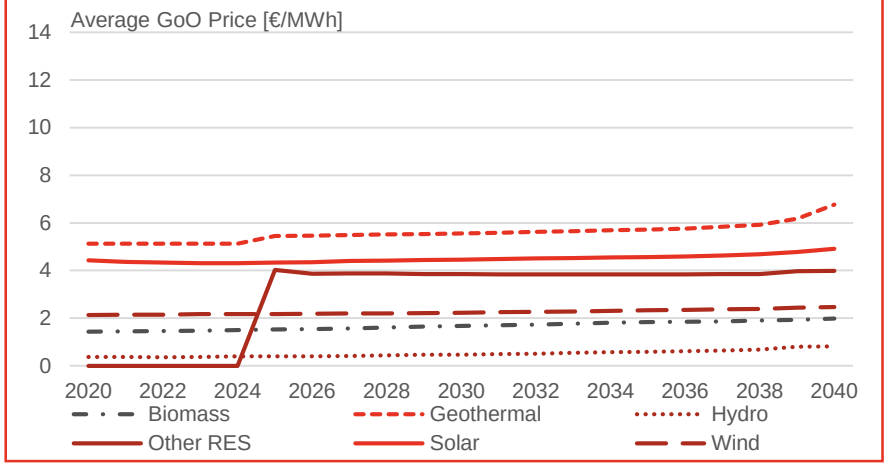
Results | Future Prices per Technology

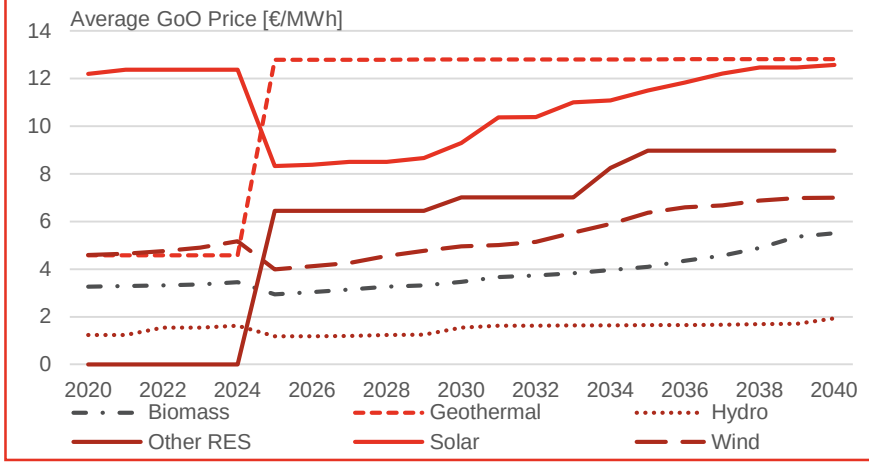
Scenario 1: Status Quo



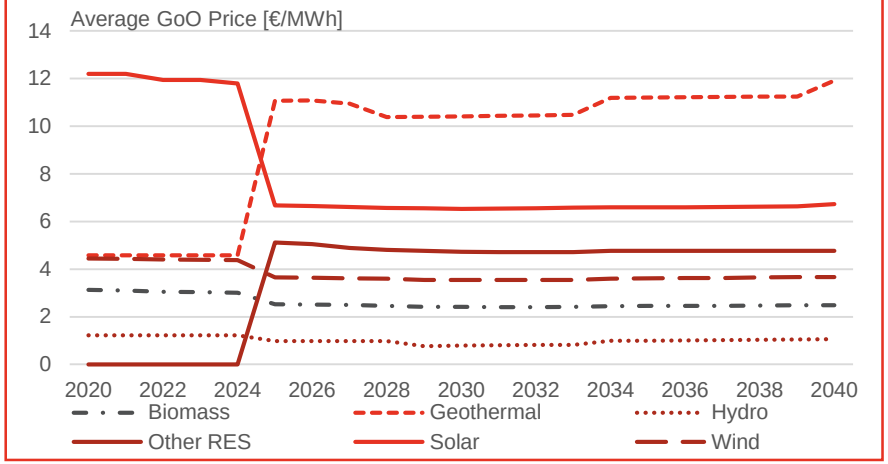
Scenario 2: Sustainable Development



Scenario 3: Harmonization



Scenario 4: Ideal Development



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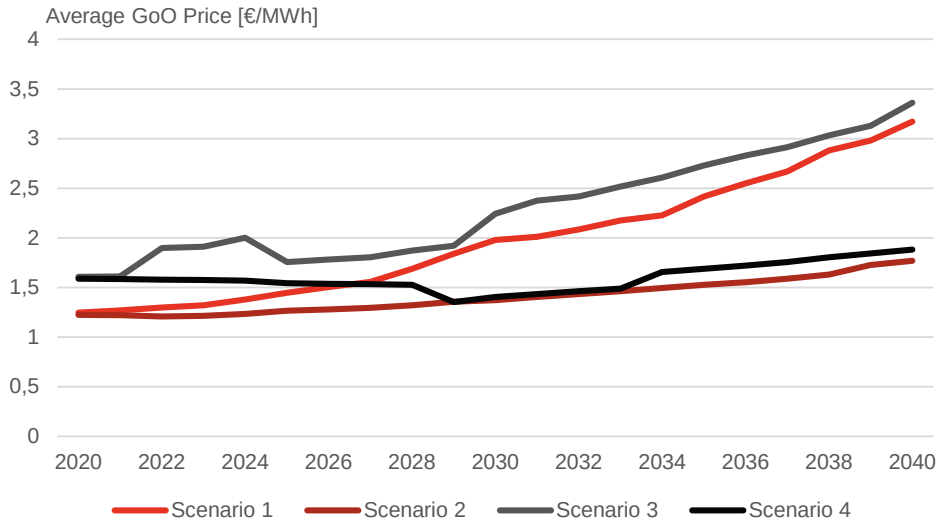
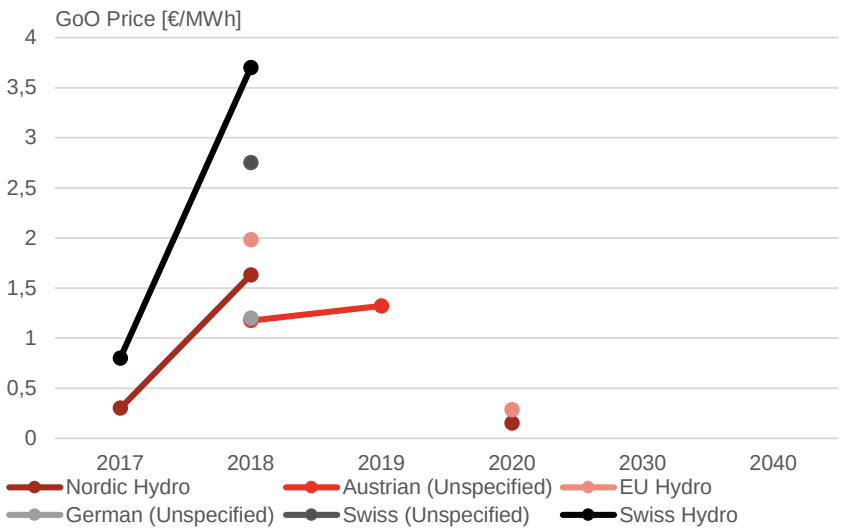
Results | Validation

Average Prices From the Model's Calculations



Historic Prices



Sources for historic price levels can be found in the Backup section of this presentation.

