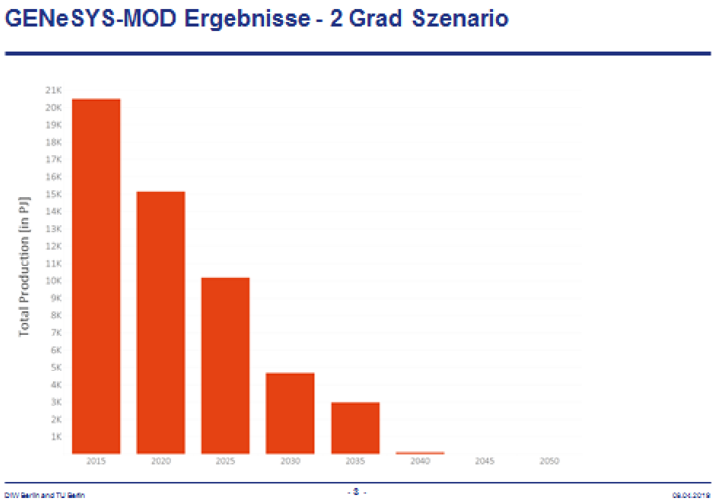
"Gotta get used to not living next door to natural gas" -

Or: Natural gas exit -

The next logical step of the European low-carbon energy transformation



Prof. Christian von Hirschhausen, co-authors, and swarm


"Never change a winning team" (?)
TU Berlin - WIP
Thorsten Beckers

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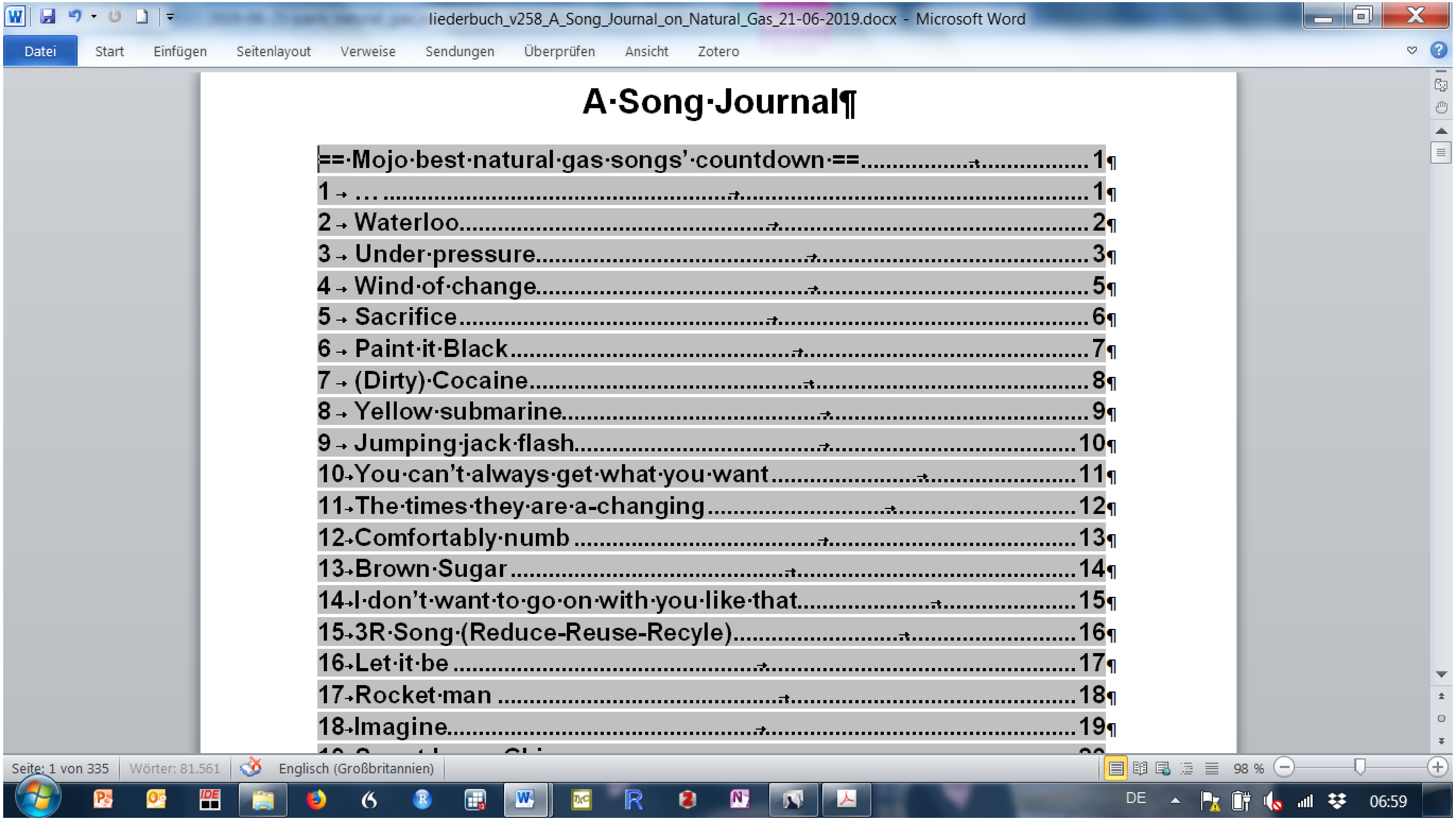


A Song Journal

Main messages / conclusions

1. Just like 24 years ago, from socialism to capitalist market economies (“Wind of Change“), we are witnessing a major transformation, of the energy system, the “Great Transformation“, in France, Germany, Europe, North America, South Asia, and, globally, with important implications on natural gas (“Imagine”)

2. Without un-economic nuclear power and without plausible carbon-dioxide removal technologies (CDR), natural gas has no place in a decarbonized European energy system (“Yesterday”)

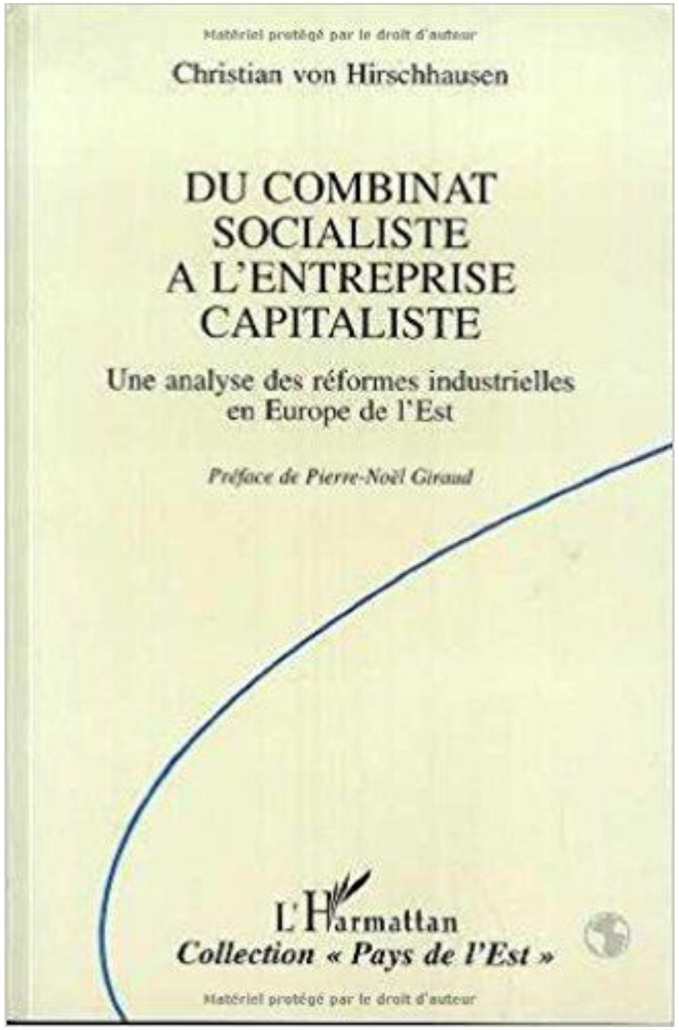
3. Investing in to new natural gas infrastructure is not necessary anymore and is most likely to lead to „stranded assets“, e.g. “North Stream 2“, LNG-import terminals, or natural gas power plants (“Waterloo”)

6. In the light of the European experience, trends in global and other regional and national gas markets may be re-visited, e.g. India and Bangladesh (“Under pressure”)

5. Suggest to change the narrative: From “bridge technology“ to “natural gas exit“ in Europe (and perhaps elsewhere, “Paint it black”)

1 24 years of living next door to natural gas: 1995 - 2019

1.1 Two major transformations …



Ch. 1: Introduction

Part I: The Origins of the „Energy Transformation“

- Ch. 2: German Energy and Climate Policies: An Historical Overview
- Ch. 3: The Transformation of the German Coal Sector from 1950 to 2017 – A Historical Overview

Part II: The Energy Transformation at Work in the Electricity Sector

- Ch. 4: Greenhouse Gas Emission Reductions and the Phasing-out of Coal in Germany
- Ch. 5: Nuclear power: Effects of plant closures on electricity markets and remaining challenges
- Ch. 6: Renewable energy sources as the cornerstone of the German energiewende
- Ch. 7: Energy efficiency: A key challenge of the energiewende
- Ch. 8: The role of electricity transmission infrastructure
- Ch. 9: Sector Coupling – A Techno-Economic Introduction and Application to Germany

