

# Program

## 40th International Energy Workshop

May 25-27, 2022 | Freiburg, Germany  
[iew.conexio-pse.de](http://iew.conexio-pse.de)

**Wednesday, 25.05.2022**

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08:00 - 09:00    **Admission & Networking**

08:00 - 09:00  
Admission & Networking

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09:00 - 10:15    **Runder Saal**

### **Welcome & Plenary Session 1 (Part I)**

09:00 - 09:45  
Welcome and opening remark  
Prof. Dr. Hans-Martin Henning, Fraunhofer ISE  
Martin Horn, Mayor of Freiburg im Breisgau

09:45 - 10:15  
Keynote: Challenges in decarbonising the energy industry  
Dr. Georg Stamatelopoulos, EnBW

Chair  
Prof. Bob van der Zwaan  
TNO and University of Amsterdam

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10:15 - 10:45    **Coffee Break**

10:15 - 10:45  
Coffee Break

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10:45 - 12:30    **Runder Saal**

### **Welcome & Plenary Session 1 (Part II)**

10:45 - 11:15  
Keynote: Climate policy in times of crisis, building a resilient energy transition  
Francesco Ferioli, DG Energy

11:15 - 11:45  
Keynote: Understanding climate action  
Prof. Dr. E.M. Linda Steg, University of Groningen

11:45 - 12:30  
Discussion

Chair  
Prof. Bob van der Zwaan  
TNO and University of Amsterdam

12:30 - 14:00

## Lunch

12:30 - 14:00  
Lunch

12:40 - 14:00

## Runder Saal

### IRENA Session

12:40 - 14:00  
Energy scenario communication for strengthened inputs and trustworthy outputs

14:00 - 15:40

## Konferenzraum 9

### Energy Policy

14:00 - 14:25  
International climate finance to accelerate the low-carbon transition in emerging countries? A global assessment of financial de-risking potential  
Thibault Briera, CIRED

14:25 - 14:50  
Trade-offs between CO2 utilization and CO2 transport and storage in the global energy transition  
Lucas Desport, MINES Paris

14:50 - 15:15  
How do Climate Policy Events Shape the Pricing of Carbon in ETS Compliance and Voluntary Carbon Credit Markets?  
Papa Orgen, Hochschule Fulda

15:15 - 15:40  
Deployment of CO2 Capture and Storage in Europe Under Limited Public Acceptance: an Energy System Modeling Perspective  
Prof. Bob van der Zwaan, TNO and University of Amsterdam

Chair  
Dominik Peper  
Fraunhofer ISE

## Konferenzraum 8

### Carbon Neutral Future

14:00 - 14:33  
Achieving Economy-Wide Net-Zero Carbon Emissions in the U.S.  
Dr. Geoffrey Blanford, Electric Power Research Institute

14:33 - 15:06  
Investigation of New Energy Storage in Chinese Carbon-neutral Optimal Power Expanding Plan by 2060  
Ye Yi, University of Tokyo

15:06 - 15:40  
Insights from the German modeling project ARIADNE: Scenarios and pathways for Germany on its way to climate neutrality in 2045  
Christoph Kost, Fraunhofer ISE

Chair  
Verena Fluri  
Fraunhofer ISE

## Konferenzraum 6+7

### Energy and Households

14:00 - 14:33  
The Elasticity of Electricity Demand and Carbon Emissions Reductions in the Residential Sector: Evidence from a tariff shift in Russia  
Salim Turdaliev, Institute of Economic Studies, Faculty of Social Sciences, Charles University

14:33 - 15:06  
Decarbonization pathways for the residential sector in the United States  
Dr. Peter Berrill, TU Berlin

15:06 - 15:40  
An Investigation of Energy Self-sufficiency of Bangladesh for Different Socio-economic Scenarios using Dynamic Energy Economic Model  
Dr. Jubair Sreed, University of Tokyo

Chair  
Jessica Thomsen  
Fraunhofer ISE

## Konferenzraum 2+3

### Energy System Modeling

14:00 - 14:33  
Assessing flexibility options and operational impact of a renewable-dominant power grid in China  
Dr. Jiang Lin, UC Berkeley

14:33 - 15:06  
Developing decarbonisation pathways in changing TIMES for Irish homes  
Jason Mc Guire, University College Cork

15:06 - 15:40  
An Econometric Model to Improve the Predictability of Electricity Load in the Presence of Distributed Renewable Energy: The Case of Ireland  
Dr. Kevin Forbes, Energy and Environmental Data Science

Chair  
Julian Brandes  
Fraunhofer ISE

## Konferenzraum 1

### Mobility

14:00 - 14:25  
Competing Forces in the German New Car Market: How do they Affect Diesel, PHEV, and BEV sales?  
Prof. Anna Alberini, University of Maryland

14:25 - 14:50  
Modeling geographic density of electric vehicles chargers in a metropolitan area  
Giovanni Santoboni, Transurban, USA

14:50 - 15:15  
Co-benefits of air quality and net-zero carbon mitigation pathways: Case of the road transport sector in Ireland  
Vahid Aryanpur, Energy Policy and Modelling, University College Cork

15:15 - 15:40  
Charging and refueling demand for heavy-duty zero emission trucks in Norwegian transport corridors  
Janis Danebergs, IFE

