Costs or benefits? Assessing the economy-wide effects of the electricity sector's low carbon transition – The role of capital costs, divergent risk perceptions and premiums (updated title)

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Introduction

INTRODUCTION

- Electricity sector plays key role in transition to low carbon society
- Crucial to understand the macroeconomic effects of a transition of the electricity sector
- For assessing such effects integrated energy-economy models have been developed
  - use information from bottom-up energy sector models and feed it into top-down macroeconomic models
  - very sensitive to assumptions on technology costs
  - Especially "**weighted average costs of capital**" (WACC) strongly drive results, as renewables are very capital intensive

$$WACC = i_E \frac{E}{E+D} + i_D \frac{D}{E+D}$$

→ levelized costs of electricity (LCOE)

E… Equity [€]
D… Debt [€]
i_E… Return on Equity
i_D… Return on Debt

Introduction
Gaps in Literature

1. WACC typically chosen without differentiation across technologies & regions
   - even though it has been shown that there are substantial differences (Angelopoulos et al., 2016; Oxera, 2011; Sweerts et al., 2019; ECOFYS, 2014)
   - Ignores potential differences and changes in risk (perceptions), which would be reflected in different risk premiums

2. De-risking of renewables focuses on developing regions (Africa, MENA)
   - De-risking could be an effective leverage point also in developed regions (Schmidt, 2014)

3. Strong focus on the WACC of renewables, fossil fuels are left unattended
   - Fossil fuel based assets: technological-change-driven risk from loss of competitiveness or stranding – even without any further climate policy (Mercure et al., 2018)
   - Moreover, future (climate) policy add to uncertainty (and risk) of fossil fuel based assets; e.g. “ratcheting-up” (Noothout et al., 2016)

INTRODUCTION

We address the stated shortcomings to:

→ demonstrate the importance of WACC differentiation in energy-economy modeling in general

→ demonstrate the importance of possible diverging risk perceptions

For the case of a transition to a renewable electricity system in Europe

Methodology

METHODOLOGY

- Computable General Equilibrium (CGE) model (Mayer et al., 2019)
  - Economy-wide model
  - Multi-regional: Global, 16 regional aggregates
  - Europe: Austria (AUT), Greece (GRC), Northern, Eastern, Southern and Western Europe (NEU, EEU, SEU, WEU)
  - Multi-sectoral
    - 16 economic sectors
    - Focus on electricity sector: eight different generation technologies; vintage based investment module

- Two scenarios:
  - Baseline: EU-reference scenario (Capros et al., 2016)
  - RES-e: transition to 100% renewables by 2050 (Pleßmann and Blechinger, 2017)
    - by imposing a renewable portfolio standard (RPS), enforced by policy