Part III: The German Energywende in the Context of the European Low-carbon Tranformation

- Ch. 10: The European Context: Generation
- Ch. 11: The European Context: Infrastructure
- Ch. 12:Future International Coordination within Europe
- Ch. 13: Modeling the Low-Carbon Transformation in Europe - Developing Paths for the European Energy System until 2050

Ch. 14: Assessment, Perspectives, and Conclusions: 15 Theses

Source: von Hirschhausen et al. (2018)

1.2 … with major ramifications on natural gas

~ 1990s: restructuring and infrastructure access (Bill Hogan, Jeff Makholm)

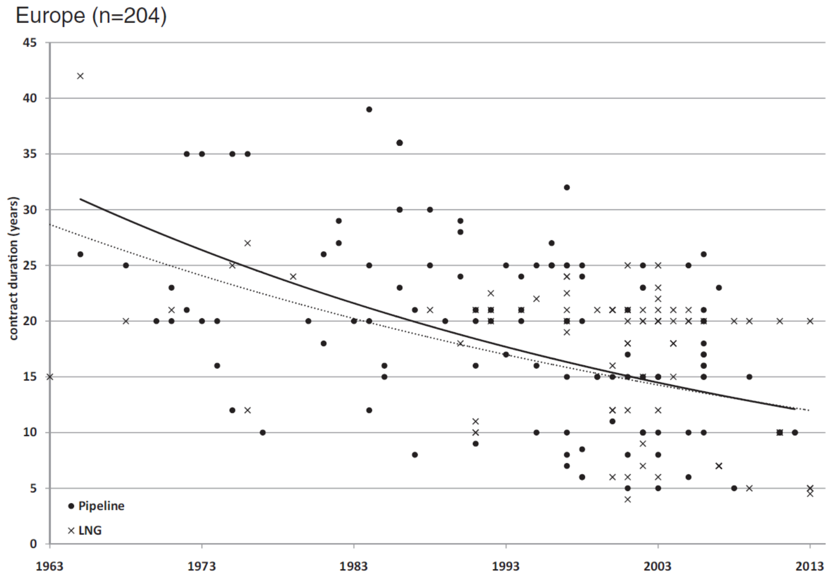
~ Succeeded in the US, still pending in the EU

~ Breaking up and change of nature of "long-term contracts"

Rev Ind Organ
DOI 10.1007/s11151-008-9165-0

Long-Term Contracts and Asset Specificity Revisited: An Empirical Analysis of Producer–Importer Relations in the Natural Gas Industry

Christian von Hirschhausen · Anne Neumann



(Hirschhausen and Neumann 2008; Hirschhausen, Neumann, and Ruester 2008; Neumann, Rüster, and Hirschhausen 2015)

~ 2000s: “Globalization of natural gas markets“ (Jim Jensen, etc.)

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Energy Economics 27 (2005) 603–615

Energy Economics

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International market integration for natural gas? A cointegration analysis of prices in Europe, North America and Japan

Boriss Siliverstovs[a], Guillaume L’Hégaret[b], Anne Neumann[c], Christian von Hirschhausen[a,c,*]

[a] *DIW Berlin, Germany*
[b] *Electricité de France, France*
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Received 4 December 2003; received in revised form 2 June 2004; accepted 8 March 2005

(Siliverstovs et al. 2005; Neumann 2009)

~ Organizational models for H_2 or “syngas“ open to research

~ 2007/2015: Climate considerations rising (“Paris“)

2 Natural gas in Europe (“Yesterday”)

2.1 Nuclear power not part of a low-carbon energy mix

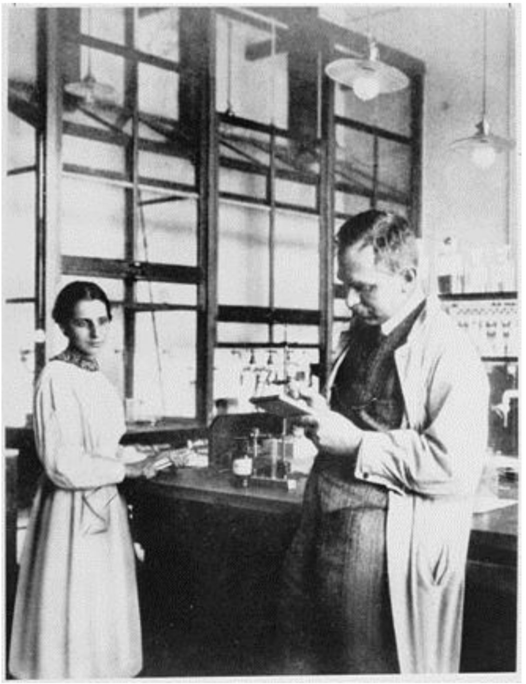
~ „Fille de la science et de la guerre“ (Lévêque 2014, 212)

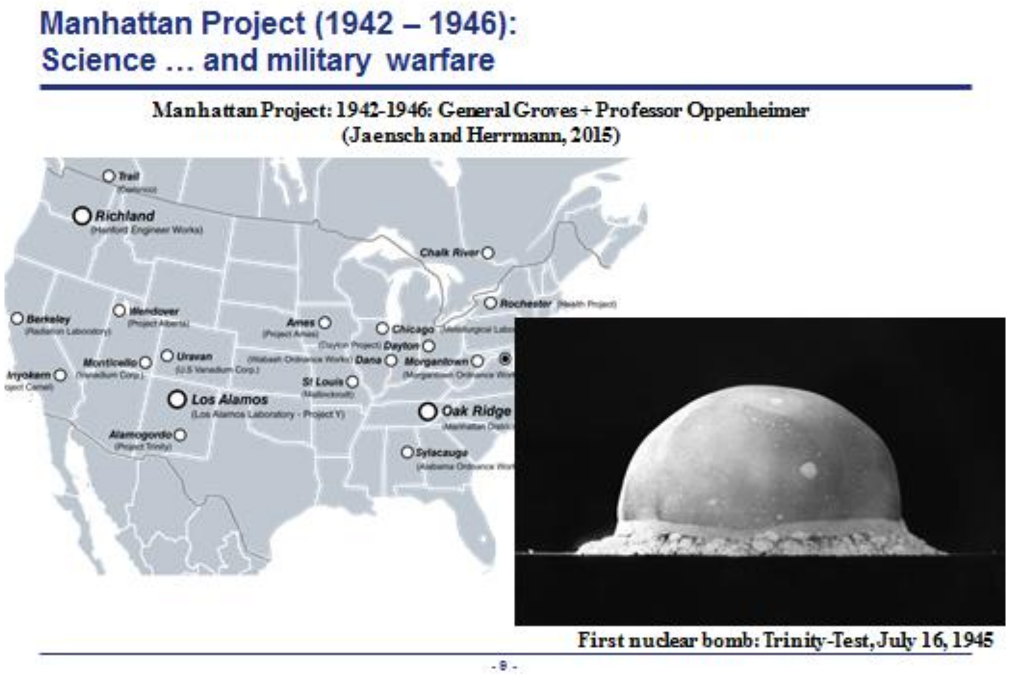
~ None of the 674 reactors has ever been constructed economically (Wealer et al. 2018)

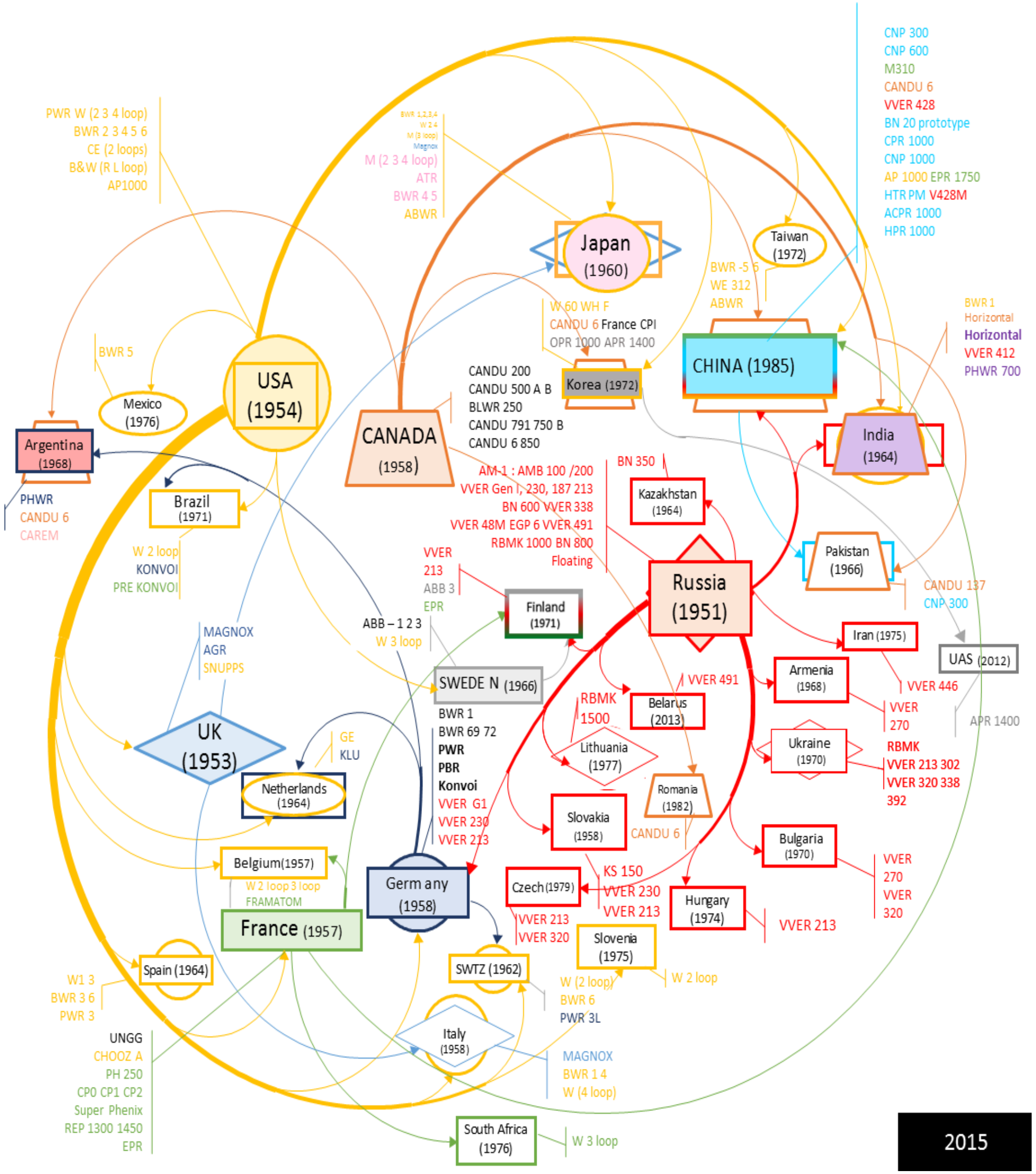
~ Current economic perspectives hopeless (Davis 2012, 201)