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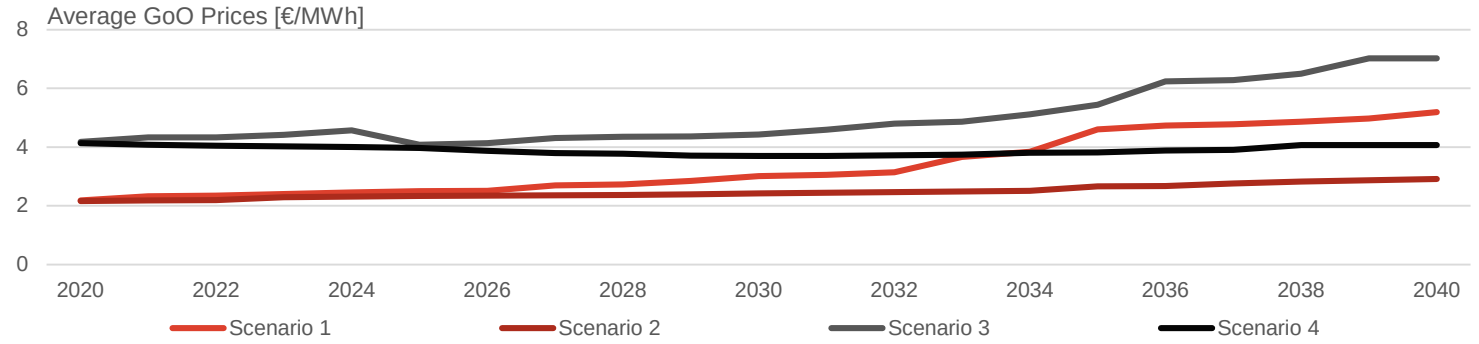
Results | Validation – Selected Price Developments

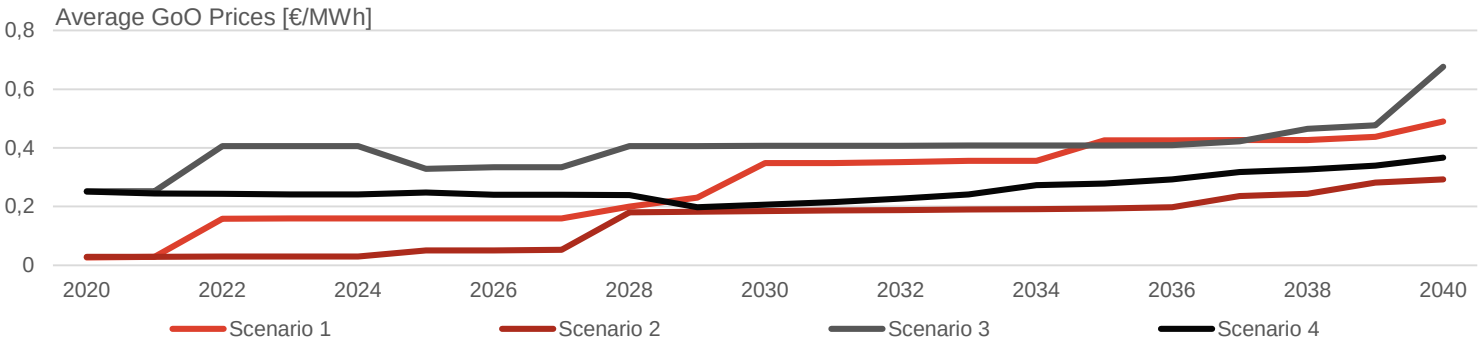
NL



HISTORIC PRICE LEVELS

≈ 8 €/MWh for Dutch Wind in 09/2018

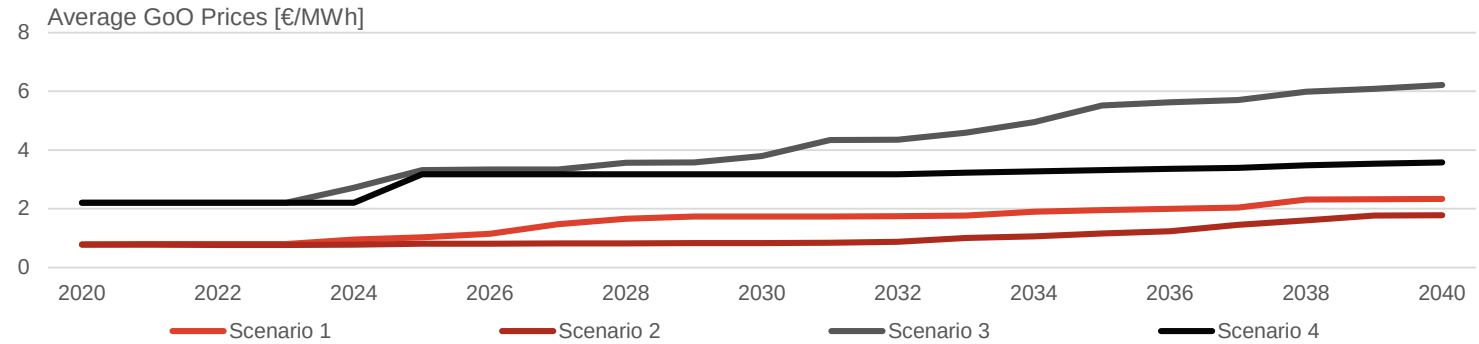
NOR



HISTORIC PRICE LEVELS

0.05–2.0 €/MWh from 2007 to 2018

GER



HISTORIC PRICE LEVELS

0.8–1.6 €/MWh in 2018

Sources for historic price levels can be found in the Backup section of this presentation.

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Conclusion and Future Outlook

This Study Provides…

- A detailed analysis of AIB members and the EECS by **classifying** member states into **six different categories**, gathering **historic GoO price information**, and calculating **historic market behavior** of AIB member states
- An estimation of **industrial** and **commercial WTP** for GoOs and green electricity in general (based on Env. Concern / ATP)
- A model- and scenario-based **prediction** of **future GoO volumes** until 2040
- Reasonable **future price estimations** when compared to historic prices

Main Limitations

- When certain price levels are reached, GoO supply might become **elastic** as producers will start switching from subsidies and support schemes to GoO issuance for revenue generation (→ **lower equilibrium price**, increased quantity)
- We assume that **GoO over-supply** will be overcome, which is uncertain
- As GoOs are issued, traded and cancelled on a monthly basis, the **yearly approach** will have likely lead to **inaccuracies**
- Limited harmonization of data sources, with **varying data quality** add further uncertainty

Future Research

- Data: Obtain **more accurate and reliable data** to mitigate this source of uncertainty
- WTP: The WTP of industrial and commercial consumers could be determined in a **survey approach (stated preferences)**, or calculated based on scientifically grounded assumptions of environmental concern and ATP
- Resolution: A better picture of the GoO market may be gained if **transactions** are modeled **on a monthly basis**