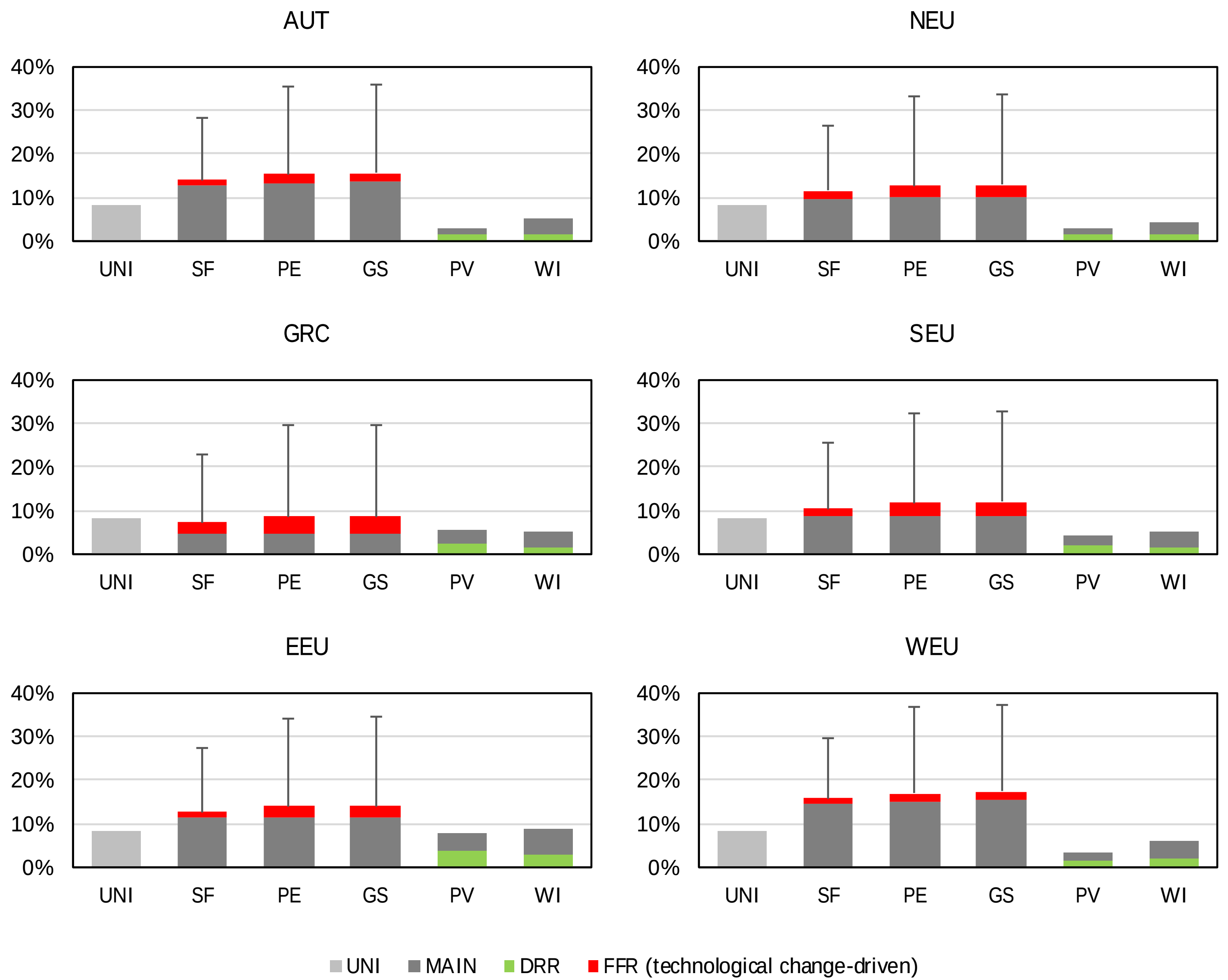
→ **Comparison: RES-e versus Baseline until 2050**

Methodology
WACC settings

Comparison (RES-e versus Baseline) is done under **different WACC settings**:

- UNIFORM: uniform WACC assumption of 8%
- MAIN: region and technology specific WACC
  - based on World Bank and IMF data as well as Steffen (2018)
  - Fossil technologies: high equity shares; Renewables: high debt shares
- DRR: "de-risking of renewables"
  - perceived policy signal (i.e. RPS), elevates investors' trust in renewables → reduces WACC for renewables in the RES-e scenario
  - WACC reduced to levels as observed in recent years in Germany (Egli et al., 2018)
- FFR: "fossil fuel risk"
  - investors price-in carbon-content-related risks for new investments
    - In EU-ref: technological change-driven
    - In RES-e: in addition also risk from uncertain "ratcheting-up"
- COMBINED: DRR+FFR