~ Critical issues of decommissioning and long-term storage of nuclear waste unresolved (Wealer 2018)

~ Only “Nuclear paradox“ can explain the European Reference scenarios (EC 2016; Löffler et al. 2018)







None of the 674 or so reactors analyzed in the text and documented in the appendix, has been developed based on what is generally considered “economic” grounds, i.e. the decision of private investors in the context of a market-based, competitive economic system. Given current technical and economic trends in the global energy industry, there is no reason to believe that this rule will be broken in the near- or longer-term future (Wealer et al. 2018).

Nobody has ever said nuclear power was economic (Hirschhausen 2017)

Table 3

Levelized Cost Comparison for Electricity Generation

	Levelized cost in cents per kWh		
Source	*Nuclear*	*Coal*	*Natural gas*
MIT (2009) baseline	8.7	6.5	6.7
Updated construction costs	10.4	7.0	6.9
Updated construction costs and fuel prices	10.5	7.4	5.2
With carbon tax of $25 per ton CO_2	10.5	9.6	6.2

Source: These calculations follow MIT (2009) except where indicated in the row headings.

Notes: All costs are reported in 2010 cents per kilowatt hour. Row 1 reports the base case estimates reported in MIT (2009), table 1. The cost estimates reported in row 2 incorporate updated construction cost estimates from U.S. Department of Energy (2010). Row 3, in addition, updates fuel prices to reflect the most recent available prices for uranium, coal, and natural gas reported in U.S. DOE (2011a). Finally, row 4 continues to incorporate updated construction costs and fuel prices and, in addition, adds a carbon tax of $25 per ton of carbon dioxide.

	Own caluclations: Levelized costs in €cents/kWh		
	Nuclear	Coal	Natural Gas
Baseline (2016)	12,1	5,1	5,0
CO_2-price: 25 €/t	12,1	6,3	5,7
CO_2-price: 100 €/t	12,1	10,0	7,9

2.2 Illusive (Bio-)CCTS, or “negative emissions“

How a “Low Carbon” Innovation Can Fail—Tales from a “Lost Decade” for Carbon Capture, Transport, and Sequestration (CCTS)

CHRISTIAN VON HIRSCHHAUSEN,[a] JOHANNES HEROLD,[a] and PAO-YU OEI[a]

Economics of Energy & Environmental Policy, Vol. 1, No. 2.

(Hirschhausen, Herold, and Oei 2012)

(Failed) CCTS projects in Europe

Project	Jänschwalde	Porto-Tolle	ROAD	Belchatow	Compostilla	Don Valley	Killingholm (C-GEN)	Longannet Project	Getica	ULCOS	Green Hydrogen
Country	DE	IT	NL	PL	ES	UK	UK	UK	RO	FR	NL
Plan in 2011	2015	2015	2015	2015	2015	2015	2015	2015	2015	2016	2016
Status in 2018	canceled 2011	canceled 2014	canceled 2017	canceled 2013	canceled 2013	canceled 2015	canceled 2015	canceled 2011	canceled 2014	canceled 2012	canceled 2012

	White Rose (UK Oxy)	Peel Energy	Peterhead	Teesside (Eston)	Eemshaven	Pegasus	Maritsa	Mongstad	Caledonia Clean Energy	Norway Full Chain CCS
Country	UK	UK	UK	UK	NL	NL	BG	NO	UK	NO
Plan in 2011	2016	2016	2016	2016	2017	2017	2020	2020	-	-
Status in 2018	canceled 2016	canceled 2012	canceled 2015	mid 2020s	canceled 2013	canceled 2013	canceled 2013	canceled 2013	2024	2022

Source: Based on Hirschhausen et al.(2018, 260).

24 unsuccessful years …

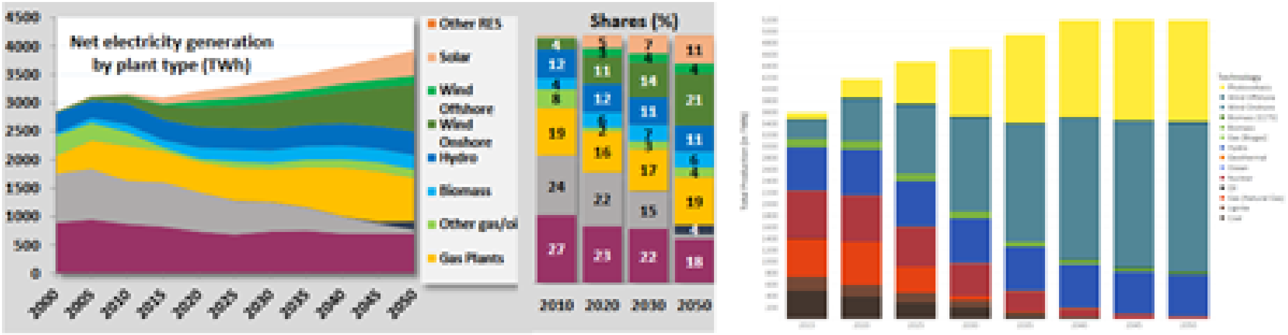
	Pre-2000 “clean coal“	2000-2010 “lost decade“ for CCTS	2010 - 2020 “lost decade” for BE-CCTS	2020 - … DACCTS + geoengineering
CDS/R	~ fossil fuel industry, coal dominant ~ IEA program “Clean Coal“	~ failed attempts ~ illusion of CCTS maintained (Hirschhausen, Herold, and Oei 2012)	~ emergence of BE-CCTS in climate scenarios (Fuss, Flachsland, et al. 2018) ~ but: if CCTS does not work, how can BECCTS?	~ Direct air capture: technically possible, but implausible at scale ~ Geoengieering: organizational model unclear
Energy system, renewables as alternatives	~ alternatives inexistent (e.g. low cost renewables)	~ emerging, but not @large scale	~ breakthrough of renewables, though facing political opposition	~ perhaps well-meaning coalition of climate modelers and engineers (Creutzig et al. 2019)

2.3 Contradictory European scenarios

(EC 2016; Löffler et al. 2018)

