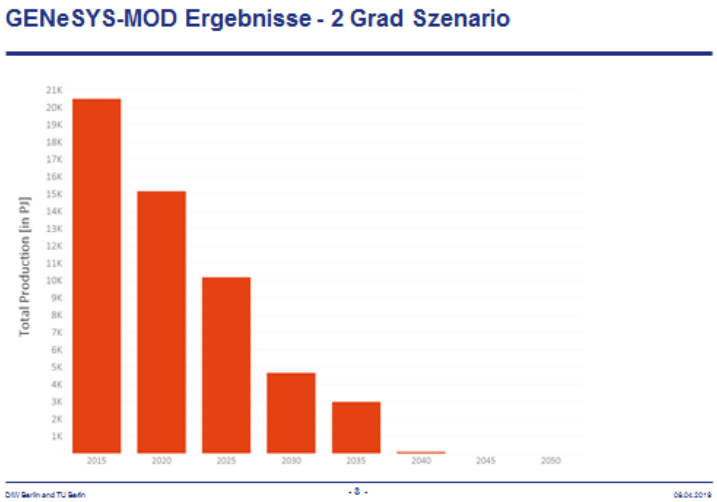
Natural gas exit -

The next logical step of the European "no-carbon-no-nuclear" energy transformation



Christian von Hirschhausen, Fabian Präger, co-authors, and swarm

1 Transformation of natural gas: 1995 - 2019

1.1 Two major transformations: Liberalization and no-carbon transformation

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

Christian von Hirschhausen · Anne Neumann

1.2 The "Great Transformation" and the 5 Ds

~ No-carbon-no-nuclear energy transformation is not a gradual change of the energy mix, from more fossil-fuel based to more renewables-based systems

~ profound changes of the technical, societal, and the economic structure of the system

Decarbonization: Means: no more emissions from 2040 onwards if the EU wants to make a sufficient contribution to Paris Agreement

Disruption: Suggests, that the traditional utility business model is under threat by disruptive technologies, leading to new corporate and market structures. Restructuring of the industry, from infrastructure monopolies to competitive markets (decentralization, prosumage, municipal companies…)

Digitization: Less advantages of traditional vertical integration due to the spreading of digital devices and information, allowing lower transaction costs.

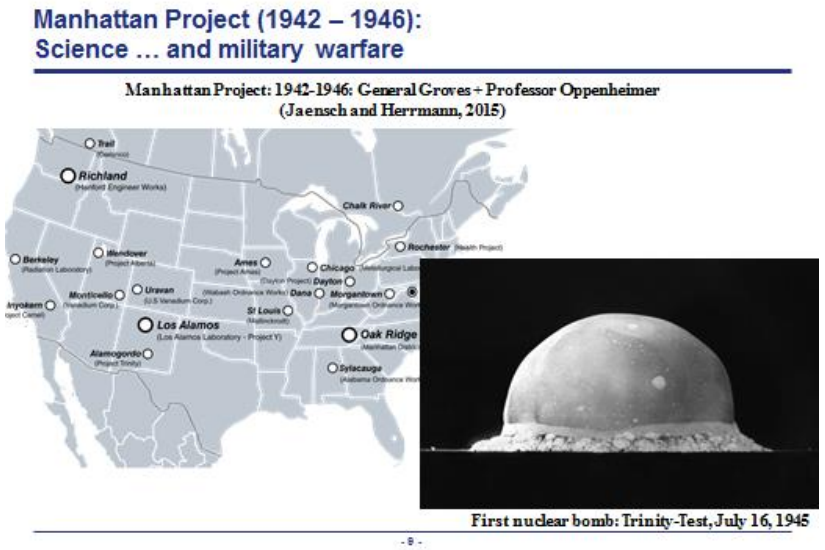
Decentralization: From being highly centralized, energy can become a very decentral activity, the extreme case being self-provision with "prosumage" (production - consumption – storage

Democratization: The cheap access of decentral generation units to energy and self-determination, private choice of energy fuel and technology, and new control structures for energy at large

2 Natural gas in Europe - The EU Reference Scenarios and the nuclear power and CCTS paradoxes

2.1 The nuclear power paradox

~ Nuclear power is no option for the future energy system



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

~ Hopes in a technology that is neither technically nor economically available

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 …

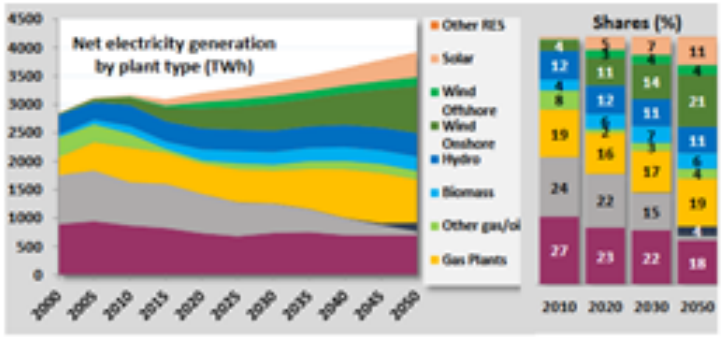
	Pre-2000 “clean coal“	2000-2010 “lost decade“ for CCTS	2010 - 2020 “lost decade” for BE-CCTS	2020 - … DACCTS + geoengineering
CDS/R	~ fossil fuel industry, coal dominant ~ IEA program “Clean Coal“	~ failed attempts ~ illusion of CCTS maintained (Hirschhausen, Herold, and Oei 2012)	~ emergence of BE-CCTS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