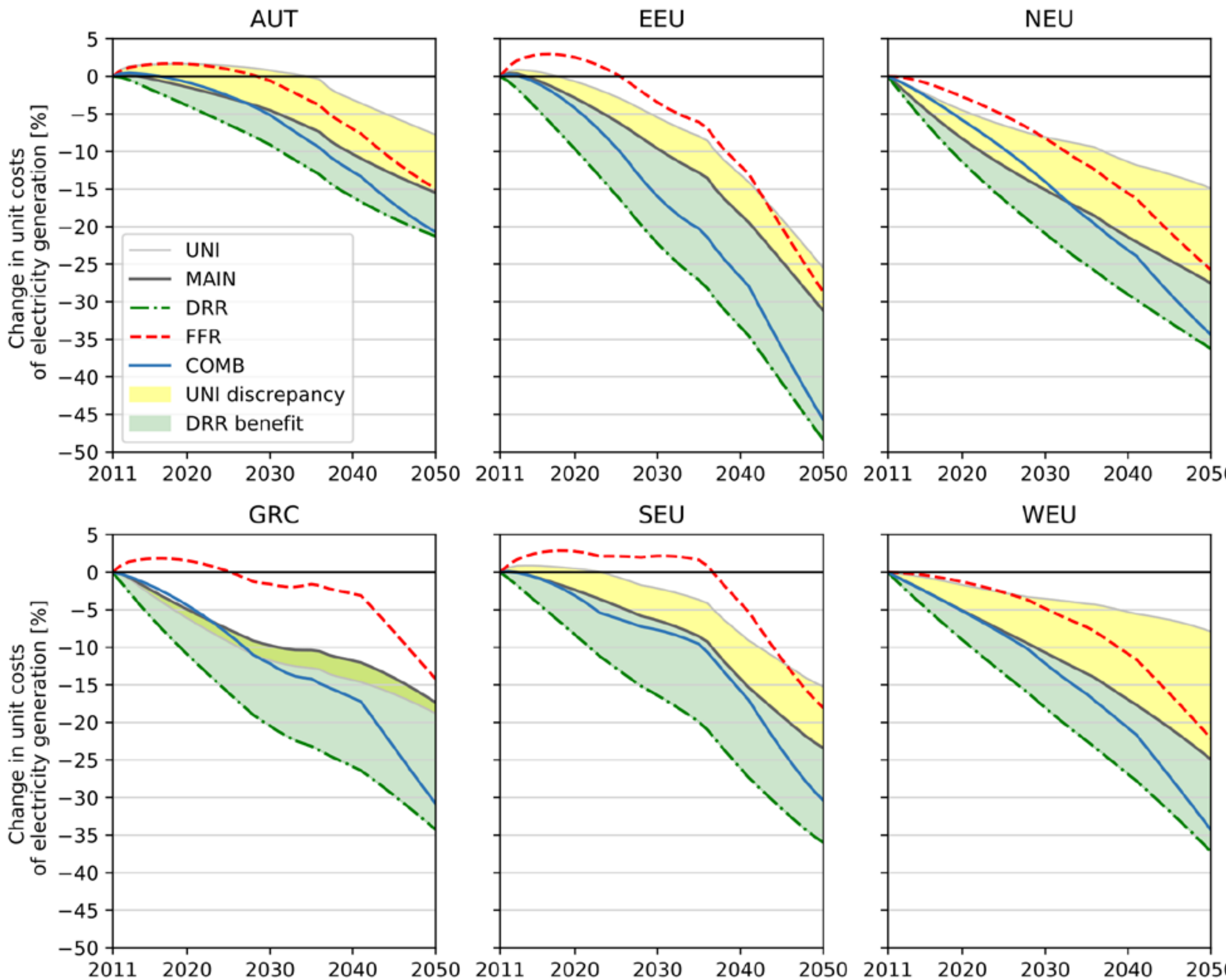
Methodology
WACC settings



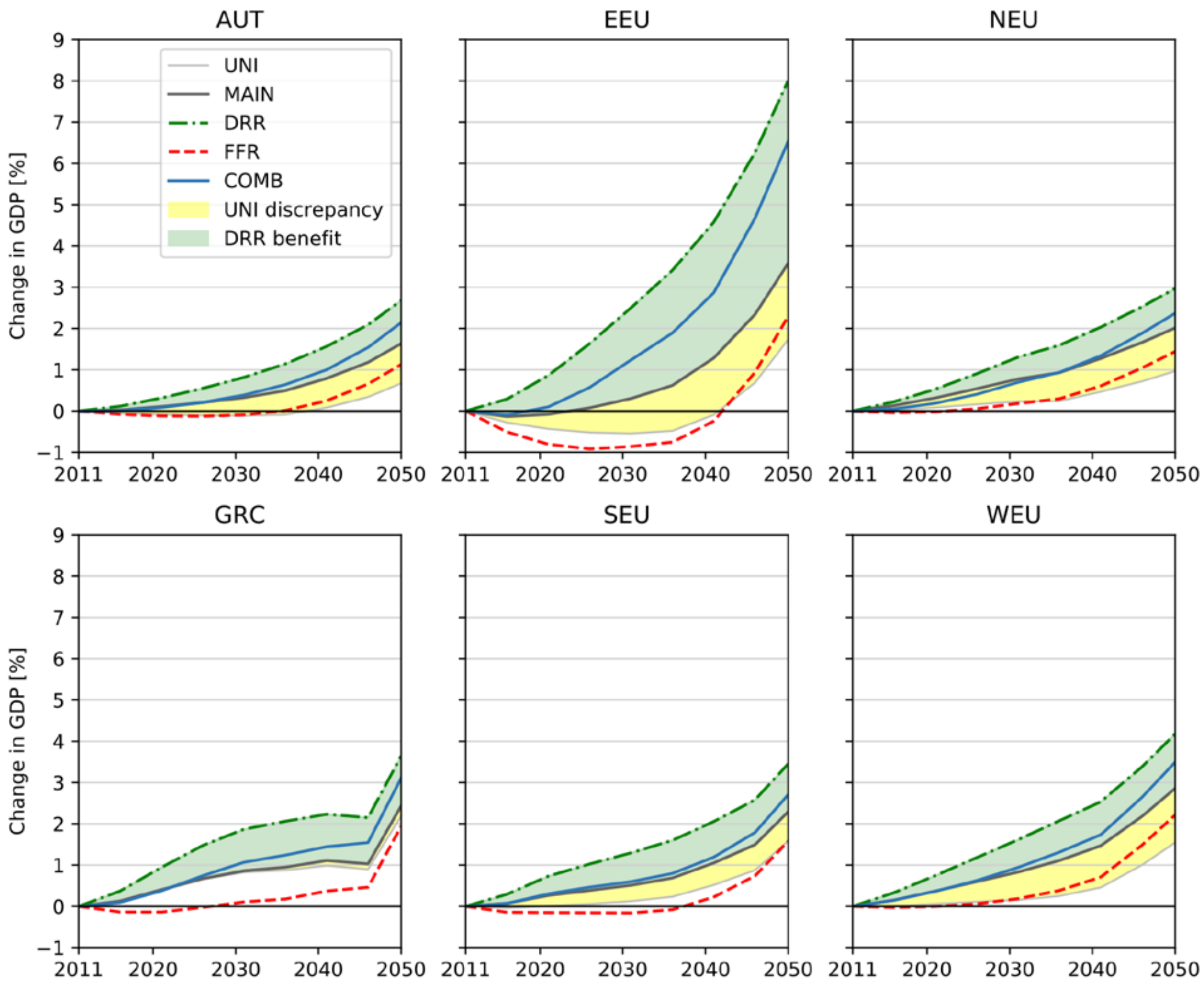
WACC rates across regions and technologies of the Uniform (UNI), Main (MAIN), Fossil Fuel Risk (FRR) and De-risking Renewables (DRR) settings. Whiskers show the maximum of assumed WACC increase from climate policy instability risk. (UNI=Uniform WACC across all regions and technologies; SF=Solid Fossil Fuels (coal); PE=Petrol (oil); GS=Gas; PV=Photovoltaics; WI=Wind)

Results

Results – Changes in Unit Costs of Electricity Generation



RESULTS – CHANGES IN GDP



Conclusions

CONCLUSIONS

- Immediate positive effects emerge at macroeconomic scales when using more accurate data on capital costs
  - Significant bias in results from uniform WACC assumption
- De-risking renewables further improves the effects of renewable electricity transition across all regions in Europe
  - Particularly in eastern and southern Europe, where electricity production is relatively CO_2-intensive in the reference scenario
- To increase trust in renewables, credible long-term conditions are most important
  - Does not necessarily involve large direct costs; can be implemented unilaterally
- Investors' expectations should be given a more prominent role
  - Going beyond carbon pricing

Warum ist Ihre Forschung für eine Transformation zur low-carbon society relevant?