Comparison With the EU Reference Scenario 2016

EU Reference Scenario | **GENeSYS-MOD v2.0**

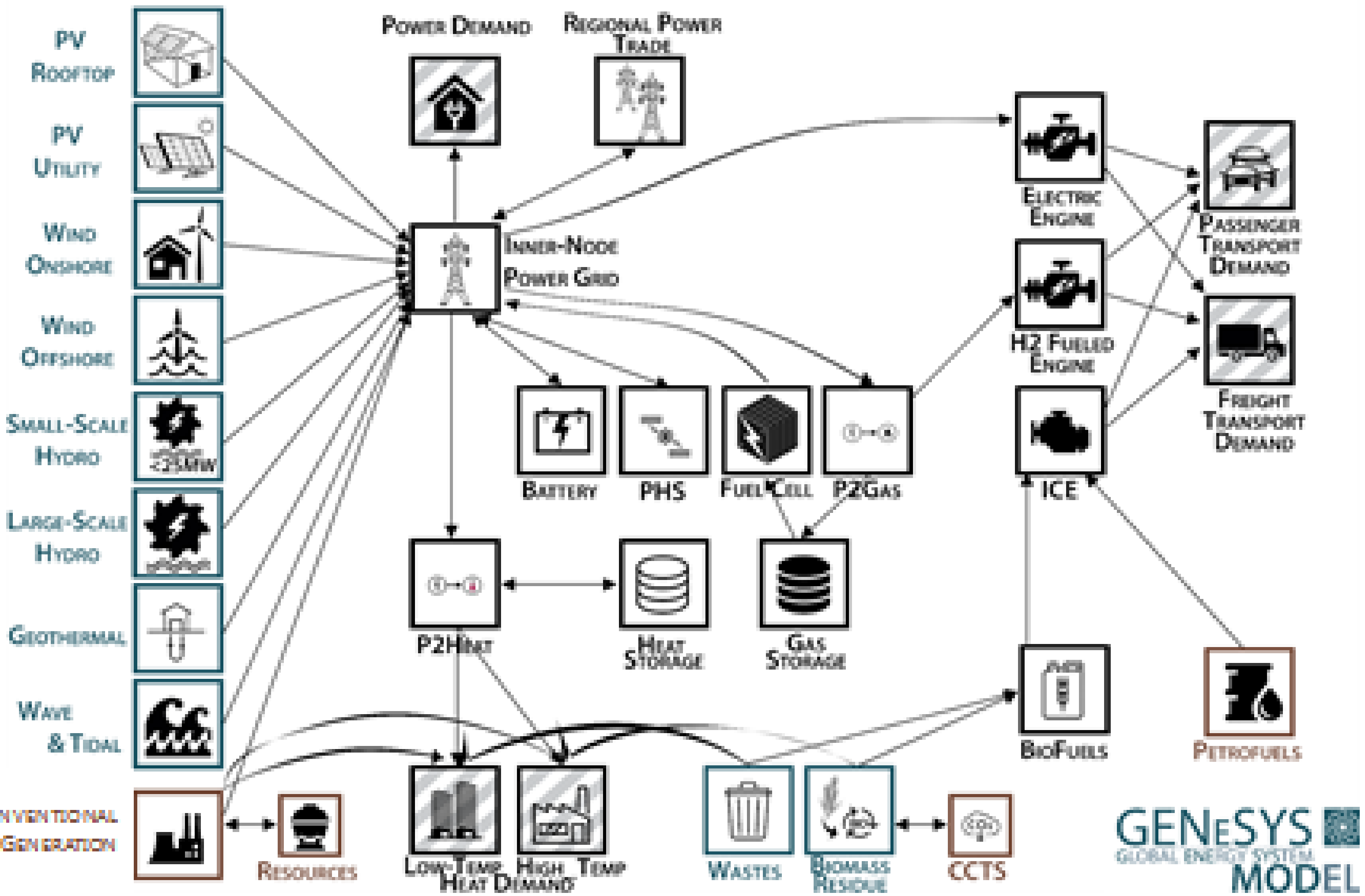


Source: European Commission (2016)

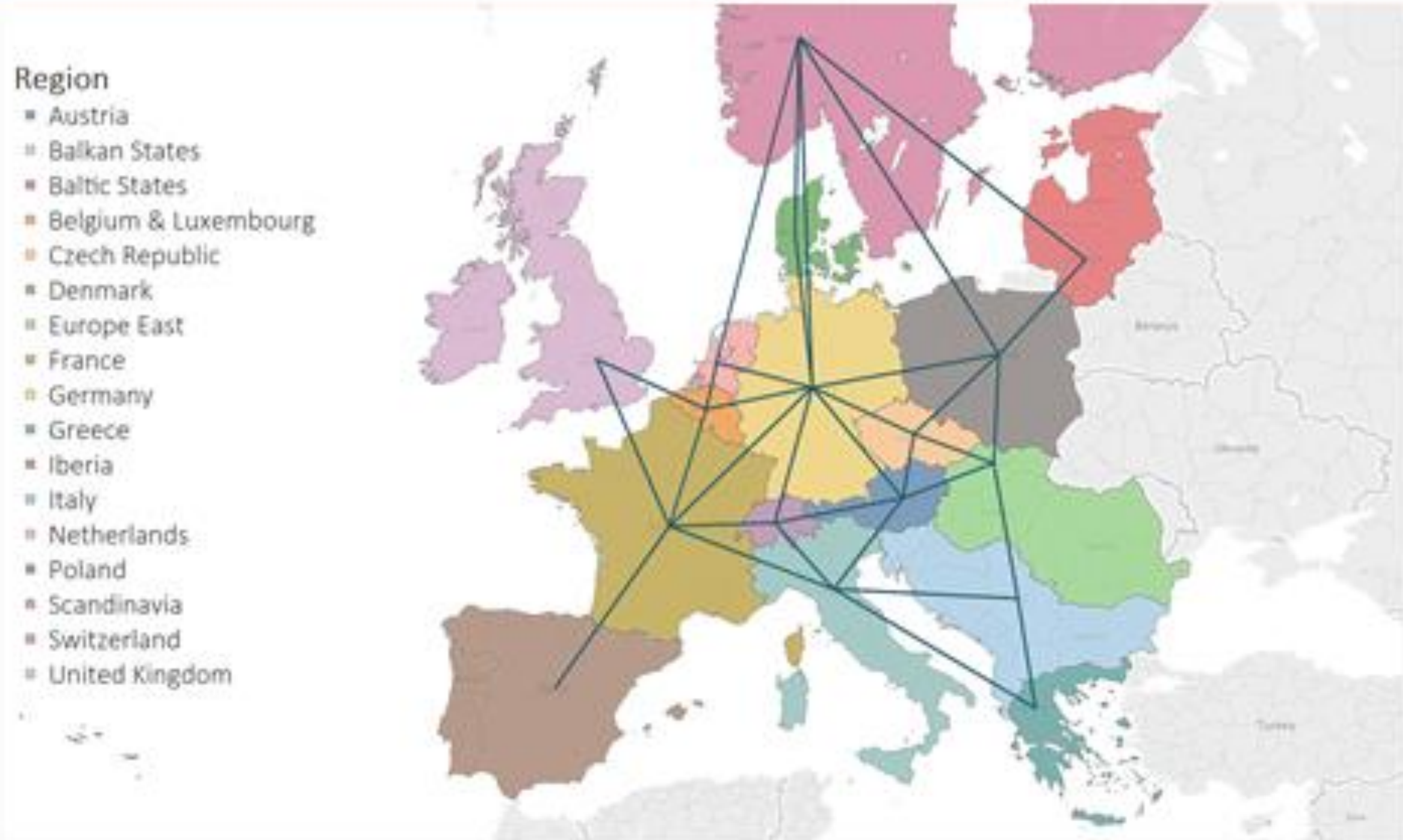
- Much higher shares of solar PV and Onshore Wind.
- Biomass, due to its limited potential, faces only small utilization in the power sector.
- Phase-out of coal and natural gas.
- No lifetime extension or capacity addition of nuclear power plants.
- Higher electricity demand due to sector coupling.