Chair  
Patrick Jürgens  
Fraunhofer ISE

15:45 - 16:15 **Coffee Break**

15:45 - 16:15  
Coffee Break

| 16:15 - 17:55 | <b>Konferenzraum 9</b>  | <b>Konferenzraum 6+7</b>  | <b>Konferenzraum 8</b>   | <b>Konferenzraum 1</b>   |
|---------------|---|---|--|--|
|               | <b>Energy Policy</b>  | <b>Buildings</b>  | <b>Carbon Neutral Future</b>   | <b>Mobility</b>  |
|               | <p>16:15 - 16:48<br/>What is the Future of Nuclear Power in Ukraine? The Role of Policy Decisions and Techno-Economic Drivers<br/>Dr. Oleksandr Diachuk, Institute for Economics and Forecasting</p> <p>16:48 - 17:21<br/>A global stocktake of COP26: implications of the Glasgow pledges for the decarbonisation of the energy system<br/>Rafael Garaffa, European Commission - Joint Research Centre</p> <p>17:21 - 17:55<br/>The impact of climate change, policies, and redistribution on within-country inequality<br/>Dr. Johannes Emmerling, RFF-CMCC European Institute on Economics and the Environment</p> <p>Chair<br/>Patrick Jürgens<br/>Fraunhofer ISE</p> | <p>16:15 - 16:40<br/>A retrofitting obligation for French dwellings - A modelling assessment<br/>Lucas Vivier, CIRED</p> <p>16:40 - 17:05<br/>Municipal heating system modelling towards urban energy transition : integration of spatial dimension based on a participatory approach<br/>Hyunkyo Yu, Chalmers University of Technology</p> <p>17:05 - 17:30<br/>Analysis of a Residential Power-to-Hydrogen-to-Power System using MILP Optimization and the Energy Hub Concept<br/>Josien de Koning, Empa / ETH Zürich</p> <p>17:30 - 17:55<br/>Decarbonizing industrial small and medium enterprises: novel solutions to known challenges<br/>Natapon Wanapinit, Fraunhofer ISE</p> <p>Chair<br/>Jessica Thomsen<br/>Fraunhofer ISE</p> | <p>16:15 - 16:48<br/>The role of biomass and carbon capture in the power system aligned with the European Green Deal<br/>Rebeka Beres, Energy and Sustainability Research Institute Groningen, University of Groningen</p> <p>16:48 - 17:21<br/>Switzerland's national mitigation pathways: towards net-zero CO2 emissions in 2050<br/>Dr. Evangelos Panos, Paul Scherrer Institute</p> <p>17:21 - 17:55<br/>Pathways to climate neutrality 2045 of the German energy system<br/>Julian Brandes, Fraunhofer ISE</p> <p>Chair<br/>Christoph Kost<br/>Fraunhofer ISE</p> | <p>16:15 - 16:40<br/>Do we need cities to decarbonise transportation? Modelling local strategies under strong national policies in TIMES-Västerbotten<br/>Jonas Forsberg, Luleå University of Technology</p> <p>16:40 - 17:05<br/>Providing the transport sector in Europe with zero-emission fuels - a model-based analysis under consideration of the MENA region<br/>Larissa Doré, Wuppertal Institut für Klima, Umwelt, Energie</p> <p>17:05 - 17:30<br/>Fuel Economy Standards and Public Transport<br/>Dr. Waldemar Marz, ifo Institute/LMU Munich</p> <p>17:30 - 17:55<br/>Electrification Futures Study: Impact of Electric Vehicles on Bulk Power Systems<br/>Dr. Matteo Muratori, National Renewable Energy Laboratory</p> <p>Chair<br/>Dominik Peper<br/>Fraunhofer ISE</p> |

19:00 - 21:00 **Fraunhofer Institute for Solar Energy Systems ISE**

### **Reception**

19:00 - 21:00  
Reception

Thursday, 26.05.2022

08:30 - 09:00 **Admission & Networking**

08:30 - 09:00  
Admission & Networking

09:00 - 10:30 **Runder Saal**

### Plenary Session 2

09:00 - 09:30

Keynote: Innovation for deep decarbonization: from empirical research to modelling insights  
Prof. Elena Verdolini, EIEE

09:30 - 10:00

Keynote: Decarbonization regulation by a tax-transfer system: The Carbon Tax-Climate Basic Income (CaTaBi) Scheme  
Prof. Dr. Bernhard Neumaerkter, University of Freiburg

10:00 - 10:30

Keynote: Decarbonization in the Global South: Embedding efforts to mitigate climate change with those to achieve decent standards of living for all  
Dr. Shonali Pachauri, International Institute for Applied Systems Analysis (IIASA)

Chair

Dr. Geoffrey Blanford

Electric Power Research Institute

10:30 - 11:00 **Coffee Break**

10:30 - 11:00  
Coffee Break

11:00 - 12:40

### Konferenzraum 1

#### Energy System Modeling

11:00 - 11:25  
Multi-Objective  
Optimization to identify  
carbon neutrality scenarios  
for the Italian electric  
sector  
Alice Di Bella, Post Degree  
Researcher

11:25 - 11:50  
What adds more exibility?  
An energy system analysis  
of storage, demand-side  
response, heating electri  
cation, energy e ciency and  
distribution reinforcement  
Arthur Rinaldi, Assistant  
PhD

### Konferenzraum 2+3

#### Renewables

11:00 - 11:20  
MAPSEN Project - Methods  
and Analyses to Determine  
the Impact of Decentralized  
Prosumers and Energy  
Storage on Germany's  
Power Generation and  
Electricity Grid  
Verena Fluri, Fraunhofer ISE

11:20 - 11:40  
Battery storage bends the  
curve of solar and wind  
integration costs in India  
Ahmad Murtaza Ershad,  
Potsdam Institute for  
Climate Impact Research

11:40 - 12:00

### Konferenzraum 6+7

#### Emission Trading

11:00 - 11:33  
Allowance Transactions in  
the EU ETS – Evidence from  
Austrian Companies  
Dr. Claudia Kettner,  
Austrian Institute of  
Economic Research

11:33 - 12:06  
Pricing and Competition  
with 100% Variable  
Renewable Energy and  
Storage  
Prof. Tommi Ekholm,  
Finnish Meteorological  
Institute

12:06 - 12:40  
What buildings

### Konferenzraum 8

#### International Cases

11:00 - 11:25  
Minigrid sizing and the  
issue of data-paucity in  
developing countries. A  
case study in rural Rwanda.  
Nicolò Stevanato,  
Politecnico di Milano

11:25 - 11:50  
Reducing externalities from  
road freight transportation  
in Europe: can hydrogen  
play a role?  
Julien Lafaille, Grenoble  
Ecole de Management

11:50 - 12:15  
Impacts of grid electricity  
access on rural non-farm

### Runder Saal

#### Energy Policy

11:00 - 11:25  
Should models account for  
governance regimes?  
Insights from retrospective  
modeling of electricity  
system transitions in  
European countries  
Xin Wen, University of  
Geneva

11:25 - 11:50  
Assessment of the role of  
green Hydrogen for the long  
term development of the  
energy system - a case  
study for Algeria  
Naima Chabouni, MINES  
Paris Tech - CMA, Center  
for Applied Mathematics