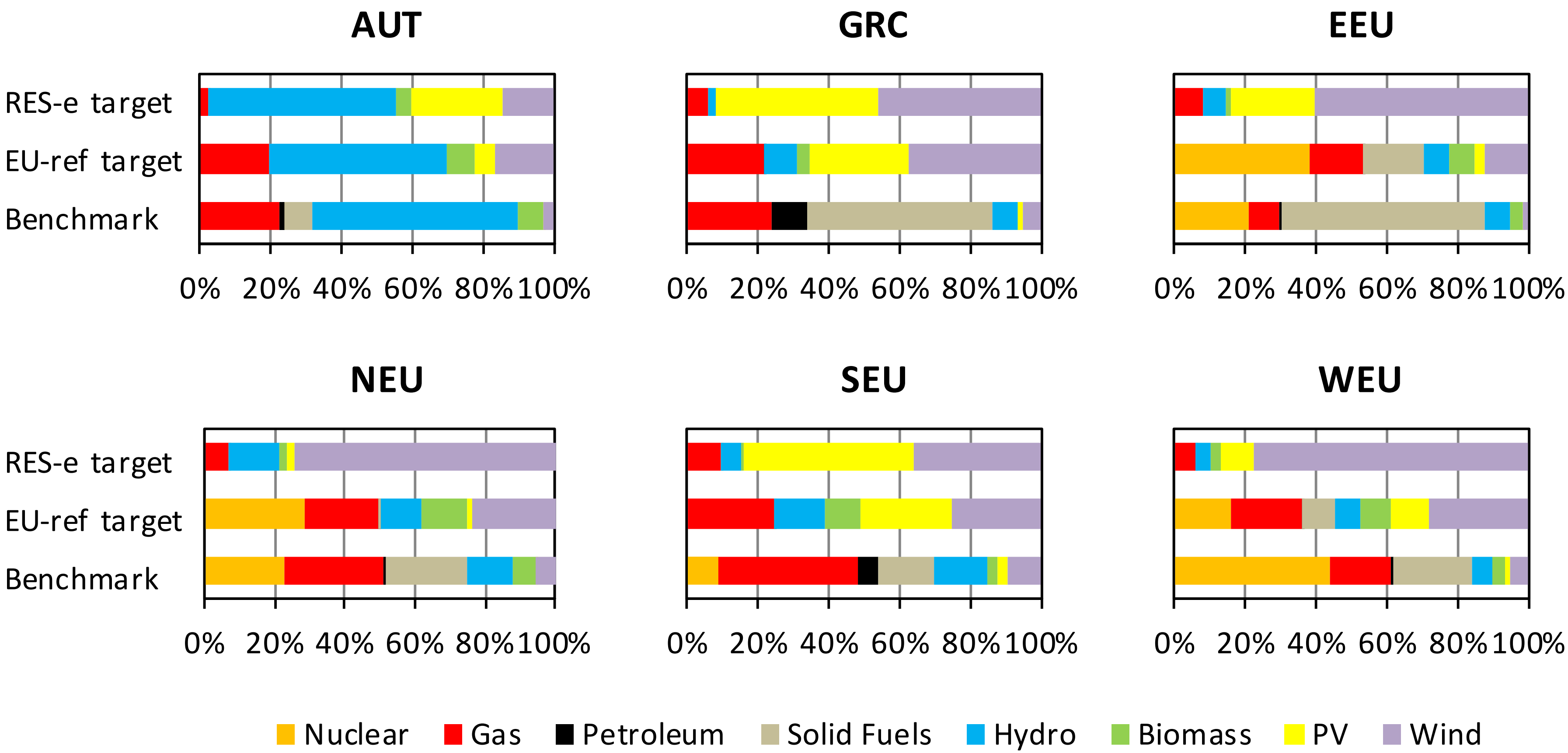
Zeigt, dass eine solche Transformation erheblichen volkswirtschaftlichen Zusatz-Nutzen bringen kann.