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- AIB (2020), Activity statistics [Online] URL: https://www.aib-net.org/facts/market-information/statistics/activity-statistics-all-aib-members [27 August 2020].
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- Umweltbundesamt (2020b), Herkunftsnachweisregister (HKNR) [Online] URL: https://www.umweltbundesamt.de/themen/klima-energie/erneuerbare-energien/herkunftsnachweisregister-hknr#herkunftsnachweise-und-register [21 August 2020].
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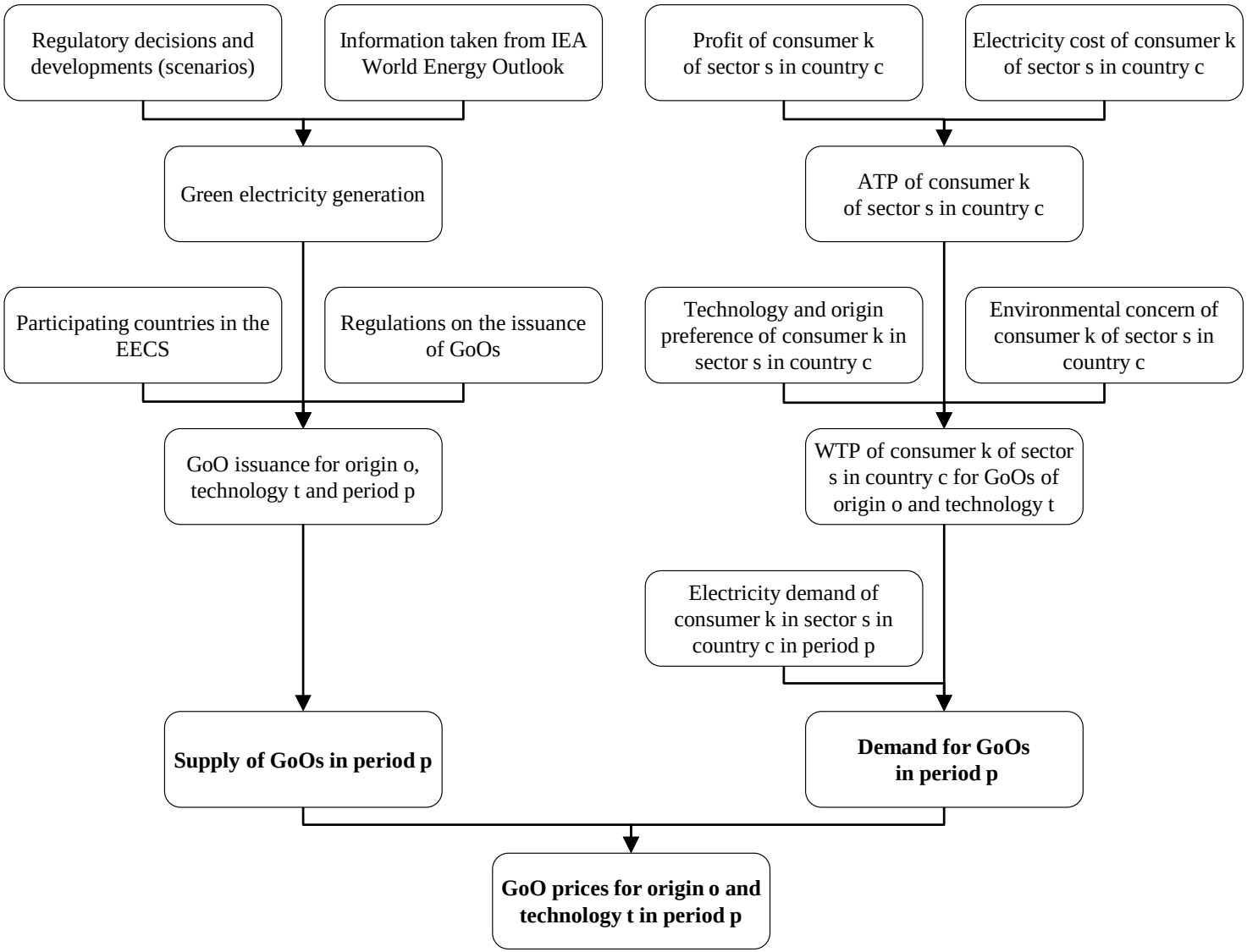
Backup | Heuristic Model Design | Flow Diagram



Backup | Heuristic Model Design | Determination of WTP for GoOs

1 Determination of Environmental Concern

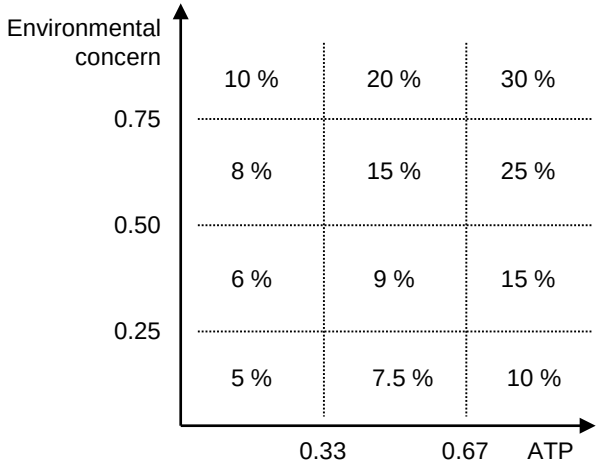
- The term “Environmental Concern” describes the willingness of company to acquire green electricity based on intrinsic motivation or pressure from customers
- Values range from 0 to 1
- For all 151 NACE sectors, a value is assigned based on RE100[1] or own estimations

2 Calculation of the Ability to Pay (ATP)

- The ATP determines whether a consumer is able to pay for green electricity
- It is defined as the ratio of the average profit of a company and its electricity costs
- ATPs are calculated based on data taken from Eurostat[2] for all NACE sectors and varying company sizes

1 + 2 → 3 Determination of the Basic WTP

- The WTP is determined as a function of the environmental concern and ATP
- %age values obtained are then applied to the consumer’s electricity price per kWh to receive a value in €/MWh



4 Determination of WTP of Households

- The WTP for households is based on average values for European countries taken from OECD (2014)[3]

5 Determination of WTP for different GoO Types

- A general reduction factor is introduced because GoOs represent the least asked for green electricity acquisition approach
- The basic WTP value in €/MWh is multiplied with derating factors depending on the location of the consumer
- Additionally, derating factors for the different RES technologies[4,5] are applied

Sources: [1] RE100 (2020); [2] Eurostat (2020a, 2020b, 2020e); [3] OECD (2014), pp.102-103; [4] Borchers et al. (2007), p.3333; [5] Grilli (2017), pp.28-259

Backup | Model Design | Supply and Demand

Determination of Future Supply

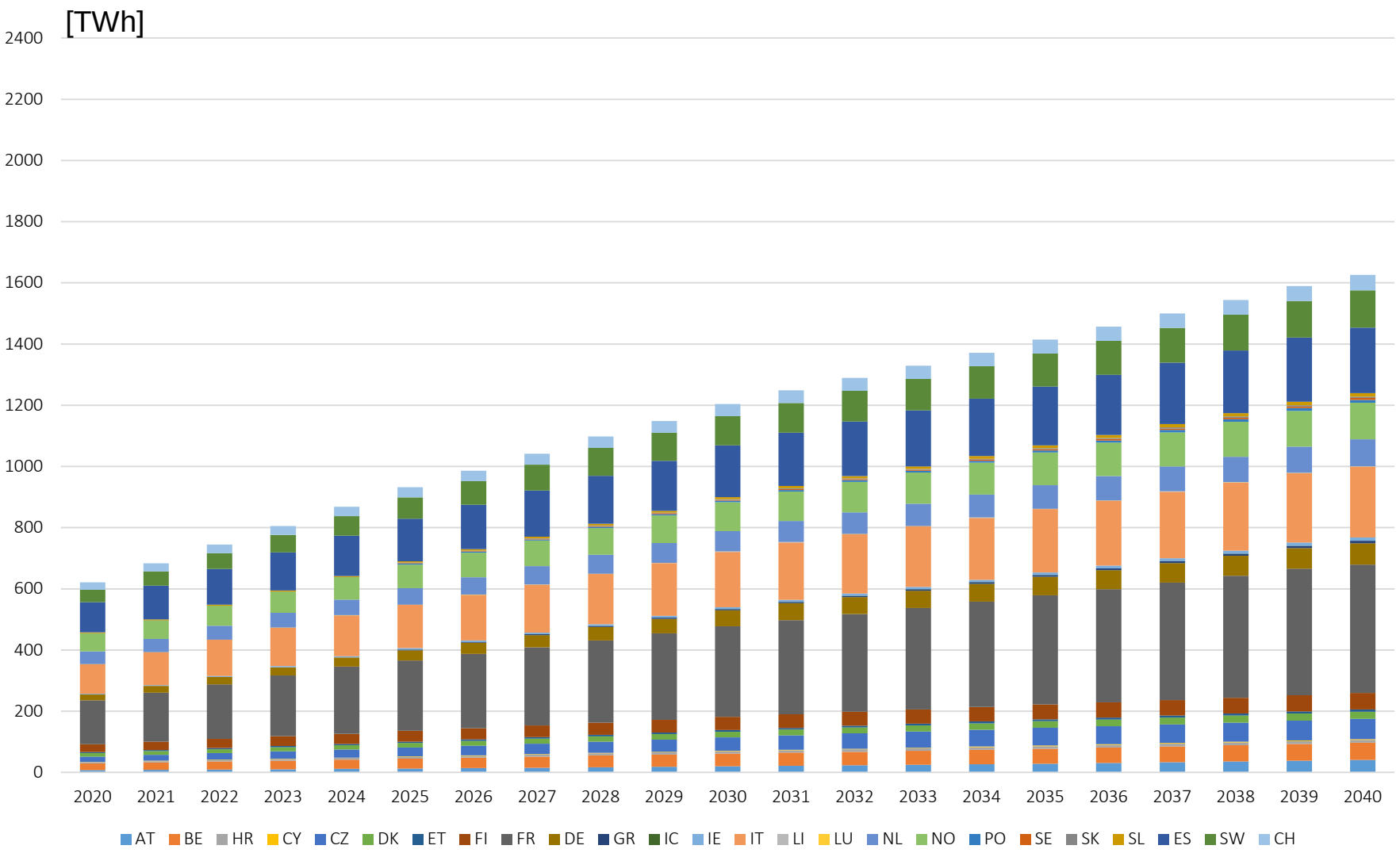
- Future GoO issuance is influenced by future issue rates of member states per technology and the amount of produced green electricity
- Future issue rates are determined by an analysis of past data[1,2]
- By 2025, countries that had previously issued no GoOs begin issuing
- The development of RES in the member states is based on current electricity mixes[2] and scenarios from the current *IEA World Energy Outlook*[3]