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|--|--|---|---|--|
| 11:50 - 12:15<br>TIMES-Europe: A Novel European Integrated Energy System Model<br>Dr. Stefan Luxembourg, TNO Energy Transition Studies   | The multi-facets of increasing the renewable energy integration in power systems<br>Sophie Chlela, MINES Paris, PSL University         | decarbonisation means for the EU ETS<br>Dr. Sebastian Osorio, Potsdam Institute for Climate Impact Research | entrepreneurship and employment in Ethiopia and Nigeria<br>Setu Pelz, International Institute for Applied Systems Analysis  | 11:50 - 12:15<br>Electricity Market Design and Market-Based Environmental Policy in India<br>Dr. Shefali Khanna, Imperial College London                       |
| 12:15 - 12:40<br>"It takes two to tango" – Modeling detailed power sector dynamics by coupling hourly investment and dispatch energy system model with IAM<br>Chen Chris Gong, Potsdam Institute for Climate Impact Research | 12:00 - 12:20<br>Harmonising utility-scale solar PV auction results globally<br>Dr. Malte Jansen, Imperial College London              | Chair<br>Charlotte Senkpiel<br>Fraunhofer ISE   | 12:15 - 12:40<br>Measuring the Impacts of Renewable Energy Deployment on Employment: An Empirical Study in Thailand<br>Phawida Jongsuwanwattana, Kyoto University | 12:15 - 12:40<br>Distributional effects of carbon pricing and structural change in India<br>Dr. Marian Leimbach, Potsdam Institute for Climate Impact Research |
| Moderator<br>Markus Kaiser<br>Fraunhofer ISE   | 12:20 - 12:40<br>The role of Rooftop Solar PV in global energy transitions<br>James Glynn, Columbia University in the City of New York |   | Chair<br>Patrick Jürgens<br>Fraunhofer ISE  | Chair<br>Franziska Riedel<br>Fraunhofer ISE  |
|  | Chair<br>Verena Fluri<br>Fraunhofer ISE  |   |   |  |

12:45 - 14:00

**Lunch**

12:45 - 14:00  
Lunch

14:00 - 15:40

**Konferenzraum 1**

**Konferenzraum 2+3**

**Runder Saal**

**Konferenzraum 6+7**

**Konferenzraum 8**

**Energy and Households**

**Renewables**

**Energy Policy**

**Impact Assessment**

**Power to X**

14:00 - 14:33  
Buildings Energy Consumption If Work-From-Home Is Here To Stay  
Giacomo Marangoni, Politecnico di Milano / RFF-CMCC-EIEE

14:33 - 15:06  
Analysing and predicting the impact of spatial development on energy service demands to aid deep mitigation pathway development  
Ankita Gaur, Energy Policy and Modelling, University College Cork, Ireland

15:06 - 15:40  
How to support residential energy conservation cost-effectively? An analysis of public financial schemes in France  
Bettina Chlond, ZEW Mannheim

14:00 - 14:25  
The role of offshore wind in the Norwegian low-carbon transition  
Kristina Haaskjold, Institute for Energy Technology

14:25 - 14:50  
As simple as possible but not simpler - Comparing detailed and simplified representations of a deterministic hydropower model  
Hanna Ek Fäth, Chalmers University of Technology

14:50 - 15:15  
Wind power potentials in models – A GIS based reality check  
Prof. Fredrik Hedenus, Chalmers University of Technology

15:15 - 15:40  
Return of crop production and energy use for

14:00 - 14:25  
The impact of major emitters mid-century strategies and Glasgow pledges  
Dr. Lara Aleluia Reis, RFF-CMCC EIEE

14:25 - 14:50  
Mapping national development priorities under the Sustainable Development Goals framework – a systematic analysis  
Auriane Meilland, CIRED

14:50 - 15:15  
Efficiency in Wholesale Electricity Markets: On the Role of Externalities and Subsidies  
Dr. Sylwia Bialek, New York University

15:15 - 15:40  
Reaching climate targets with carbon pricing -

14:00 - 14:25  
Optimal emissions under exogenous and endogenous learning  
Léo Coppens, University of Mons

14:25 - 14:50  
System-level Effects of Increased Energy Efficiency in Global Low-carbon Scenarios: a Model Comparison  
Dr. Francesco Dalla Longa, TNO

14:50 - 15:15  
An open-source IAM for Energy-Land-Material-Climate Scenarios  
Nadine Freistetter, Finnish Meteorological Institute

15:15 - 15:40  
The Low Carbon Lifestyle Module: A Dynamic Mechanism for Incorporating Lifestyle

14:00 - 14:25  
Establishing low-carbon hydrogen trade relations - where to go and who to partner with?  
Johannes Brauer, CERN, MINES Paris PSL

14:25 - 14:50  
Assessing green energy growth in Nepal with a hydropower-hydrogen integrated power grid model  
Dr. Khem Gyanwali, Tribhuvan University

14:50 - 15:15  
Import options for chemical energy carriers from renewable sources to Germany  
Johannes Hampp, Justus-Liebig Universität Gießen

15:15 - 15:40  
On the cost competitiveness of blue

|   |  |   |  |  |
|---|--|---|--|--|
| Chair<br>Charlotte Senkpiel<br>Fraunhofer ISE | irrigation: Empirical<br>Evidence from Ethiopia<br>Dr. Rahel Deribe Bekele,<br>International Food Policy<br>Research Institute (IFPRI) | Analysis of the German<br>buildings sector<br>Alexander Burkhardt, IER<br>Universität Stuttgart | Change into Global<br>Integrated Assessment<br>Models<br>Dr. Hazel Pettifor,<br>University of Oxford | and green hydrogen<br>Dr. Falko Ueckerdt,<br>Potsdam Institute for<br>Climate Impact Research<br>(PIK) |
|   | Chair<br>Verena Fluri<br>Fraunhofer ISE  | Chair<br>Franziska Riedel<br>Fraunhofer ISE   | Chair<br>Julian Brandes<br>Fraunhofer ISE  | Chair<br>Christoph Kost<br>Fraunhofer ISE  |