Zeigt Richtung für mögliche neue effektive Klimapolitik Maßnahmen, die über Bepreisung von Treibhausgas-Emissionen hinaus gehen.

Vielen Dank für die Aufmerksamkeit!

BACKUP SLIDES

Methodology
Scenarios: Electricity mix in 2050



Benchmark electricity mix (2011) across EU regions and mixes for 2050 for the reference scenarios (EU-ref) and for the large-scale expansion of renewables scenarios (RES-e).

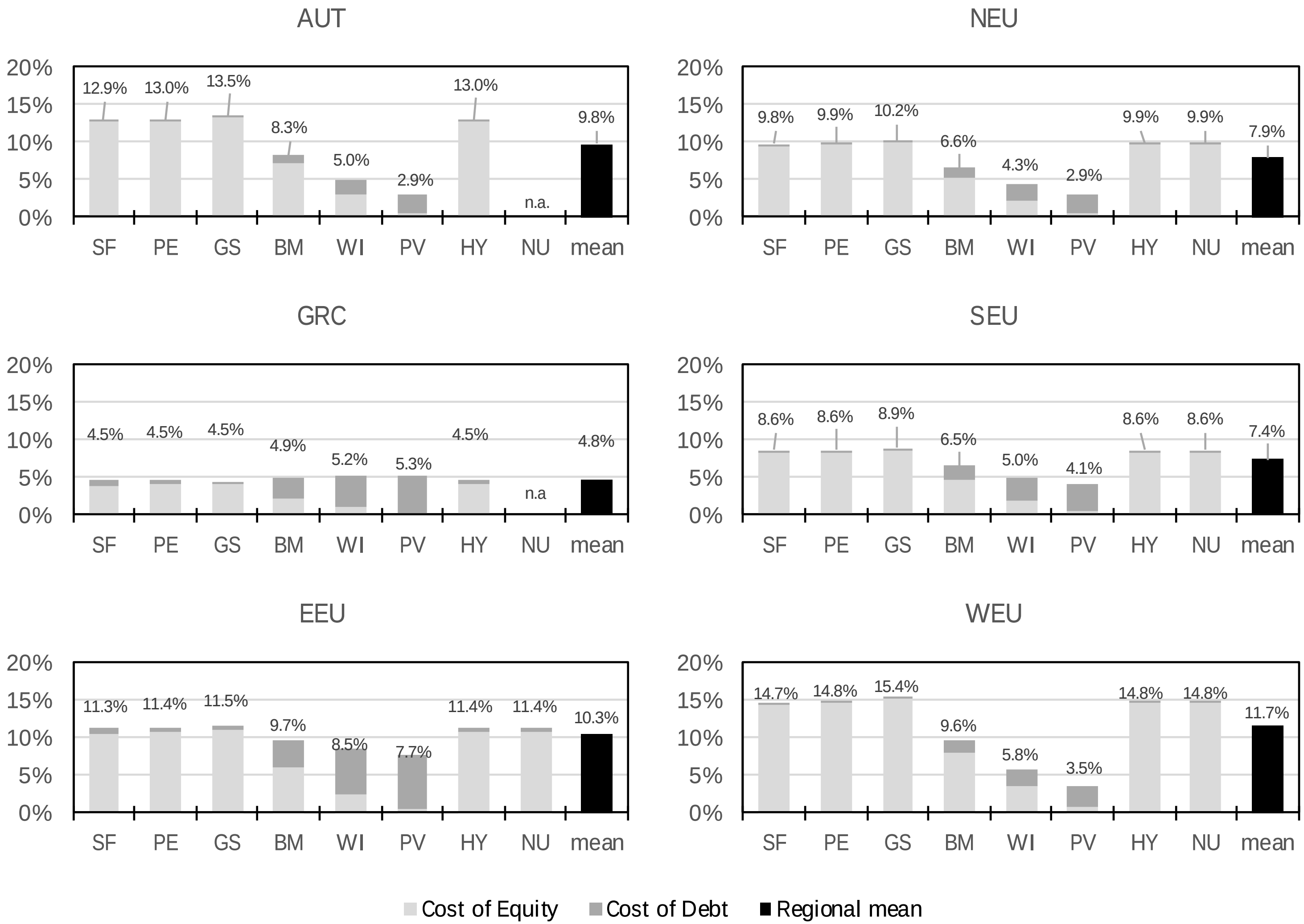


Figure 1: WACC rates across regions and technologies of the MAIN setting. (SF=Solid Fossil Fuels (coal); PE=Petrol (oil); GS=Gas; BM=Biomass, WI=Wind, PV=Photovoltaics; HY=Hydropower; NU=Nuclear)