Determination of Future Demand

- Future Demand depends on the demographic and economic development of member states
- Demand for green electricity is assumed to be an initial 22 % of total electricity demand in 2020 and will reach a total of 50 % by 2040
- Past consumption is based on Eurostat[4]
- Future development is based on scenarios from the current *IEA World Energy Outlook*[3]

Sources: [1]AIB (2020 actitiveis); [2]Eurostat (2020c); [3]International Energy Agency (2020) World Energy Outloook 2020; [4]Eurostat (2020a, 2020b, 2020d)

Backup | GoO Volumes per Country for Scenario 1



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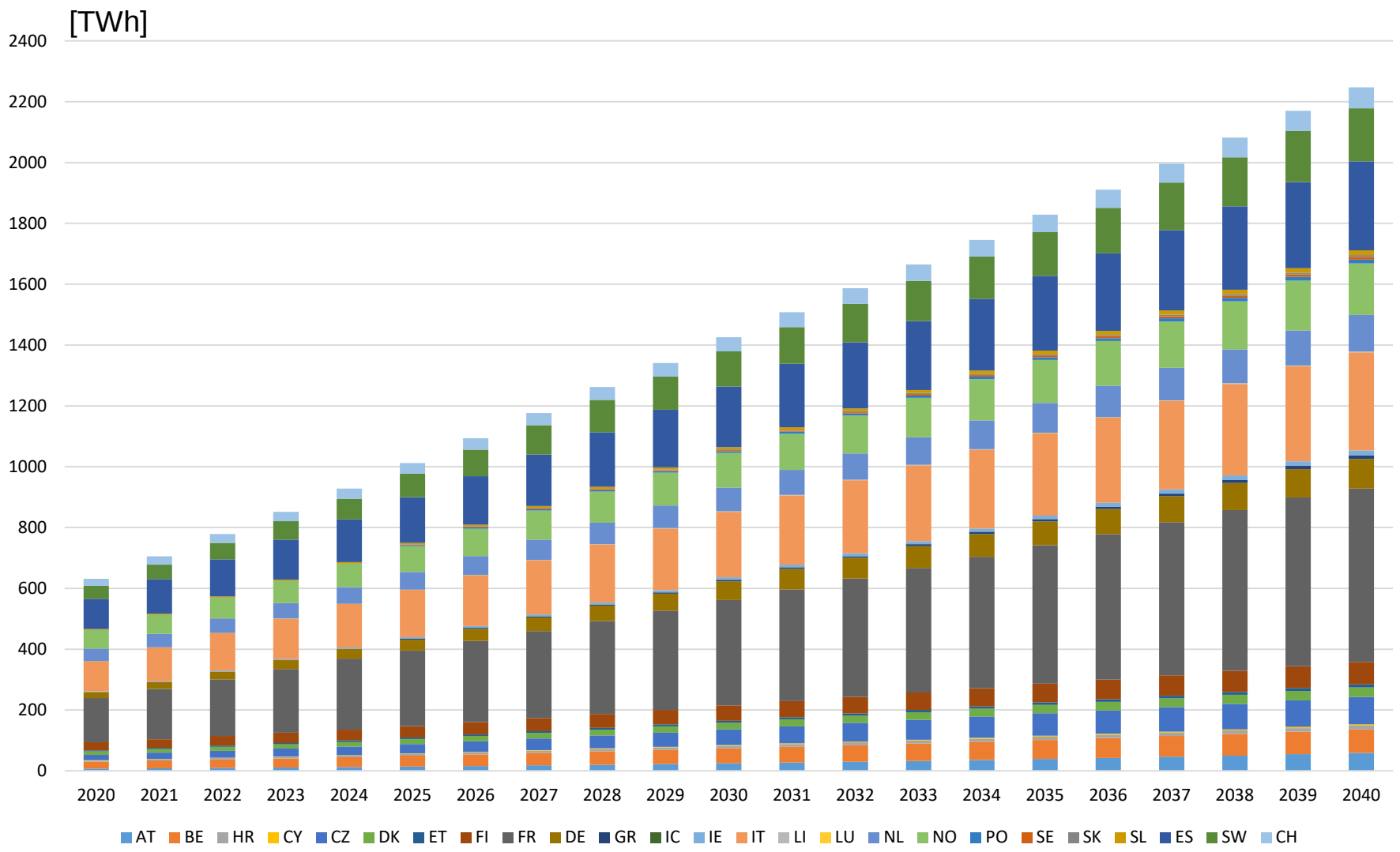
Backup | GoO Volumes per Country for Scenario 2