15:45 - 16:15 **Coffee Break**

15:45 - 16:15  
Coffee Break

| 16:15 - 17:55                                 | Runder Saal   | Konferenzraum 1   | Konferenzraum 2+3  | Konferenzraum 8  | Konferenzraum 6+7  |
|---|---|---|--|--|--|
|   | Energy Policy   | Electricity System Modeling   | Renewables   | Energy Investments   | Impact Assessment  |
| 16:15 - 16:48                                 | Analyzing the impact of energy transition policies on the economy by soft-linking bottom-up and top-down models: the case study of the Netherlands<br>Amir Fattahi, University of Groningen | 16:15 - 16:40<br>Long-term optimisation of the hydrogen-electricity nexus in France<br>Dr. Behrang Shirzadeh, Deloitte Economic Advisory                                | 16:15 - 16:40<br>Global renewable LCOE – including socio-economic factors in assessments of resource potential<br>Xiaoming Kan, Chalmers University of Technology    | 16:15 - 16:40<br>Incorporating consumer choice into an optimization model for the German heat sector: Effects on projected bioenergy use<br>Dr. Matthias Jordan, Helmholtz Centre for Environmental Research | 16:15 - 16:35<br>Paris Agreement targets under uncertain negative emission technologies and climate sensitivity<br>Theresa Schaber, Finnish Meteorological Institute                             |
| 16:48 - 17:21                                 | Carbon pricing: the green modernization of the Russian economy<br>Dr. Alexander Golub, American University  | 16:40 - 17:05<br>Intensive and extensive margins of the peak load: measuring adaptation with mixed frequency panel data<br>Dr. Francesco Colelli, Ca'Foscari University | 16:40 - 17:05<br>Renewable Energy Siting: A Major Challenge to Grid Decarbonization and Power System Modeling<br>Dr. Trieu Mai, National Renewable Energy Laboratory | 16:40 - 17:05<br>Energy-related financial literacy and collective retrofit investment decisions in post-Soviet bloc countries<br>Fissha Asmare, Vilnius University   | 16:35 - 16:55<br>Good Stick, Bad Carrot: The Impacts of Removing Fossil Fuel Subsidies and Increasing Carbon Taxation in Ireland<br>Dr. Aykut Mert Yakut, Economic and Social Research Institute |
| 17:21 - 17:55                                 | Decarbonization of the global economy: if technologies are so good, why do we still need a carbon price?<br>Dr. Alexander Golub, American University  | 17:05 - 17:30<br>When do consumers want to opt in to real-time pricing for electricity?<br>Dr. Quentin Hoarau, MIT  | 17:05 - 17:30<br>Biomass' role in Greener Albertan Electricity Generation – A Discussion and Analysis<br>Ziad Memon, University of Alberta                           | 17:05 - 17:30<br>An EU ETS paving the way to climate neutrality The right design considering myopic behavior of decision-makers<br>Joanna Sitarz, Potsdam Institute for Climate Impact Research              | 16:55 - 17:15<br>Electrification of the hard-to-abate chemical sector: implication for Net-Zero power systems in Europe<br>Meilland Cabot, MINES ParisTech, PSL University                       |
| Chair<br>Charlotte Senkpiel<br>Fraunhofer ISE |   | 17:30 - 17:55<br>Prosumage of solar electricity: batteries, heating and mobility<br>Dr. Wolf-Peter Schill, DIW Berlin   | 17:30 - 17:55<br>Did the Covid-19 pandemic speed up a transition away from coal? An expert elicitation survey<br>Lorenzo Montrone, MCC Berlin                        | 17:30 - 17:55<br>Modeling the cost-effective gas network in Austria until 2050: from the decision between decommissioning and refurbishment investments<br>Sebastian Zwickl-Bernhard, Energy Economics Group | 17:15 - 17:35<br>Electricity Outages and Health Outcomes of Children: Empirical Evidence from Transition Economy<br>Yermone Sargsyan, Institute of Economic Studies Charles University Prague    |
|   |   | Chair<br>Jessica Thomsen<br>Fraunhofer ISE  | Chair<br>Julian Brandes<br>Fraunhofer ISE  | Chair<br>Christoph Kost<br>Fraunhofer ISE  | 17:35 - 17:55<br>Severity of variable renewably energy droughts in Germany and Europe<br>Martin Kittel, German Institute for Economic Research   |

Chair  
Markus Kaiser  
Fraunhofer ISE

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19:00 - 23:00     **Konzerthaus, 1st floor**  
**Conference Dinner**

19:00 - 23:00  
Conference Dinner

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**Friday, 27.05.2022**

08:30 - 09:00 **Admission & Networking**

08:30 - 09:00  
Admission & Networking

09:00 - 10:30 **Runder Saal**

### Plenary Session 3

09:00 - 09:30  
Keynote: Hydrogen infrastructures in future integrated energy systems  
Hans Christian Gils, German Aerospace Center (DLR)

09:30 - 10:00  
Keynote: Prosumers, markets and regulations – can we get the incentives right?  
Prof. Dr. Christoph Weber, University Duisburg-Essen

10:00 - 10:30  
Keynote: Integrated Energy Systems Modeling – Case Study of Switzerland  
Prof. Dr. Gabriela Hug, ETH Zurich

Chair  
Massimo Tavoni  
EIEE

10:30 - 11:00 **Coffee Break**

10:30 - 11:00  
Coffee Break

| 11:00 - 12:40 | <b>Runder Saal</b>   | <b>Konferenzraum 1</b>  | <b>Konferenzraum 2+3</b>  | <b>Konferenzraum 6+7</b>  | <b>Konferenzraum 8</b>  |
|---------------|--|---|---|---|---|
|               | <b>Energy Policy</b>   | <b>Impact Assessment</b>  | <b>Power to X</b>   | <b>Flexibility</b>  | <b>Electricity System Modeling</b>  |
|               | 11:00 - 11:50<br>How costly are biofuel mandates? - an analysis of transport fuels and biomass usage to achieve emissions targets in the European energy system<br>Dr. Markus Millinger, Chalmers University of Technology | 11:00 - 11:50<br>The effects of climate change mitigation strategies on the energy system of Africa and its associated water footprint<br>Ioannis Pappis, KTH Royal Institute of Technology | 11:00 - 11:25<br>Role of P2X in prospective net-zero scenarios: A techno-economic assessment<br>Kannan Ramachandran, Paul Scherrer Institute  | 11:00 - 11:25<br>Storage requirements in a 100% renewable electricity system: Extreme events and inter-annual variability<br>Oliver Ruhnau, Hertie School, Berlin | 11:00 - 11:25<br>Reaching net zero emissions in Switzerland: The essential role of biomass and carbon capture and utilization<br>Dr. Adriana Marcucci, ETH Zurich |
|               | 11:50 - 12:40<br>Making the EU Carbon Border Adjustment Mechanism Acceptable and Climate Friendly for Least Developed Countries<br>Dr. Sigit Perdana, EPFL   | 11:50 - 12:40<br>International and intertemporal knowledge spillovers in carbon-free and carbon-efficient technologies<br>Dr. Yeong Jae Kim, RFF-CMCC EIEE                                  | 11:25 - 11:50<br>Who should own storage? A case study of players with large-scale P2X in cross-country electricity markets based on a game-theoretic equilibrium model<br>Yi Wan, Paul Scherrer Institute | 11:25 - 11:50<br>Flexibility capacities and contributions in the future German energy system<br>Markus Kaiser, Fraunhofer ISE                                     | 11:25 - 11:50<br>Endogenous Technological Change in Power Market Models - Learning-By-Doing<br>Jacqueline Adelowo, ifo Institut                                   |
|               |  |   | 11:50 - 12:15   | 11:50 - 12:15<br>The contribution of distributed energy systems (rooftop PV integrated with   | 11:50 - 12:15<br>A multi-scale,   |