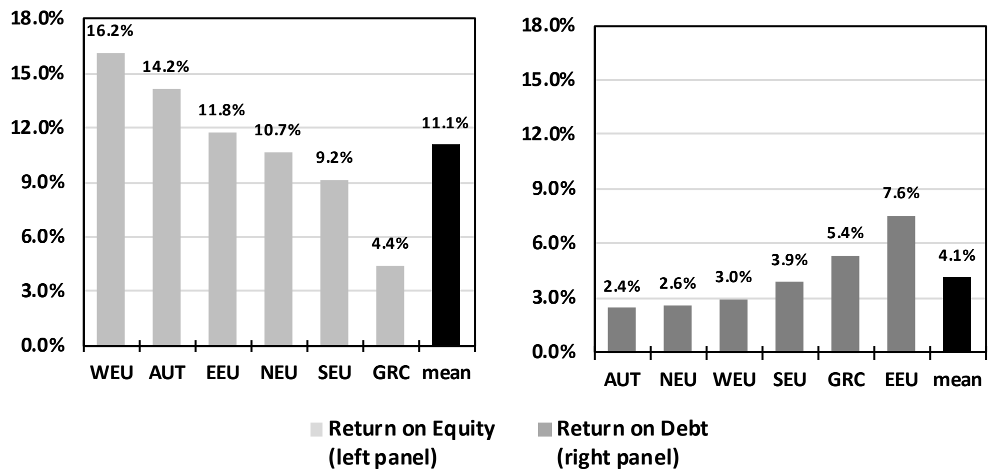


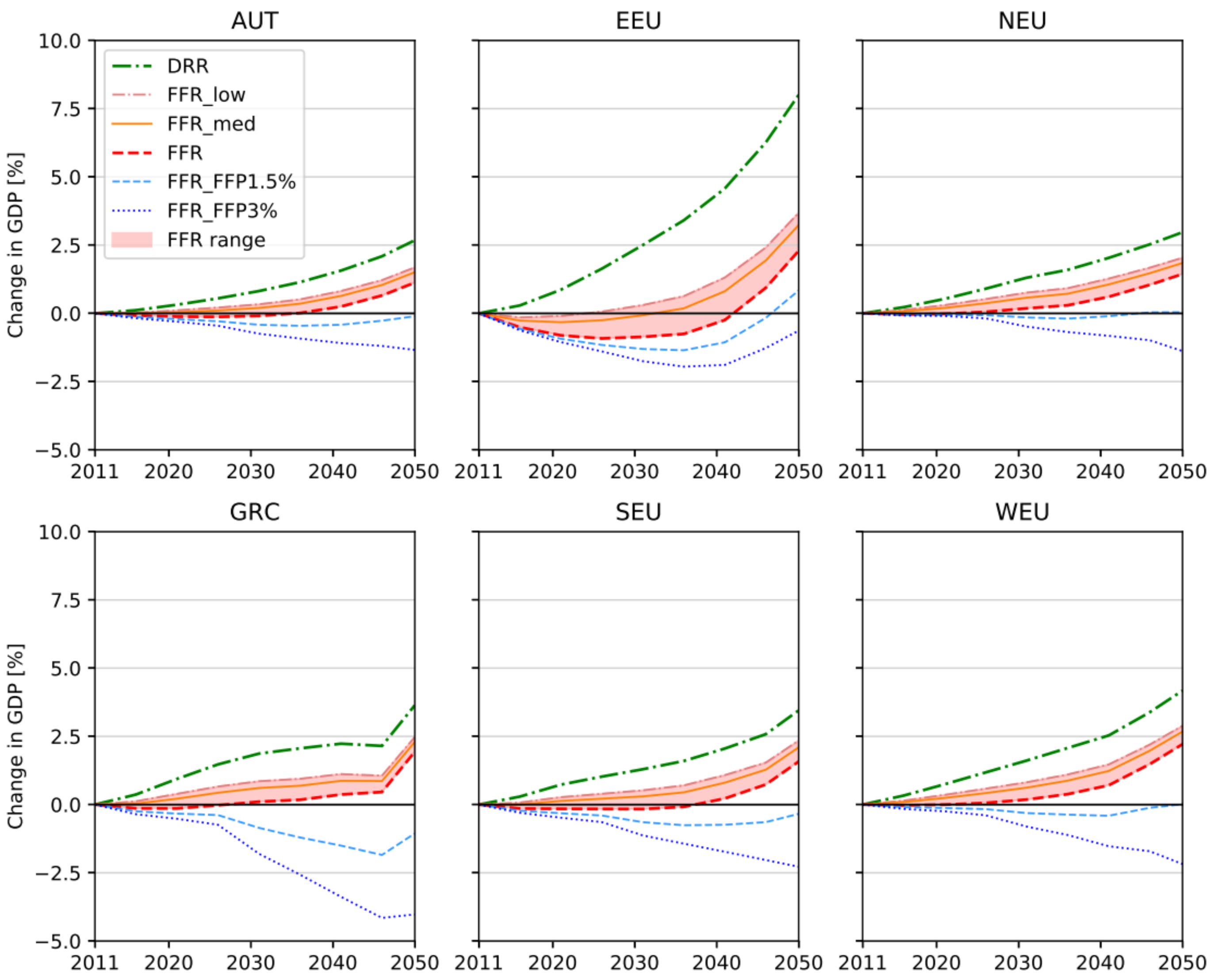
Figure A 1: Regional return on equity and return on debt rates, based on long-term country data on equity (IMF, 2019) and debt (ECB, 2019; World Bank, 2019) for non-financial corporations.

Table A 1: OPEX, investment costs (2011 and 2050) and economic lifetime of electricity generation technologies (Pleßmann and Blechinger, 2017).

	Investment costs [EUR/kW]		Economic lifetime [years]	Operating expenditures [EUR/kWh]					
	2011	2050		AUT	GRC	EEU	NEU	SEU	WEU
Solid Fuels	1,523	1,523	40	118	78	95	79	73	94
Petroleum	400	400	30	309	168	329	397	312	197
Gas	653	653	30	87	95	126	75	86	82
Nuclear	6,528	6,528	40	-	-	89	84	81	102