T. Burandt — - 32 - — Emission Pathways towards a Low-Carbon Energy System for Europe

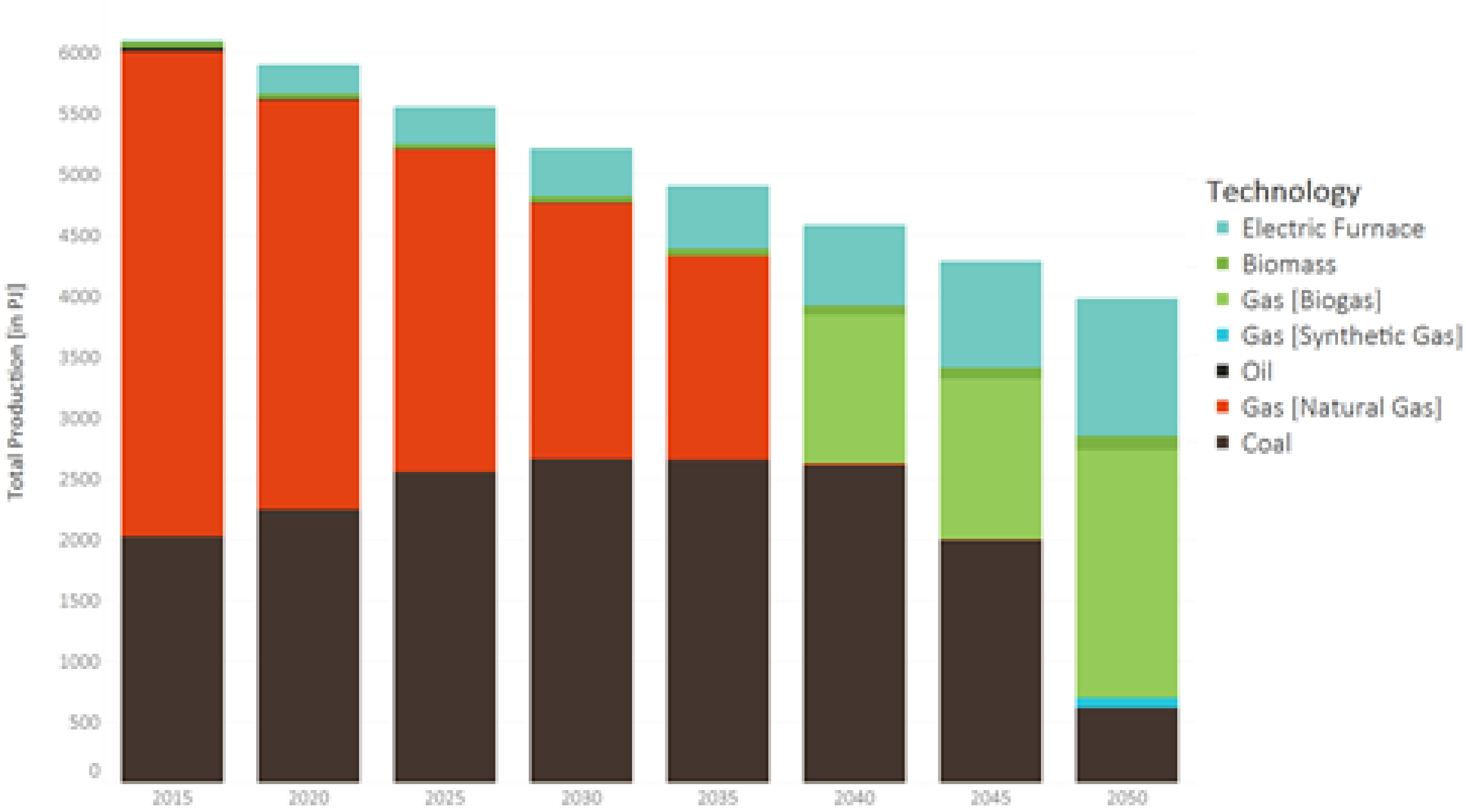
Model Design & Technologies



Model Setup: Spatial Resolution

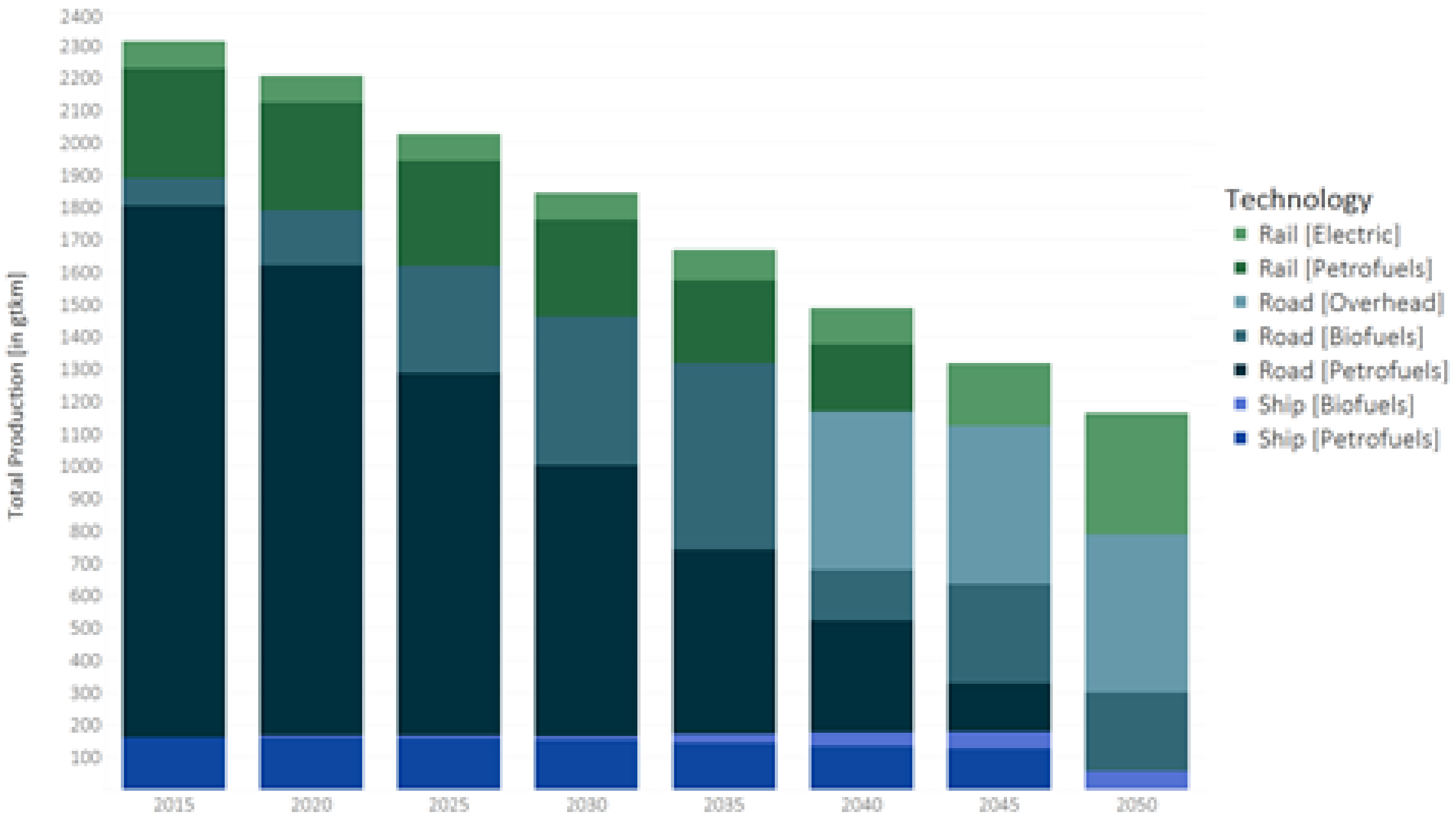


Development of High-Temperature Heat Generation



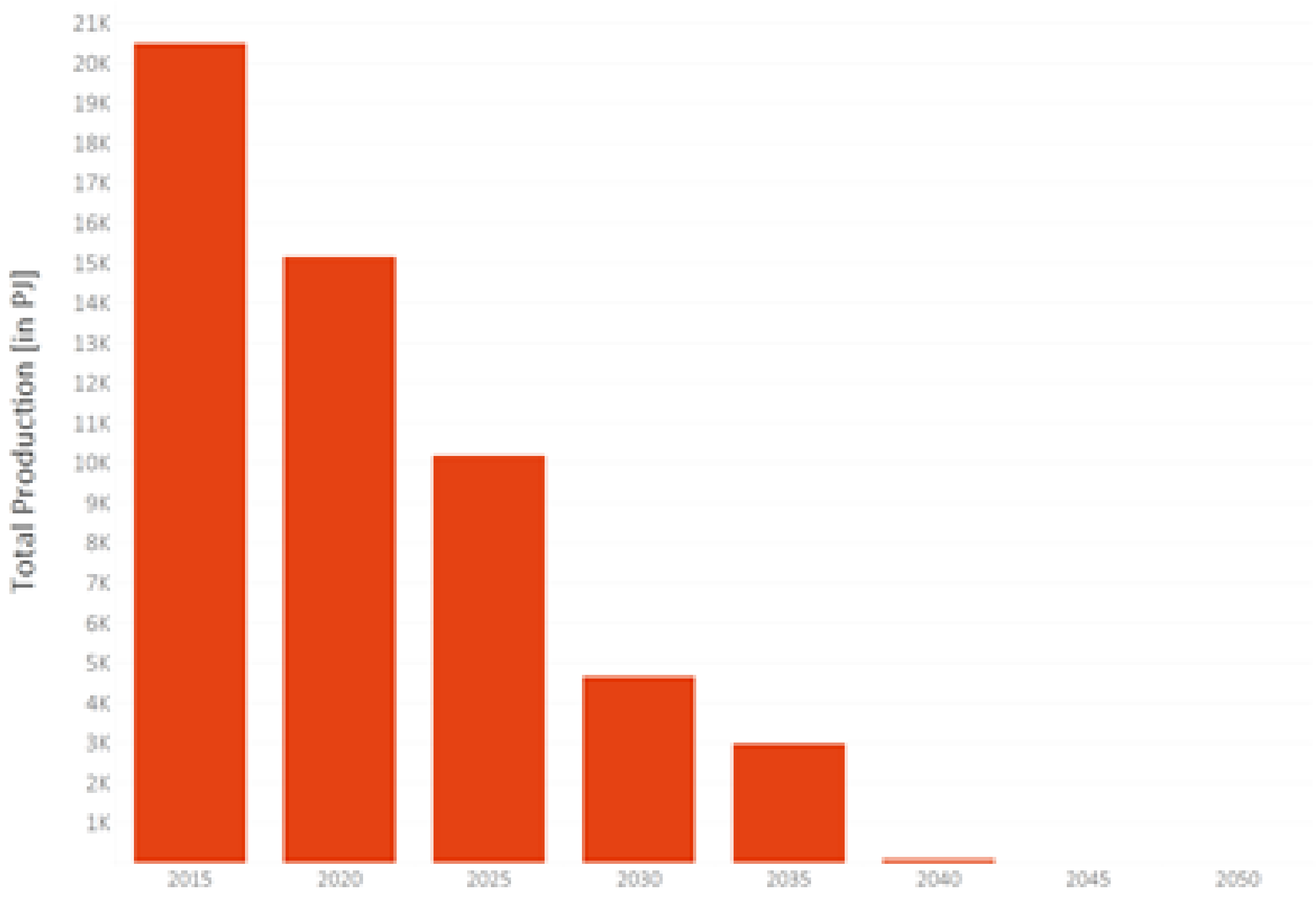
Source: Own Illustration

Development of Freight Transportation



Source: Own Illustration

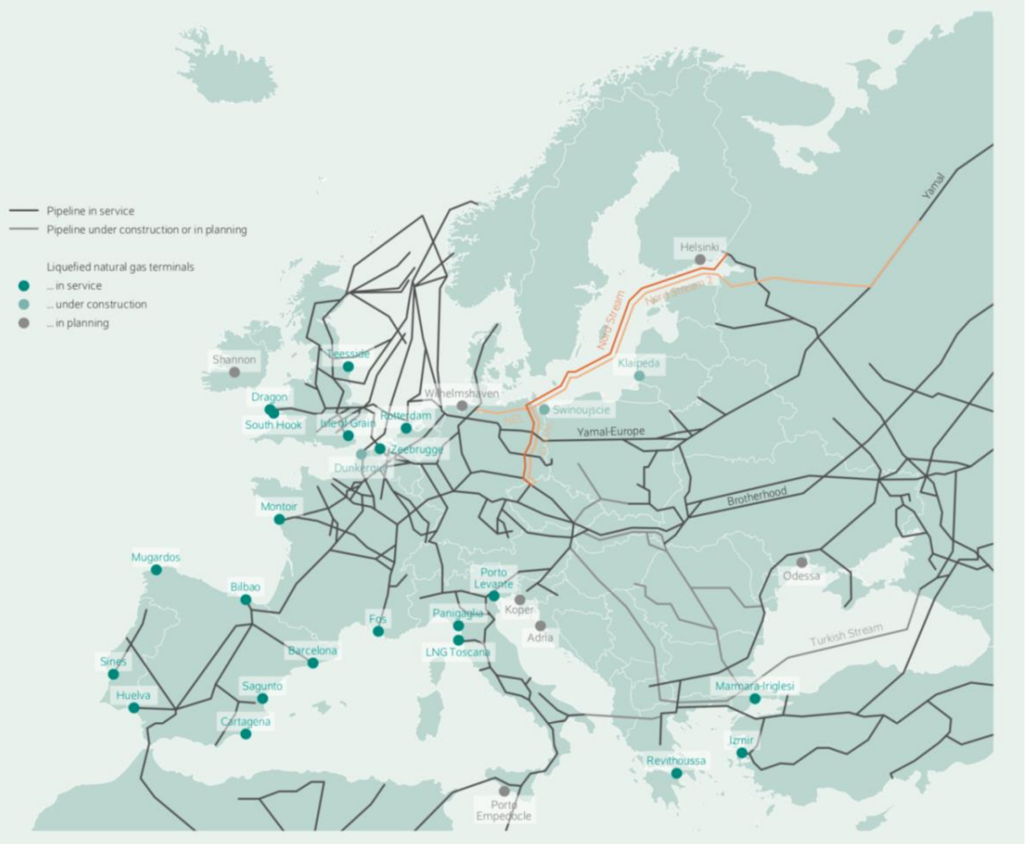
GENeSYS-MOD Ergebnisse - 2 Grad Szenario



3 “Stranded assets“ (“Waterloo”)

3.1 North Stream 2