2.3 Energy system model results: Gas exit as the reference scenario

(EC 2016; Löffler et al. 2018)

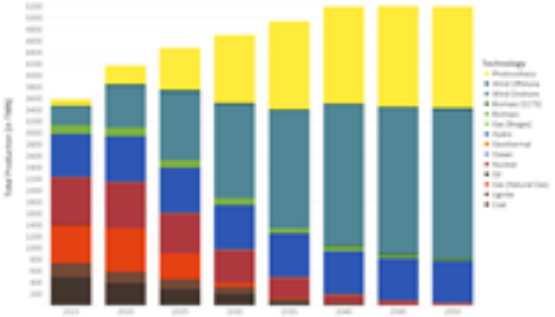
Comparison With the EU Reference Scenario 2016

EU Reference Scenario



Source: European Commission (2016)

GENeSYS-MOD v2.0



- 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.

Technically correct, politically disastrous

~ Reference Scenario is based on the sovereignty of member states and tries to emulate national priorities as far as possible
~ Until today, nobody outside the modelling team itself can trace the results of the triade of EU Reference Scenarios (fossil fuels - nuclear - renewables)

No-carbon-no-nuclear transformation for the EU

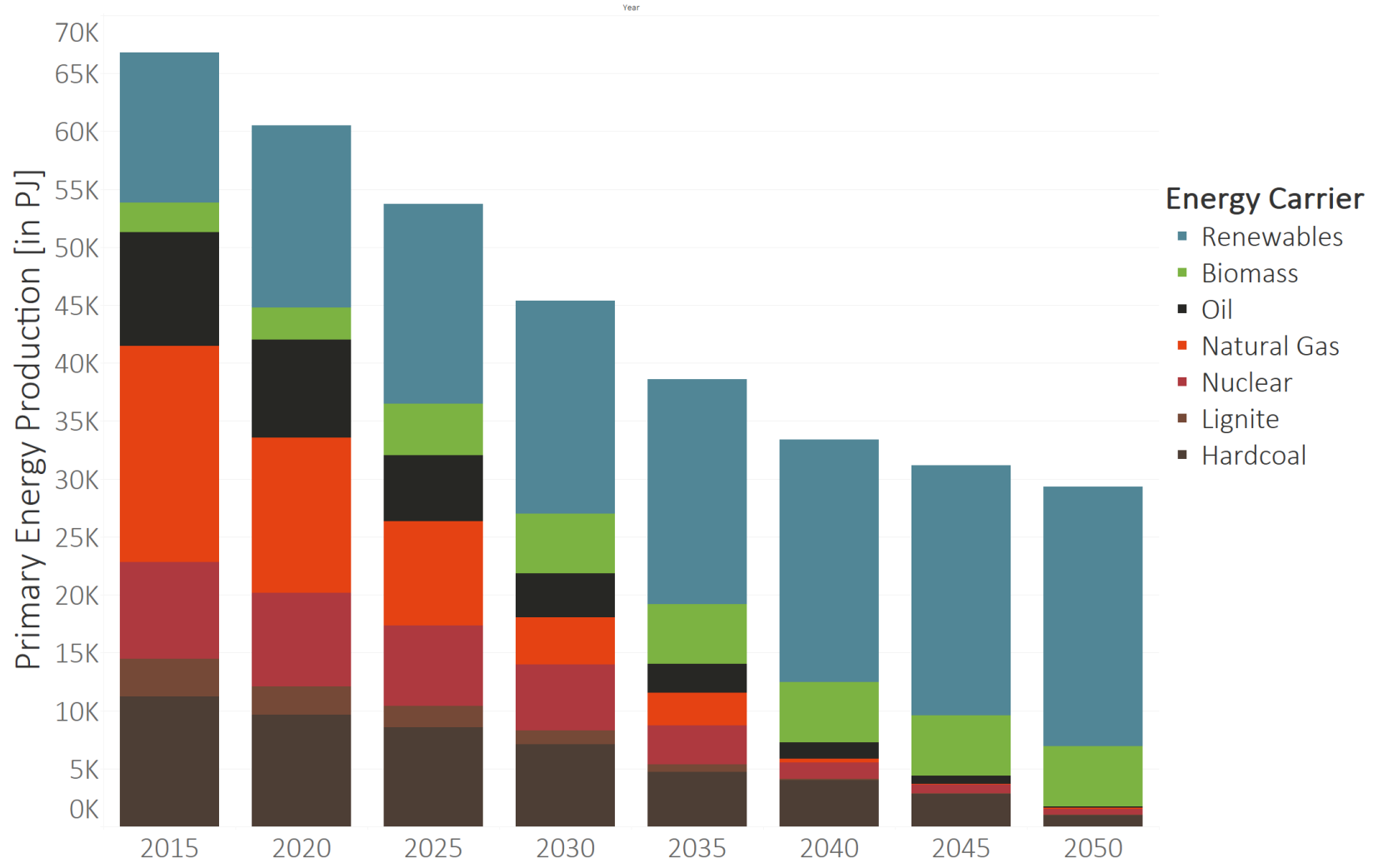
~ Assuming a no-carbon future is equivalent to exiting not only from fossil coal, but also from fossil gas and fossil oil.