|  |  |  |   |  |
|--|--|--|---|--|
| Chair<br>Dominik Peper<br>Fraunhofer ISE | Chair<br>Jessica Thomsen<br>Fraunhofer ISE | Endogenous learning for green hydrogen in a sector-coupled energy model for Europe<br>Elisabeth Zeyen, Technical University of Berlin (TUB)                    | EVs) to carbon neutrality in Shenzhen, China<br>Liya Xue, School of Economics and Management, Harbin Institute of Technology (Shenzhen)   | linking&rolling framework for long-term planning of reliable power systems in transition<br>Yacine Alimou, Mines ParisTech   |
|  |  | 12:15 - 12:40<br>Probabilistic feasibility space of scaling up green hydrogen supply<br>Adrian Odenweller, Potsdam Institute for Climate Impact Research (PIK) | 12:15 - 12:40<br>RAMP-mobility: generating stochastic mobility, charging profiles and flexibility constraints for Electric Vehicles and grid integration<br>Francesco Davide Sanvito, Politecnico di Milano | 12:15 - 12:40<br>Materials industry modelling in net-zero emissions scenarios: hydrogen contribution to low-carbon steel<br>Kimon Keramidas, Université Grenoble-Alpes |
|  |  | Chair<br>Gregor Gorbach<br>Fraunhofer ISE  | Chair<br>Markus Kaiser<br>Fraunhofer ISE  | Chair<br>Christoph Kost<br>Fraunhofer ISE  |

# Designing a model for the cost-optimal decommissioning and refurbishment investment decision of gas networks

Application on a real test-bed in Austria until 2050

International Energy Workshop (IEW)

May 25-27, Freiburg

Sebastian Zwickl-Bernhard

Corresponding author/Presenter: [zwickl@eeg.tuwien.ac.at](mailto:zwickl@eeg.tuwien.ac.at)

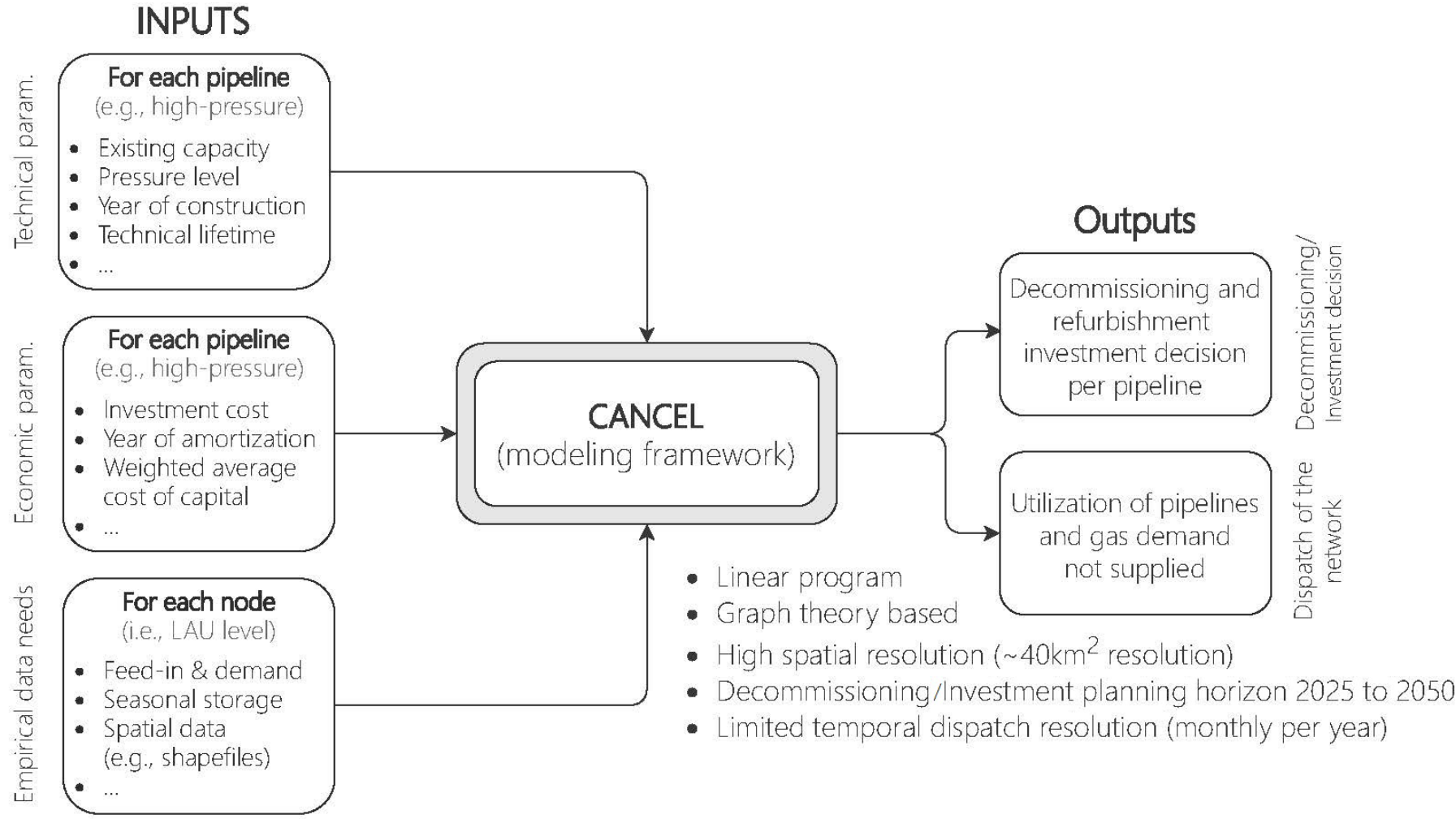
- Background / Motivation
- Core objective
- Materials and methods
- Results of a real test-bed (federal state Vorarlberg, Austria, until 2050)
- Conclusions and outlook

- Adherence to the remaining CO<sub>2</sub> budget of the 1.5°C / 2.0°C climate target requires rapid **defossilization** of the energy system
- Concrete measures include, among others, the **substitution** of **natural gas** in the provision of energy services by sustainable alternatives
- Substantial **challenge** since natural gas is currently **used** for energy supply of a **wide range** of energy service needs
- Uncertain role of **green gases** (e.g., synthetic gas, hydrogen) related to their economic viable quantities / potentials and penetration time
- ...but there are far-reaching gas transmission / distribution networks

# Core objective / main research questions

- The core objective of this work is to investigate the **cost-effective trajectory** of **gas networks** from a systemic point of view under a long-term planning horizon
- In view of necessary refurbishment investments in existing gas network infrastructure and pipelines due to their technical lifetimes, the main research question is of **which decommissioning and refurbishment investment decision result in cost-effective gas networks by 2050.**
- Equally important in the analysis is the trade-off decision from the network operator's perspective whether available **gas demands** within the network area **are supplied or not** as the decommissioning of existing gas pipelines can be cost-effective, but at the same time results in not supplied gas demands.