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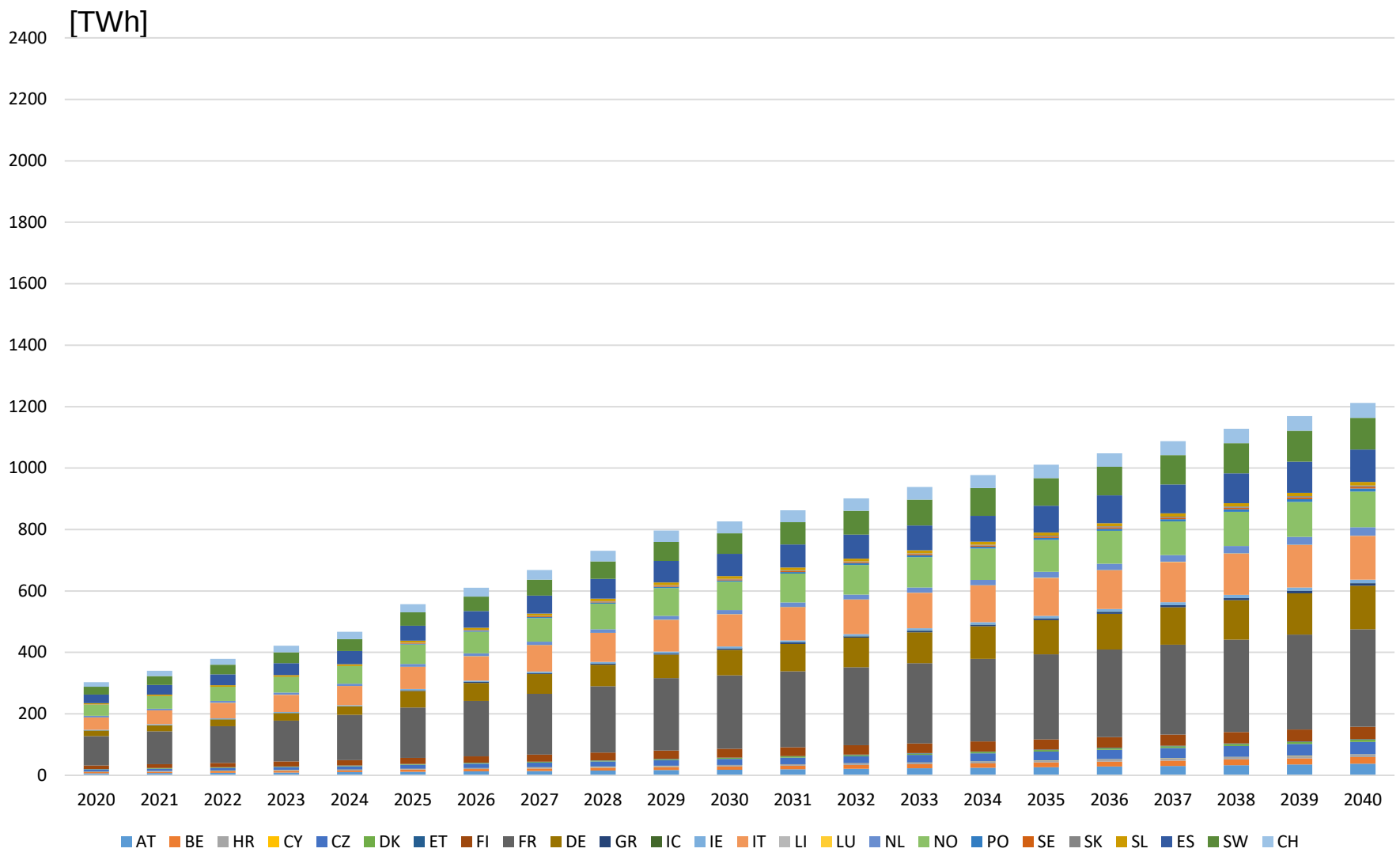
Backup | GoO Volumes per Country for Scenario 3



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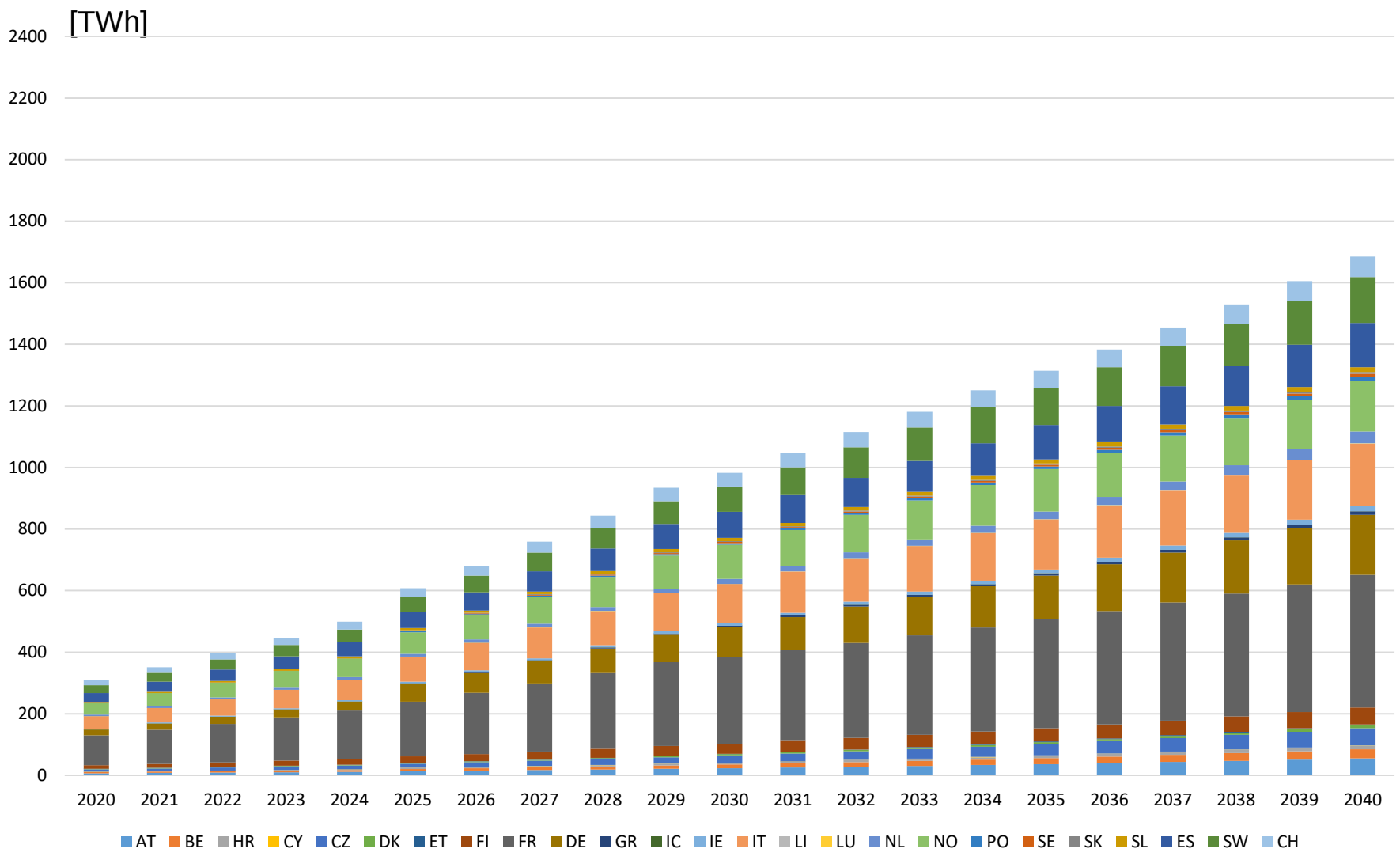
Backup | GoO Volumes per Country for Scenario 4