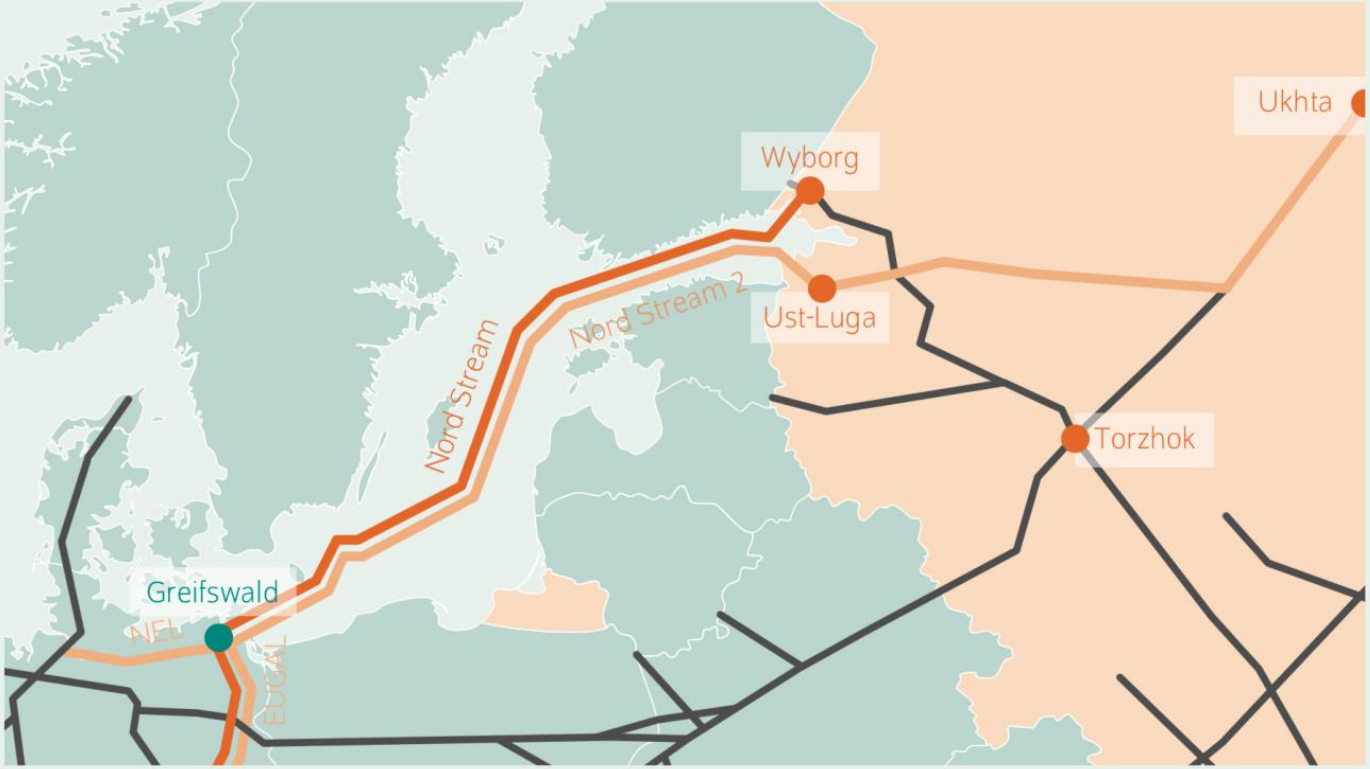
The European natural gas pipeline network



Source: Authors' own depiction based on Kai-Olaf Lang and Kirsten Westphal, "Nord Stream 2 – Versuch einer politischen und wirtschaftlichen Einordnung," SWP Studie S21 (2016); ENTSO-G, Capacity Map (2017).

The transmission pipeline network in Germany and Western Europe is well established.

The Nord Stream project



Source: Authors' own depiction.

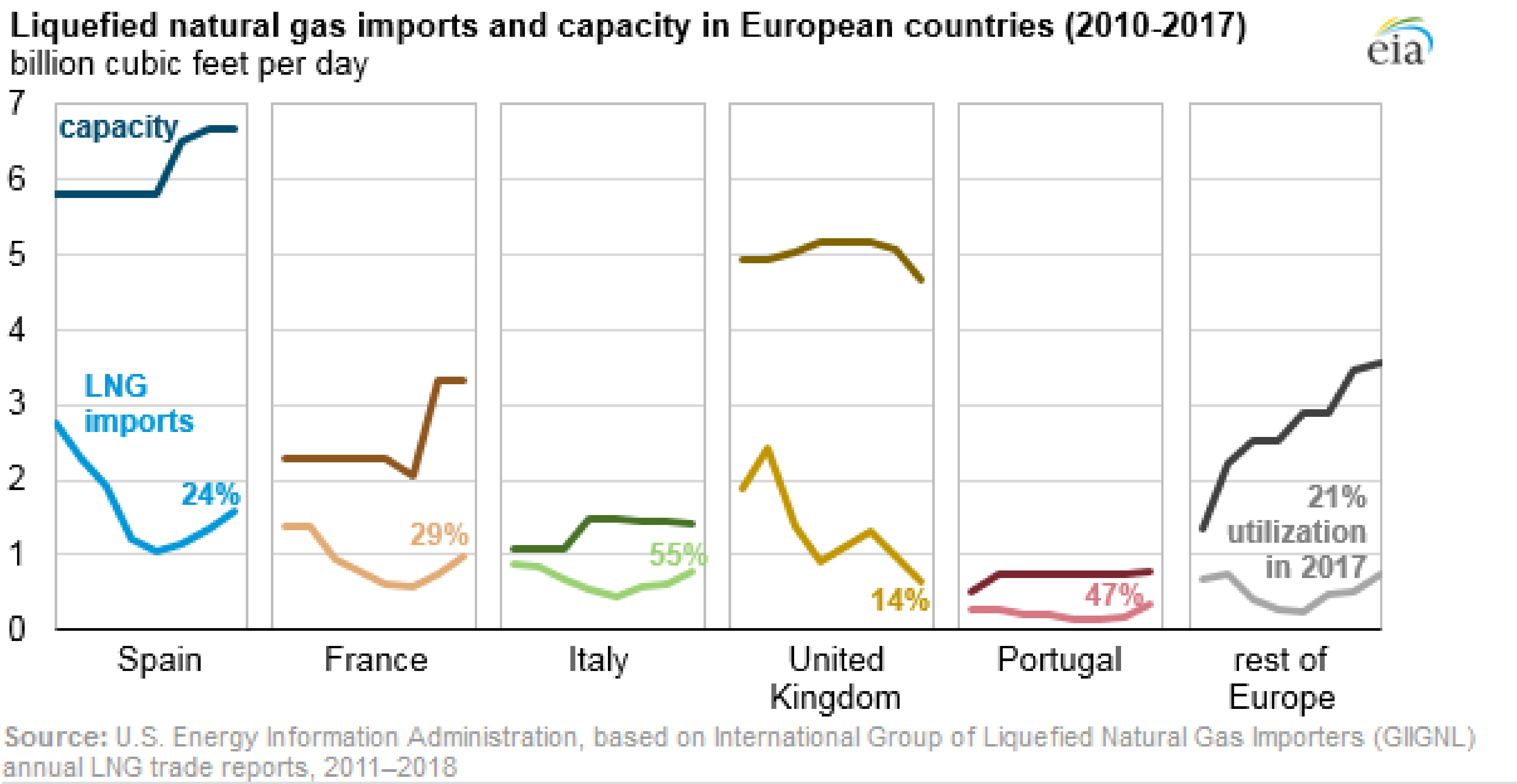
Additional connecting pipelines are required in addition to the offshore pipelines.