# Introduction into the model



# Mathematical formulation (selection) 1 / 2

| Equation  | Type               | Short description  |
|---|--------------------|--|
| $\min_x Capex + Opex - Rev + Purch$   | Objective function | Minimize gas network operator's net present value  |
| $Capex = \sum_y \alpha_y * w * \Pi_y \quad Opex = \sum_y \alpha_y * K$      | Constraint         | Calculation of capital and operational expenditures  |
| $K = \sum_l c_l^{fix} * \Upsilon_{l,y}$                                     | Constraint         | Total fixed (operating) costs per pressure / network level $l$   |
| $\Pi_{p,l,y} = \Pi_{p,l,y}^{pre} + f_{p,l}^{ref} * \Pi_{p,l,y_{p,l}}^{ref}$ | Constraint         | Book value of a pipeline $p$ at $l$ in $y$ , where $\Pi_{p,l,y}^{pre}$ is the book value of the pre-existing pipeline (capacity) |
| $\Pi_{p,l,y_{p,l}}^{ref} = c_l^{inv} * \Upsilon_{p,l,y_{p,l}}^{ref}$        | Constraint         | Book value of the refurbishment investment for $p$ and $l$ in $y_{p,l}^{inv}$  |

# Mathematical formulation (selection) 2 / 2

| Equation   | Type       | Short description   |
|--|------------|---|
| $q_{n,l,y,m}^{fed} - q_{n,l,y,m}^{dem} - \zeta_m * (q_{n,l,y,m}^{exp} - q_{n,l,y,m}^{imp}) + q_{n,l,y,m}^{sto} = 0$  | Constraint | Nodal gas balance equation at pressure / network level  |
| $q_{n,l,y,m}^{dem} = q_{n,l,y,m}^{dem,loc} + q_{n,l',y,m}^{del}$   | Constraint | Gas demand at network level $l$ , where $q_{n,l',y,m}^{del}$ is the amount of gas delivered to subordinate pressure level |
| Equation 18 $\left\{ \begin{array}{l} q_{n,l,y,m}^{dem,loc} \leq d_{n,l,y,m}^{max} : \lambda_{n,l,y,m}^{co} \\ q_{n,l,y,m}^{dem,loc} = d_{n,l,y,m}^{max} : \lambda_{n,l,y,m}^{ES} \end{array} \right.$ | Constraint | Essential demand constraint and sets the upper bound of the decision variable $q_{n,l,y,m}^{dem,loc}$                     |
| $rev = p_{l,y}^{loc} * q_{n,l,y,m}^{dem,loc}$  | Constraint | Revenues created by the local gas demands covered, where $p_{l,y}^{loc}$ is the grid usage charge at network level $l$    |



# Implication of demand constraint dual variables

| Input     |   | Output   |
|-----------|---|--|
| Model run | Formulation of Equation 18                        | Scenario description/gas network design (abbreviation) |
|           |   | Results or further used variable                       |
| 1         | $q_{n,l,y,m}^{dem} \leq d_{n,l,y,m}^{max}$        | Cost-optimal without ensured supply (CO)               |
| 2         | $q_{n,l,y,m}^{dem} = \mathbf{q}_{n,l,y,m}^{*dem}$ | Demand supplied ( $\mathbf{q}_{n,l,y,m}^{*dem}$ )      |
| 3         | $q_{n,l,y,m}^{dem} = d_{n,l,y,m}^{max}$           | Shadow price ( $\lambda_{n,l,y,m}^{CO}$ )              |
|           |   | Cost-optimal with ensured supply (ES)                  |
|           |   | Shadow price ( $\lambda_{n,l,y,m}^{ES}$ )              |

Table 1: Model runs and associated formulation of the gas demand constraint (Equation 18), scenarios, and results or further used variables.