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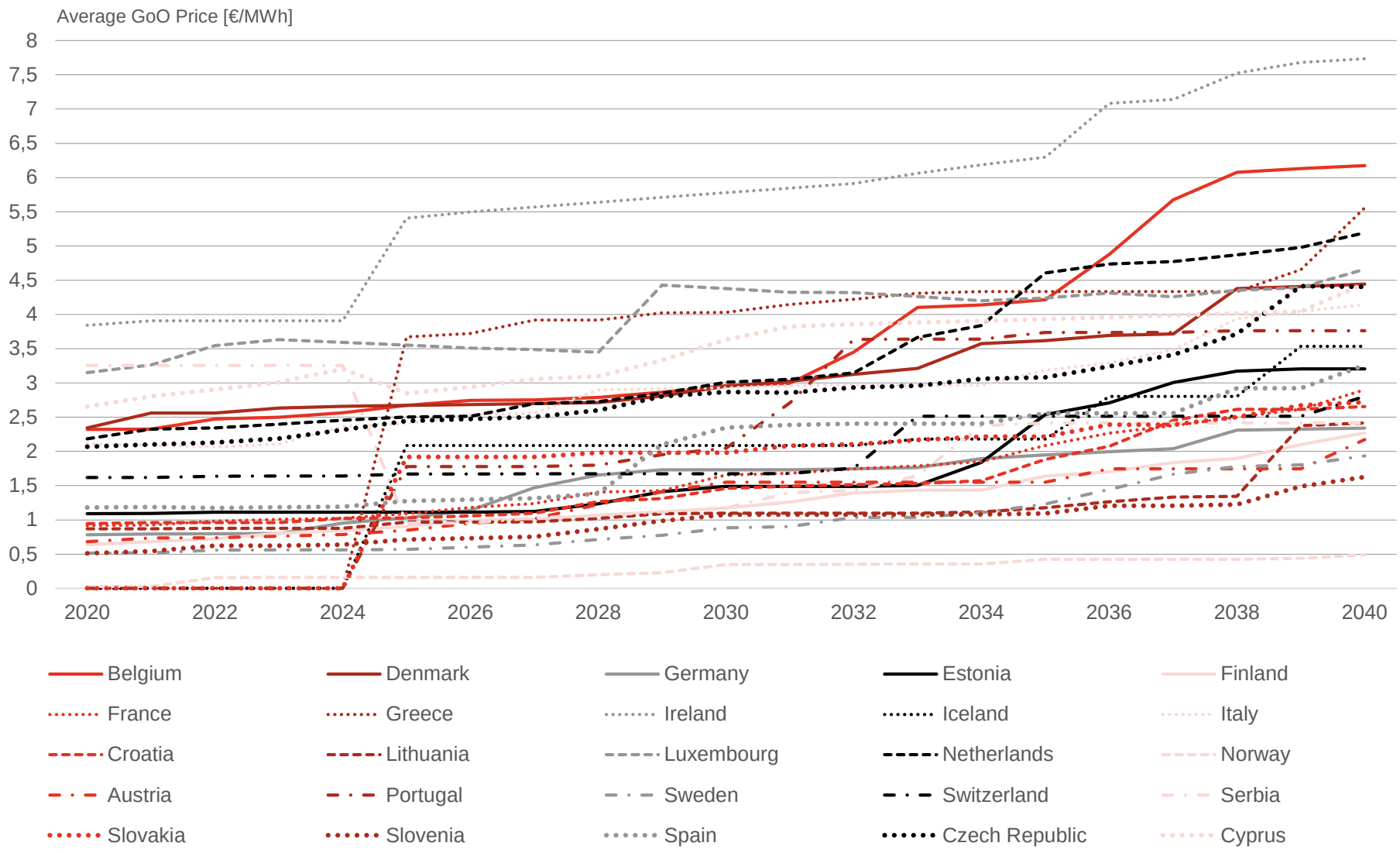
Backup | Prices on country level Scenario 1

Weighted Average prices!



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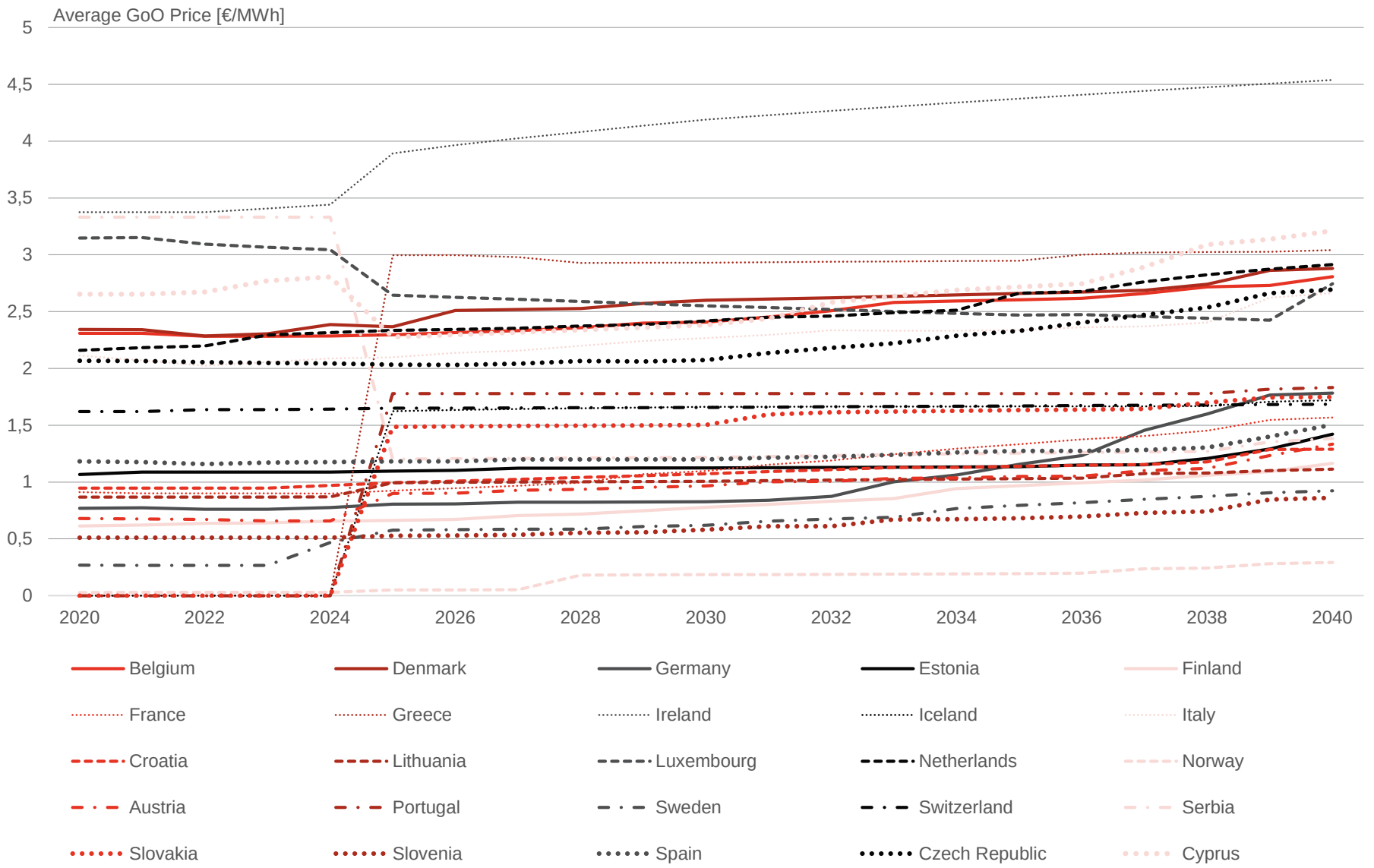
Backup | Prices on country level Scenario 2

Weighted Average prices!



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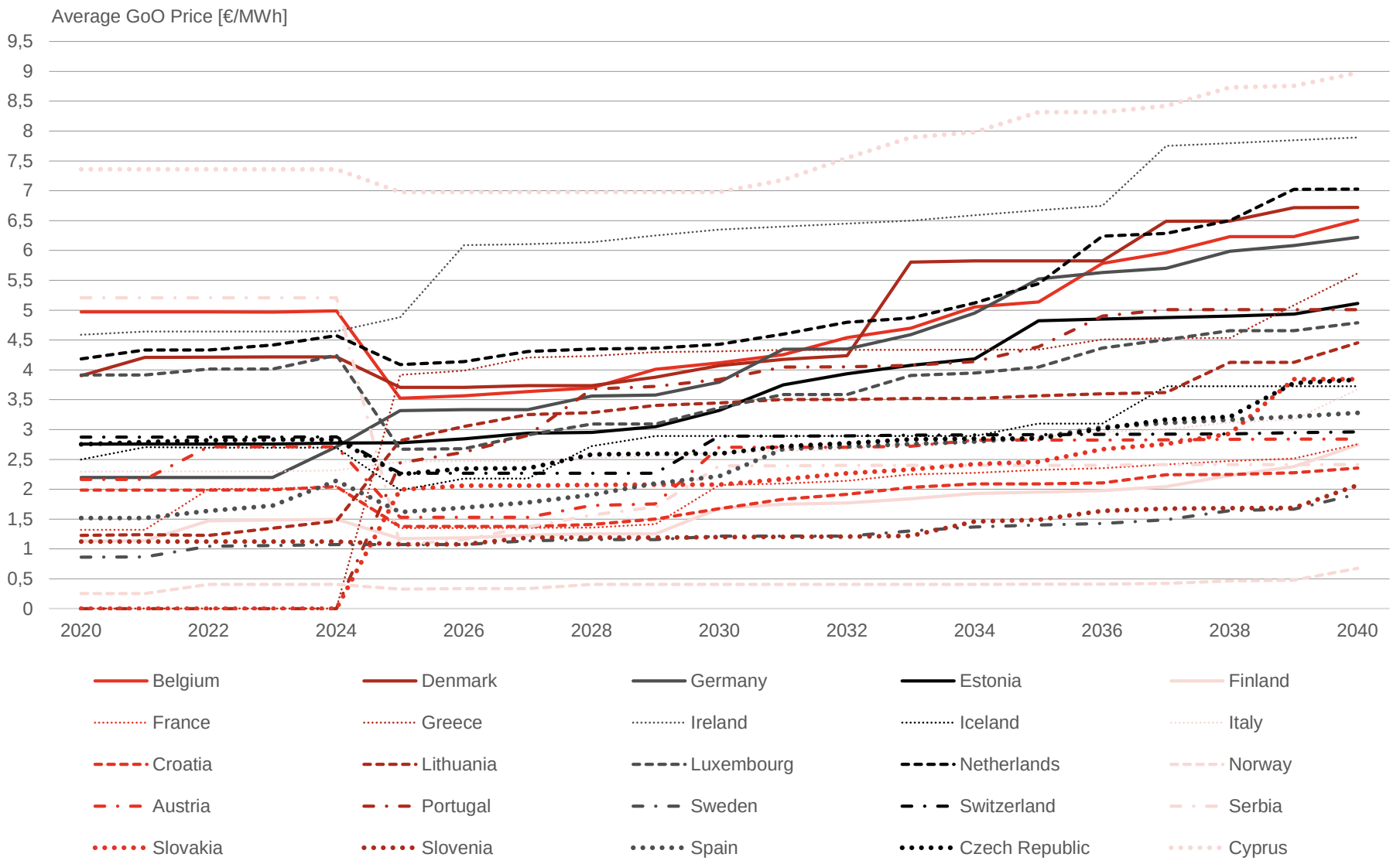
Backup | Prices on country level Scenario 3