		Units
CAPEX	- 10.000.000.000	€
equity	30%	%
borrowing	70%	%
credit period	20	a
capacity	55	bcm
utilization	50%	%
equity interest	10%	%
borrowing interest	7%	%
Reale Auslastung	28	bcm
tax rate	0%	%
WACC	8%	%
annuity	1.010.954.412	€
annuity per bcm	36.761.979	€/bcm
conversation rate	11.500.000	bcm/MWh
necessary price spread	3,20	€/MWh

(Neumann et al. 2018)

3.2 LNG-terminals (in Germany) unlikely

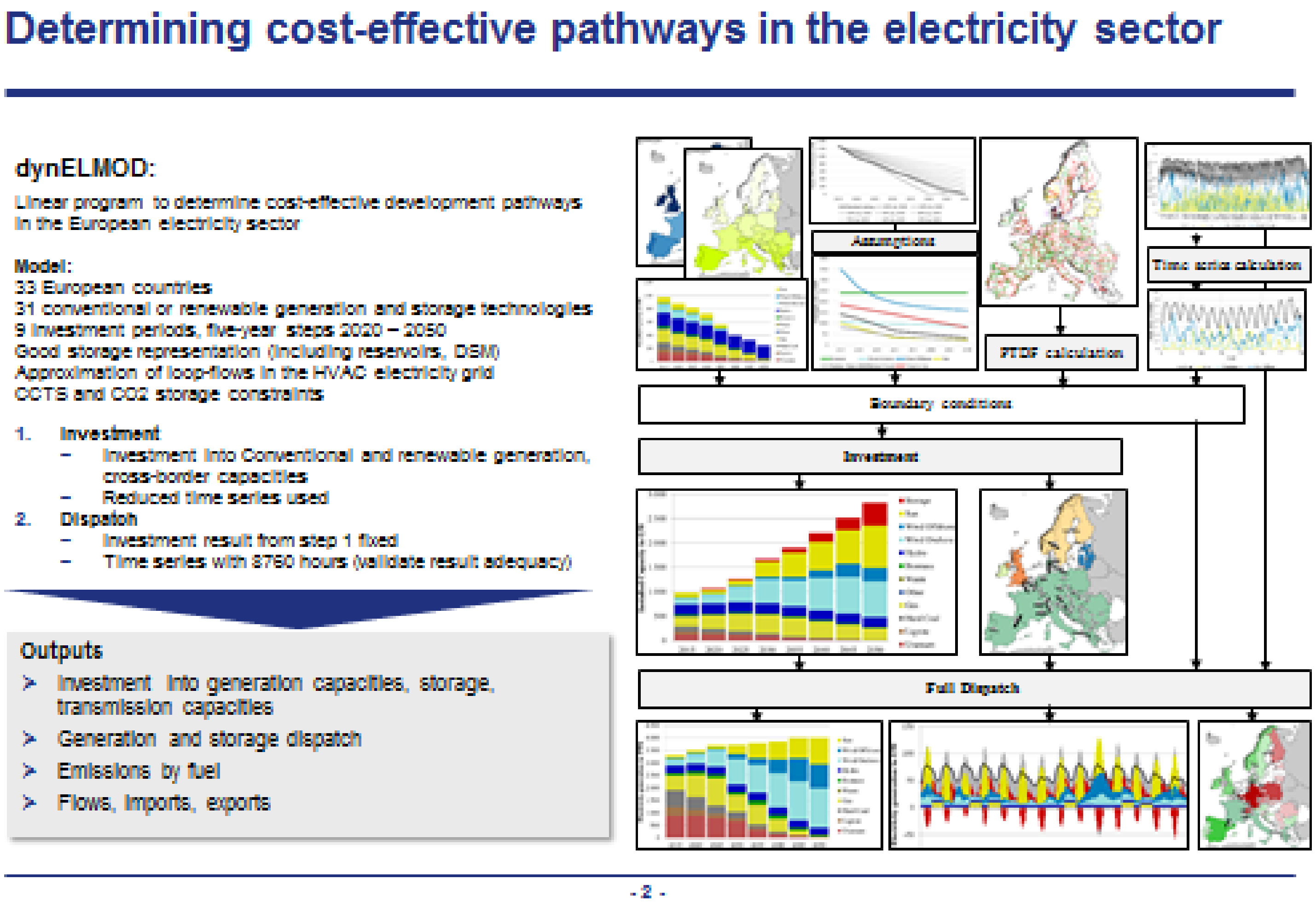
(Fitzgerald, Brauers, and Braunger 2018; Brauers et al. 2019)



Quelle: https://www.eia.gov/todayinenergy/detail.php?id=37354

3.3 Stranded investments in natural gas power plants

(Gerbaulet et al. 2019)



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European electricity sector decarbonization under different levels of foresight

C. Gerbaulet [a, b, *], C. von Hirschhausen [a, b], C. Kemfert [d, b, c], C. Lorenz [a, b, c], P.-Y. Oei [a, b]

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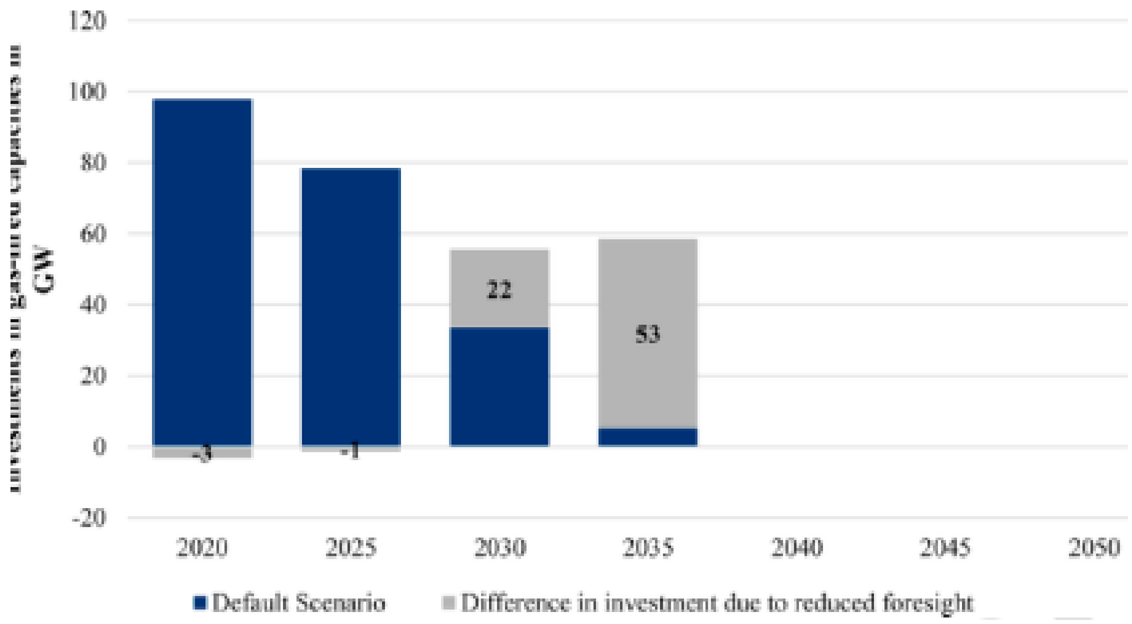


"The Great Transformation"
A (long) list of potential country studies

4 Re-visit e.g. India and Bangladesh ("Under pressure")

4.1 India: Coal or/and solar (+ Russian nuclear)

(Lawrenz et al. 2018)