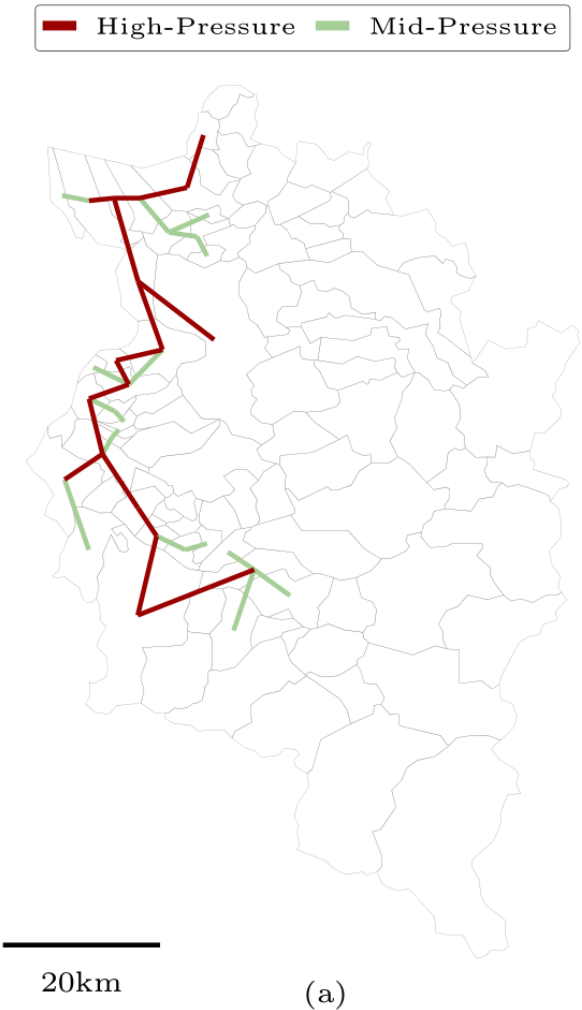
High-Pressure Mid-Pressure

Existing network



Representation in the model

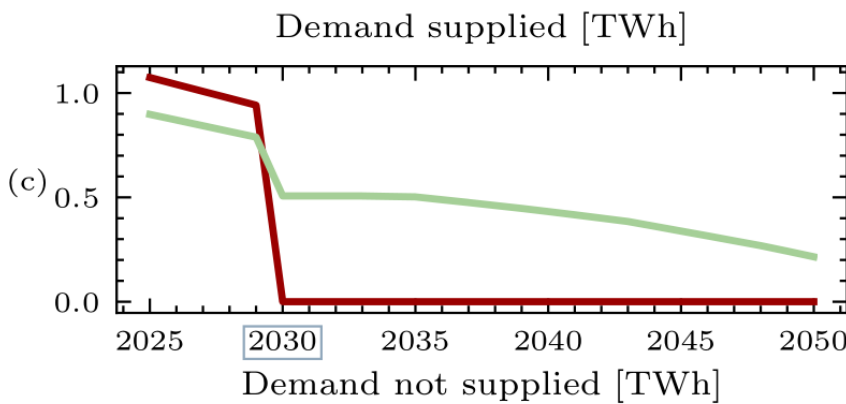




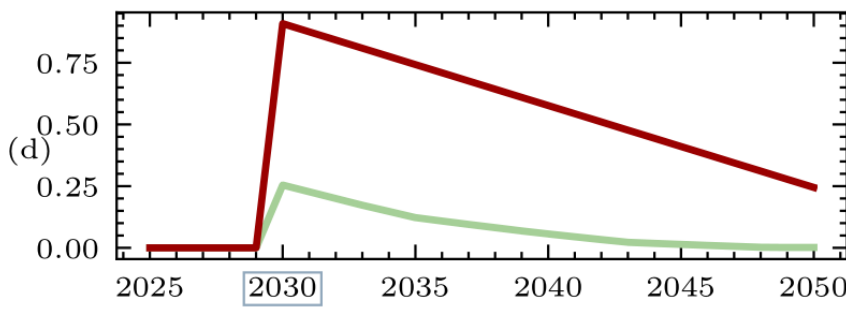
(b)

|             | High-Pres. | Mid-Pres. |
|-------------|------------|-----------|
| Max. [MW]   | 161.92     | 40.58     |
| Length [km] | 84.5       | 57.2      |
| Decom. [%]  | 0          | 41        |
| Refurb. [%] | 100        | 59        |

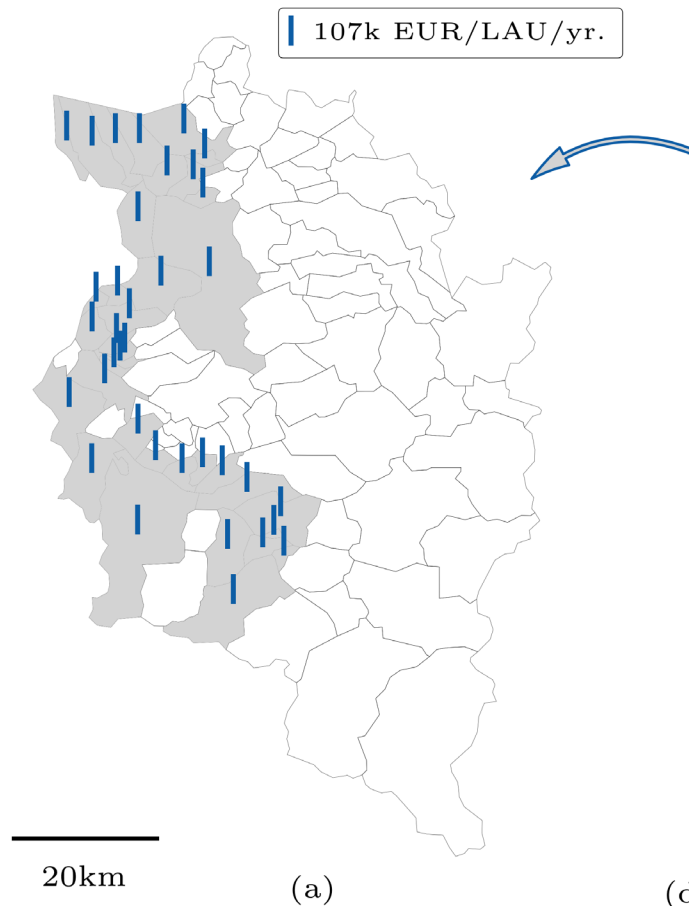
(c)



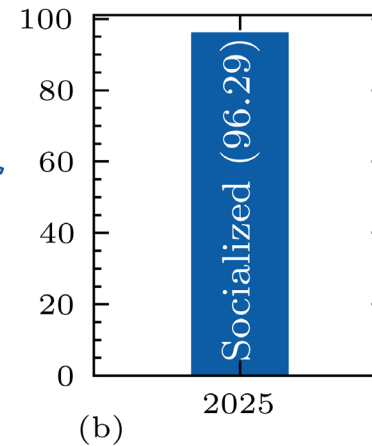
(d)



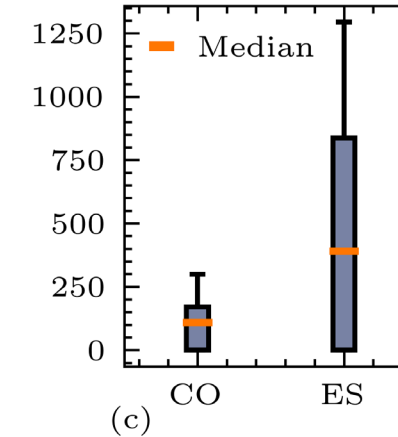
Connected LAUs to gas networks  
and socialized extra costs