Weighted Average prices!



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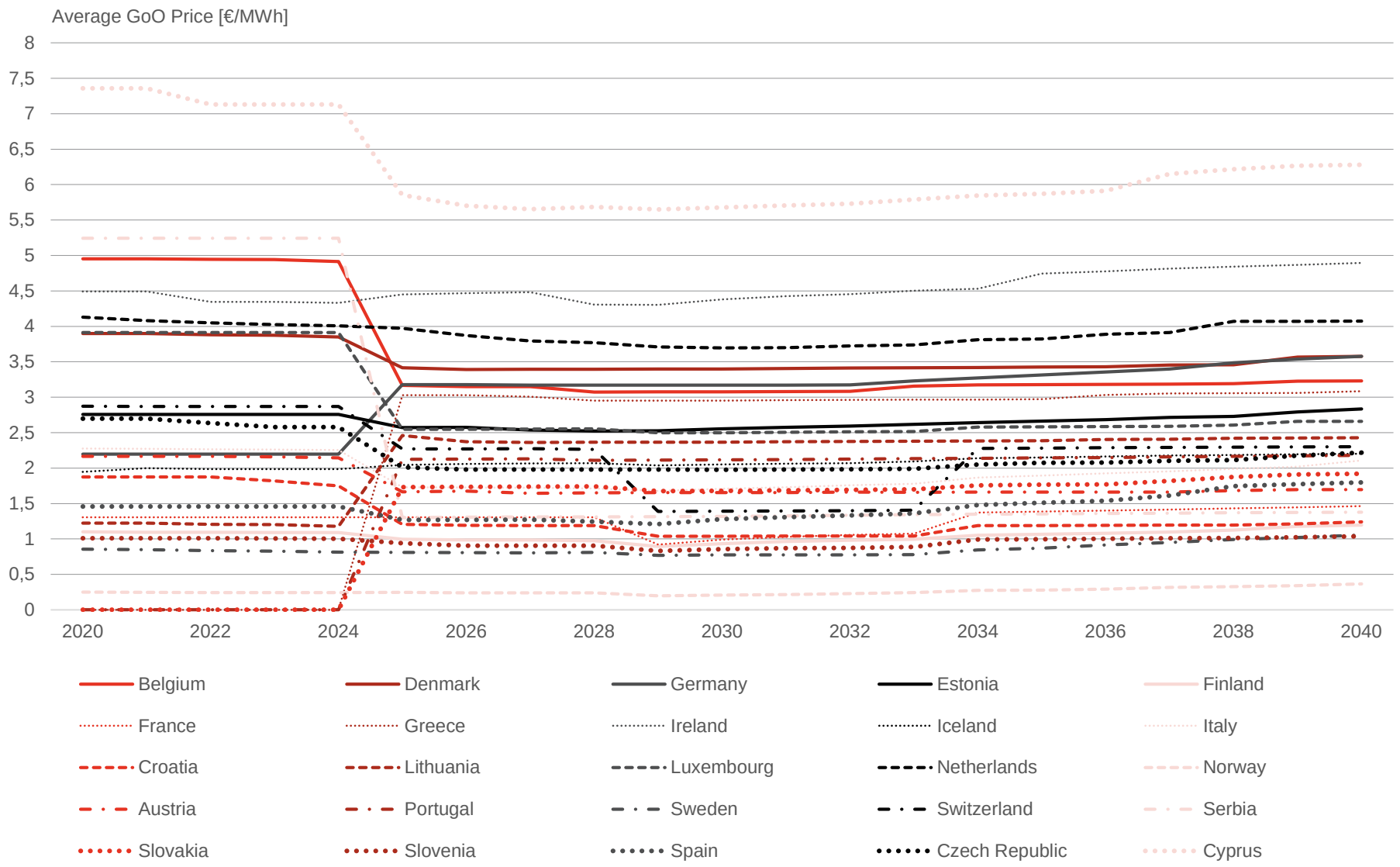
Backup | Prices on country level Scenario 4

(Note: weighted average prices)



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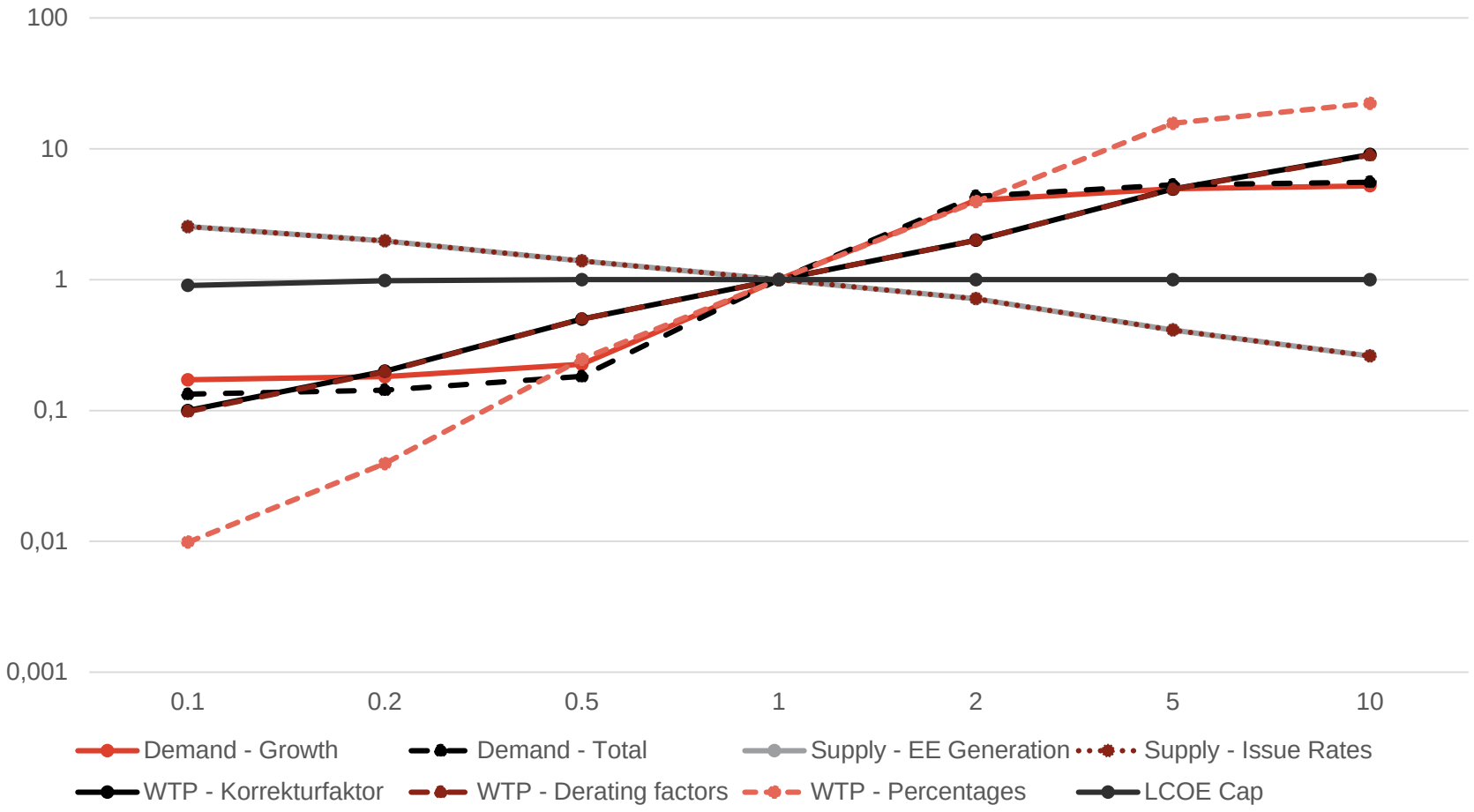
Backup | Sensitivity Analysis