Appendix B. India's Regional Electricity Production

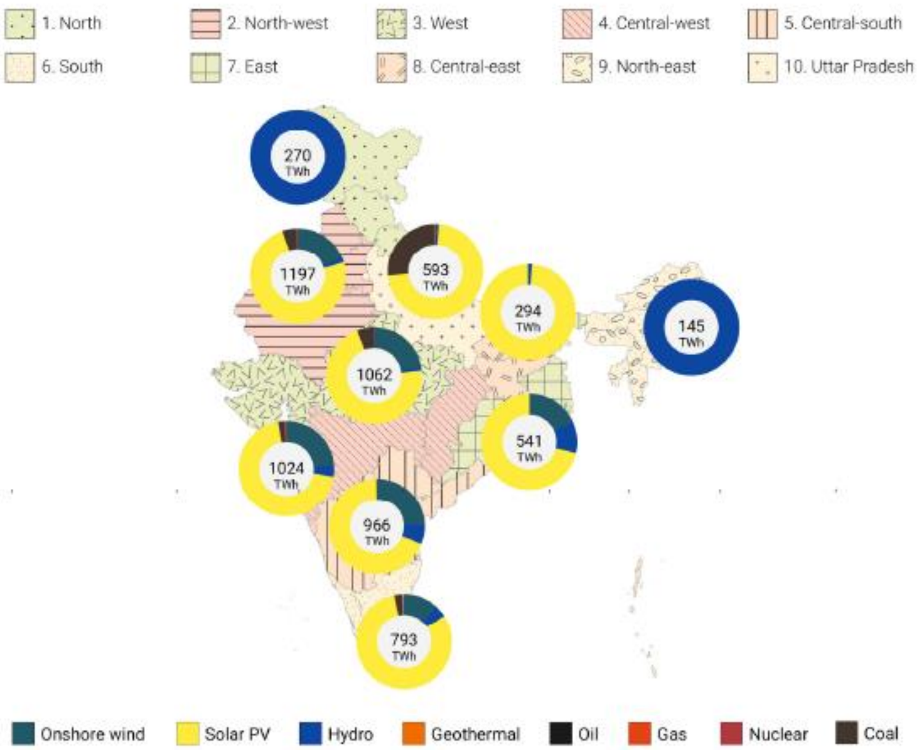


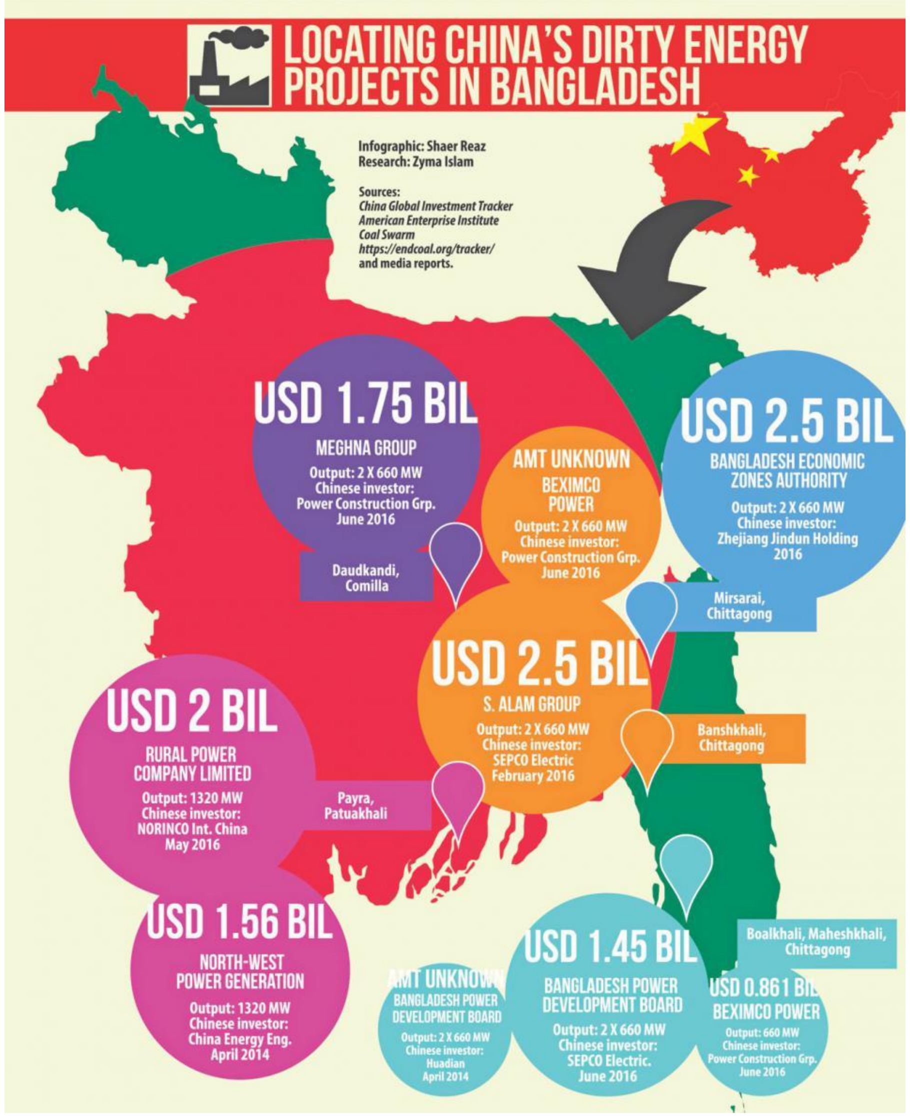
Figure A1. India's regional electricity production in the benchmark (LEO) scenario (2050).

energies
MDPI
Article

Exploring Energy Pathways for the Low-Carbon Transformation in India—A Model-Based Analysis

Linus Lawrenz [1], Bobby Xiong [1], Luise Lorenz [1], Alexandra Krumm [1], Hans Hosenfeld [1], Thorsten Burandt [1,2], Konstantin Löffler [1,2], Pao-Yu Oei [1,2,*] and Christian von Hirschhausen [1,2]

4.2 Bangladesh: Coal/and or solar (+ Russian nuclear)



5 Change the narrative

5.1 Natural gas is no longer a "bridge"

(Neumann and Hirschhausen 2015; Holz, Richter, and Egging 2015)

Natural Gas: An Overview of a Lower-Carbon Transformation Fuel

Anne Neumann* and Christian von Hirschhausen†

Introduction

Back in the 1970s, when natural gas was rapidly gaining market share in Western Europe and elsewhere, the energy industry, which was dominated by "big coal," argued that this energy source was too valuable to be burned for electricity generation. Later, in the 1990s, when security of energy supplies became an increasingly important issue in the industrialized world, concerns were raised again about the development of natural gas, in particular because of the political risks of depending on imports from producers in the Arab Gulf, Russia, and Latin America. Yet, despite being viewed as a marginal fuel in the past, we appear to be in a new "golden age" for natural gas (IEA 2011)—because it is cleaner than coal and more flexible than oil in power generation; it can serve as a back up to renewables; and, given the development of shale gas in the United States, it appears to offer accessible and almost unlimited reserves.

Until the 1980s, natural gas was highly regulated worldwide, in terms of both prices and infrastructure. In the 1980s, research on natural gas focused on trading patterns between three distinct regions: North America, Europe, Asia (see MIT 1986); in the 1990s, the emphasis was

A Global Perspective on the Future of Natural Gas: Resources, Trade, and Climate Constraints

Franziska Holz*, Philipp M. Richter*, and Ruud Egging†

Introduction

Natural gas has the potential to facilitate the transition to a low-carbon energy system and society. Its combustion leads to fewer CO_2 emissions per generated energy unit than coal and oil.[1] Moreover, natural gas can be used to improve the reliability of electricity systems that rely on intermittent renewable resources because gas-fired power plants can be ramped up quickly and provide flexible generation schedules. Nevertheless, the role of natural gas in a future climate-constrained world remains uncertain because, in the absence of widespread use of Carbon Capture and Storage (CCS), its combustion causes substantial CO_2 emissions. In fact, in 2010, worldwide natural gas consumption induced more than 6 gigatons (Gt) of CO_2 emissions, 20 percent of all energy-related CO_2 emissions (IEA 2013a).

Thus far, only the European Union (EU) has started to develop decarbonization scenarios for its economy and energy sectors that extend to 2050 (EC 2011a, 2011b, 2013). Although

~ Previous "bridge technologies":

~ Before yesterday: Nuclear power (Ackermann, Bierhoff, and et al. 2010)

~ „"Yesterday": Lignite (Debriv Bundesverband Braunkohle 2012)

~ Today: Natural gas (Zukunft Erdgas e.V., 2018)

5.2 Change the narrative ("Paint it black!")

"Old" narrative of the NG industry e.g. Stern (2019)	**New narratives for the low-carbon energy transformation** (Fitzgerald, Brauers, and Braunger 2018; Brauers et al. 2019)
~ "decarbonization" of NG	~ "Natural gas exit"
~ Large-scale technical solutions to keep on existing natural gas infrastructures occupied, e.g. CH4-reforming, hydrogen, biogas/-methane, synthetic natural gas (SNG) etc.	~ Large share of renewable energies
~ CO2 separation as success factor („CCTS")	~ Suite of failed projects: CCTS (Hirschhausen, Herold, and Oei 2012), dann BE-CCCTS (Fuss, Lamb, et al. 2018), now DACTS? (Creutzig et al. 2019)
~ Global structural change, international trade, etc. ("Desertech+")	~ Decentral, policentric approaches (graduate school "Energiewende Repowered", 2019)

6 “Gotta get used to not living next door to … natural gas”

1. Just like 24 years ago, from socialism to capitalist market economies (“Wind of Change“), we are witnessing a major transformation, of the energy system, the “Great Transformation“, in France, Germany, Europe, North America, South Asia, and, globally, with important implications on natural gas (“Imagine”)

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