Hydro	3,263	3,263	100	2	3	3	2	2	3
Biomass	2,485	1,951	30	26	11	82	38	16	28
PV	3,800	445	25	4	2	3	4	2	4
Wind	2,563	1,330	25	35	24	29	36	29	38

Table A 1: Technology-specific LCOE 2011 in EUR/kWh (EC, 2016; ECOFYS, 2014)

LCOE 2011 [EUR/kWh]	AUT	GRC	NEU	WEU	EEU	SEU
Solid Fuels	0.11	0.07	0.08	0.08	0.10	0.06
Petroleum	0.27	0.15	0.36	0.17	0.30	0.29
Gas	0.08	0.09	0.07	0.07	0.12	0.08
Nuclear	-	-	0.10	0.10	0.10	0.09
Hydro	0.03	0.04	0.04	0.05	0.04	0.03
Wind	0.09	0.09	0.10	0.09	0.09	0.09
Biomass	0.10	0.04	0.07	0.09	0.08	0.03
Solar	0.13	0.09	0.15	0.12	0.13	0.09


AUT
EEU
NEU
GRC
SEU
WEU
Change in GDP [%]
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
2011
2020
2030
2040
2050
DRR
FFR_low
FFR_med
FFR
FFR_FFP1.5%
FFR_FFP3%
FFR range