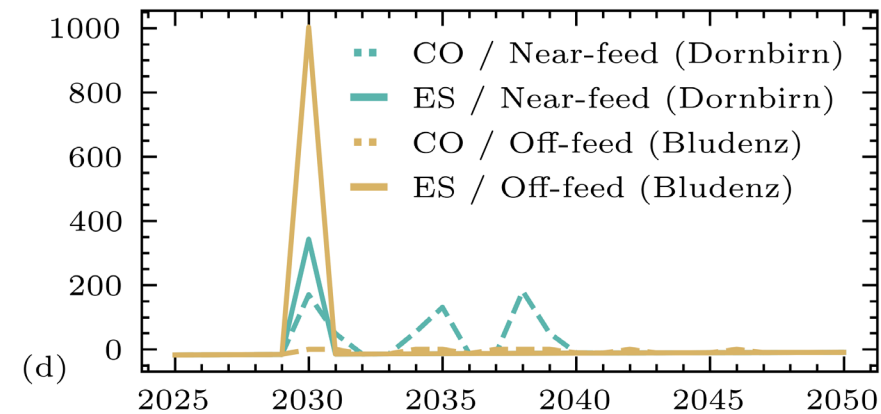
Extra costs  
in MEUR

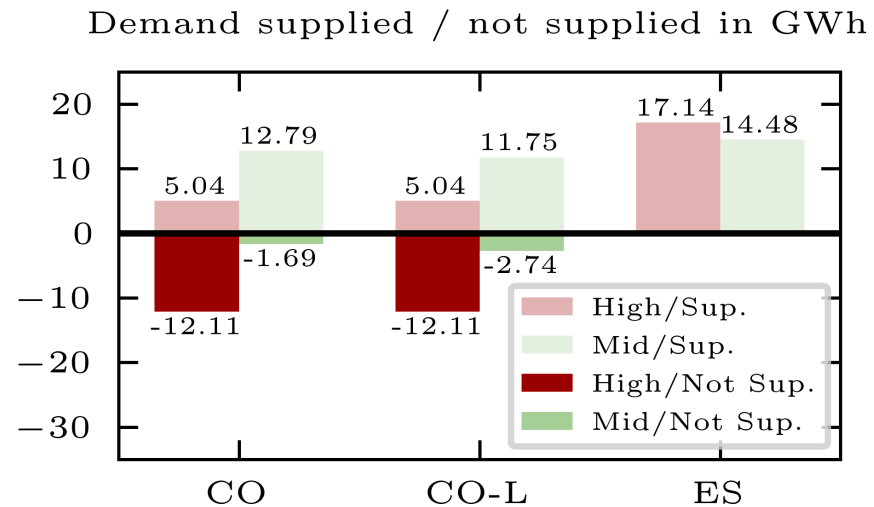
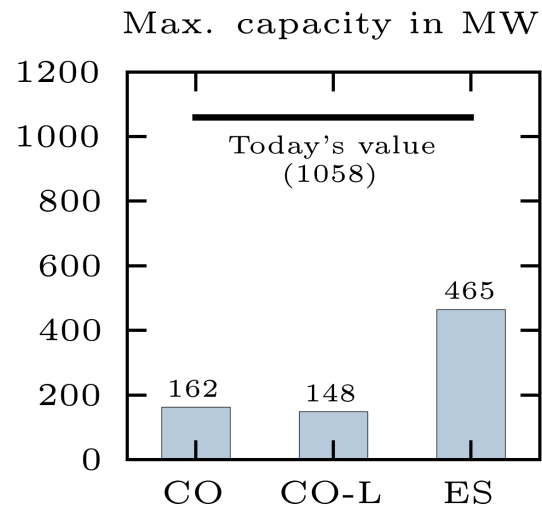
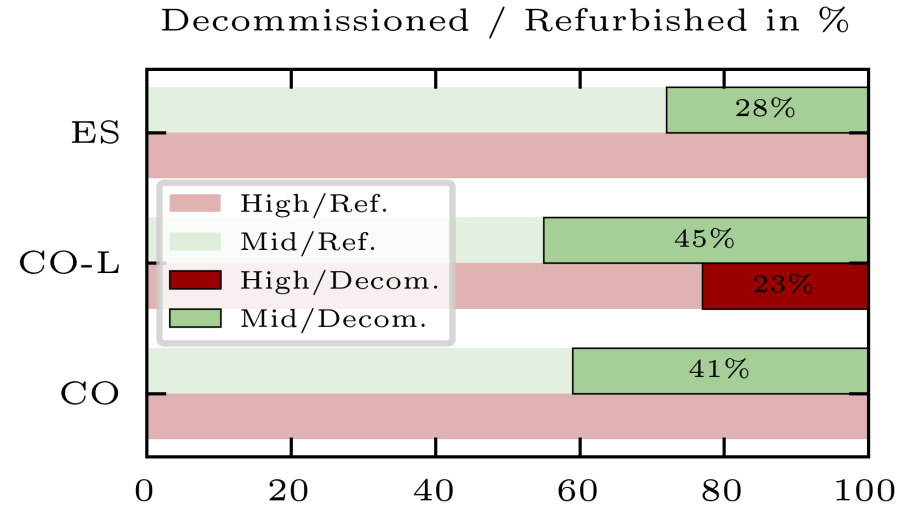
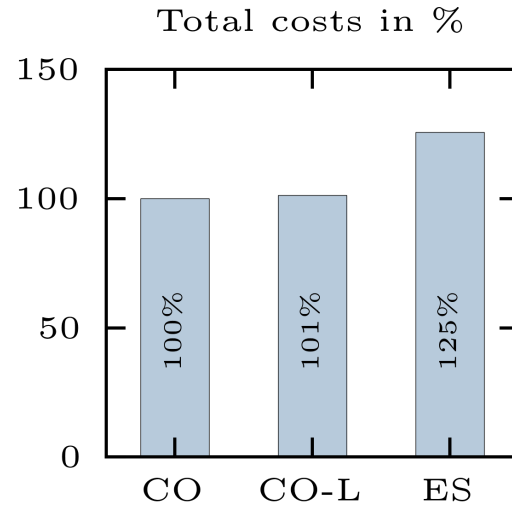


2030's shadow price  
in EUR/MWh



Shadow price in EUR/MWh





# Conclusions and recommendations

- In the future, **smaller gas networks** in both capacity and length will be necessary (regardless of secured supply) resulting from irreversible defossilization of energy services
- **Wide range of network design** between cost-optimal gas networks **w/ ensured supply** reveal crucial **trade-off** decisions for network operators in the future on how to deal with existing / available demands (i.e., decommissioning despite possible demands)
- Shadow prices of local gas balance constraints indicate that network operator should strike a **balance between cost-optimal gas network design w/ ensured supply** (e.g., flexibility and management of unexpected changes in (peak) gas demands)
- Increased network operator's **total costs** in case of ensured supply need to be **socialized** to a **few consumers** in the future (primarily at subordinate network / pressure levels)
- Influence of **socialized grid / network costs** on economic viability and **profitability** of **sustainable alternatives** substituting natural gas-based energy service needs and related trade-off decisions

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