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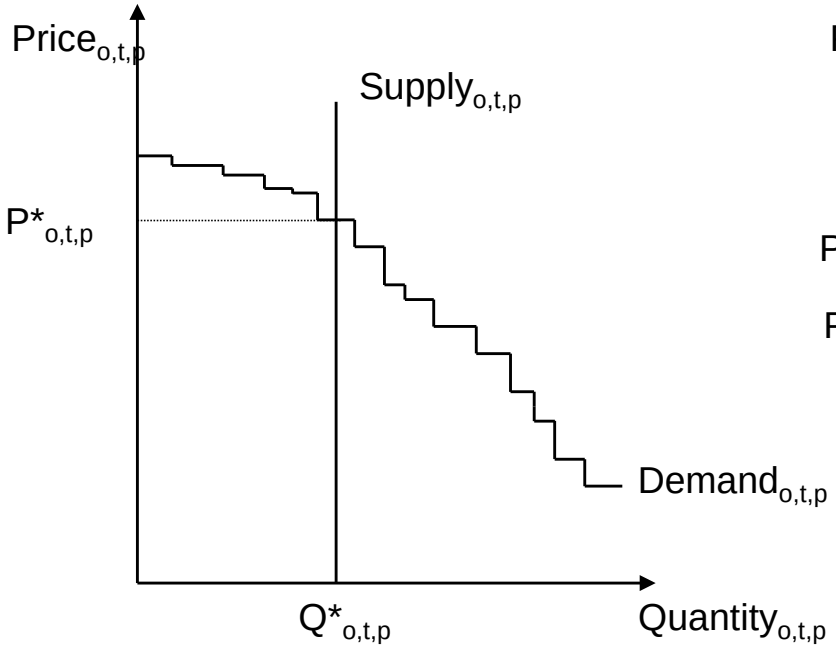
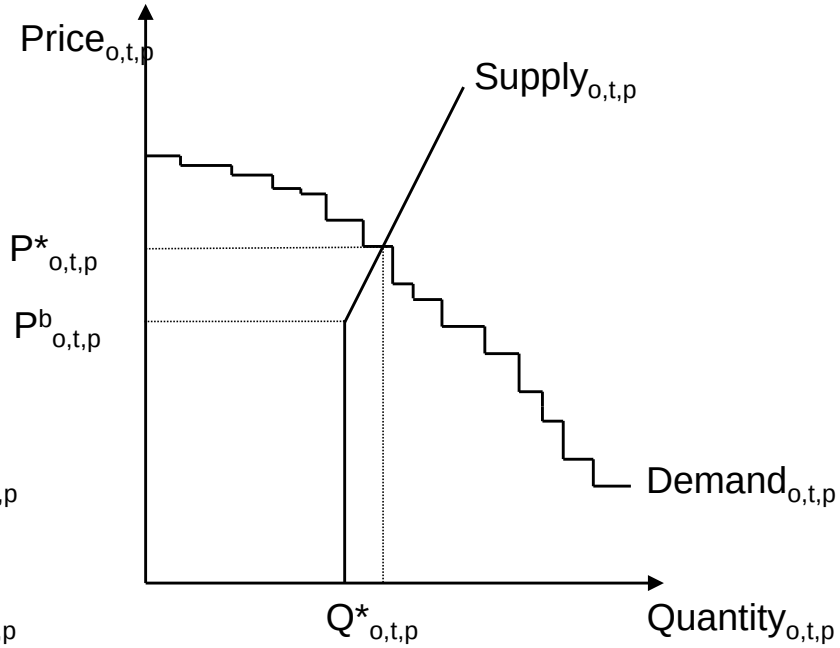
Backup | What happens, when supply elasticity no longer perfectly inelastic?

Perfectly *in*elastic supply



Change in price elasticity



Backup | Historic GoO Prices

Type of GoO	Period	Price / price range	Source
Austrian (Unspecified)	2018	0.9 – 1.45 €/MWh	Hauser et al. (2019), p. 214
Austrian Hydro (Age unspecified)	2019	1.32 €/MWh	Advantag Services GmbH [10.09.2020]
Dutch Wind	September 2018	8 €/MWh	Münster [06.08.2020]
EU Biomass (Unspecified)	2018	1.62 €/MWh	Advantag Services GmbH [10.09.2020]
EU Hydro (Age unspecified)	2018	1.24 – 1.25 €/MWh	Hauser et al. (2019), p. 214, taken from Nvalue in 2018
EU Hydro (Unspecified)	2020	0.15 – 0.21 €/MWh	Nvalue AG [03.09.2020]
EU Hydro (Unspecified)	2018-2020	0.49 - 1.98 €/MWh	Advantag Services GmbH [10.09.2020]
German (Unspecified)	2018	0.8 – 1.6 €/MWh	Hauser et al. (2019), p. 214
Large Nordic Hydro	2007-2015	0.05 – 0.6 €/MWh	Oslo Economics (2018), p. 21
Nordic (Unspecified), new	2018	2 – 2.7 €/MWh	Hauser et al. (2019), p. 214
Nordic (Unspecified), new	2018	2.34 – 3.4 €/MWh	Hauser et al. (2019), p. 215
Nordic (Unspecified), old	2018	0.55 €/MWh	Hauser et al. (2019), p. 214
Nordic (Unspecified), retrofitted	2018	1 – 1.9 €/MWh	Hauser et al. (2019), p. 214
Nordic Hydro (Age unspecified)	2015	0.05 – 0.5 €/MWh	Klimscheffskij et al. (2015), p. 4672
Nordic Hydro (Age unspecified)	2017	0.22 – 0.38 €/MWh	Hauser et al. (2019), p. 213
Nordic Hydro (Age unspecified)	09/2018 – 12/2018	1.24 - 2 €/MWh	Münster [06.08.2020]
Swiss (Unspecified)	2018	1.5 – 4 €/MWh	Hauser et al. (2019), p. 214
Swiss Hydro	2017 - 2018	1 – 4 CHF/MWh	Münster [06.08.2020]
Swiss PV (Unspecified)	2018	14.30 €/MWh	Advantag Services GmbH [10.09.2020]