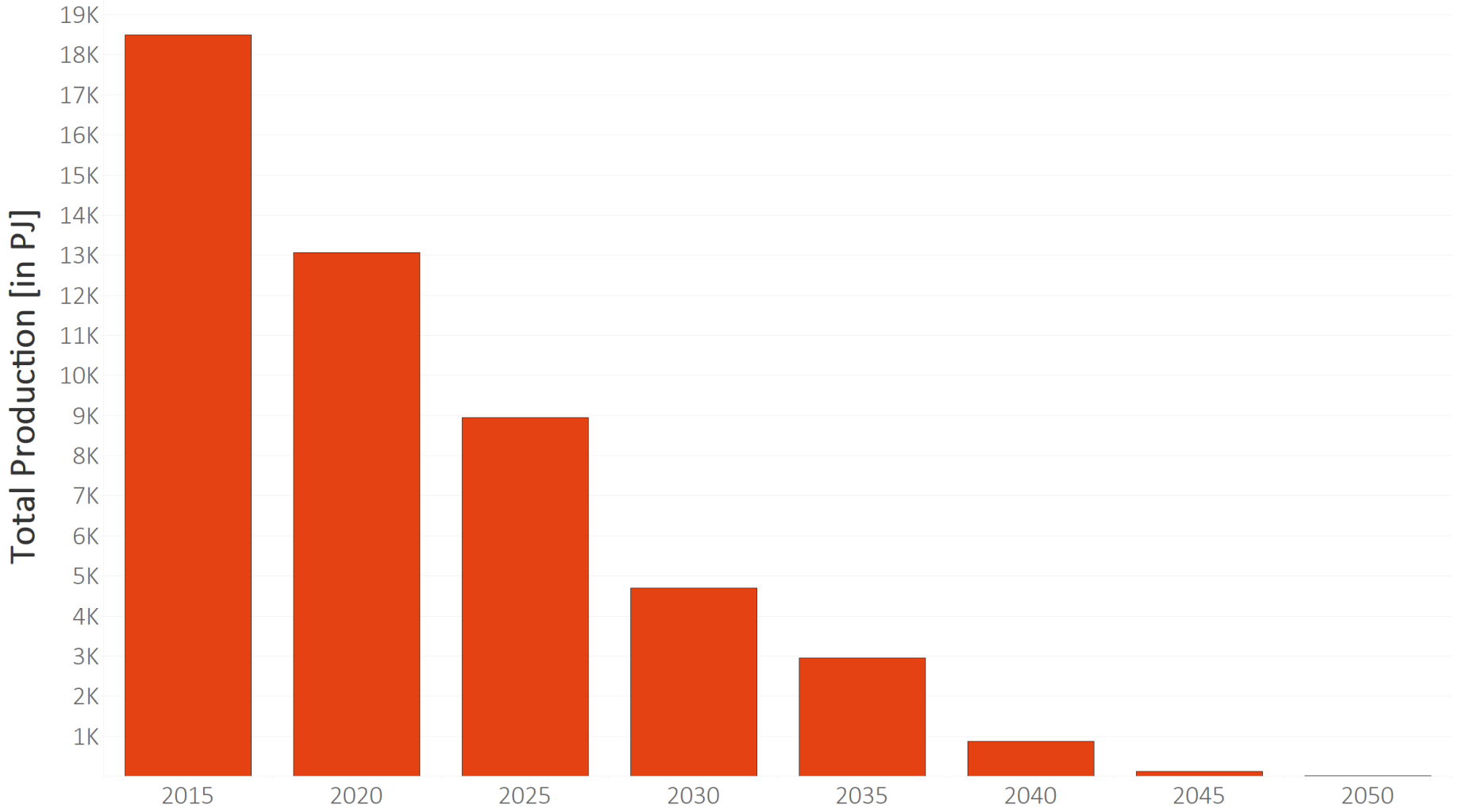
No modeling is needed to understand this, and the only open question is when the natural gas exit (and the other fossil fuel exits) would occur

Energy system models can provide insights (more than numbers) into the dynamics of decarbonization, by allowing scenario analysis, and by comparing results with other models using other assumption

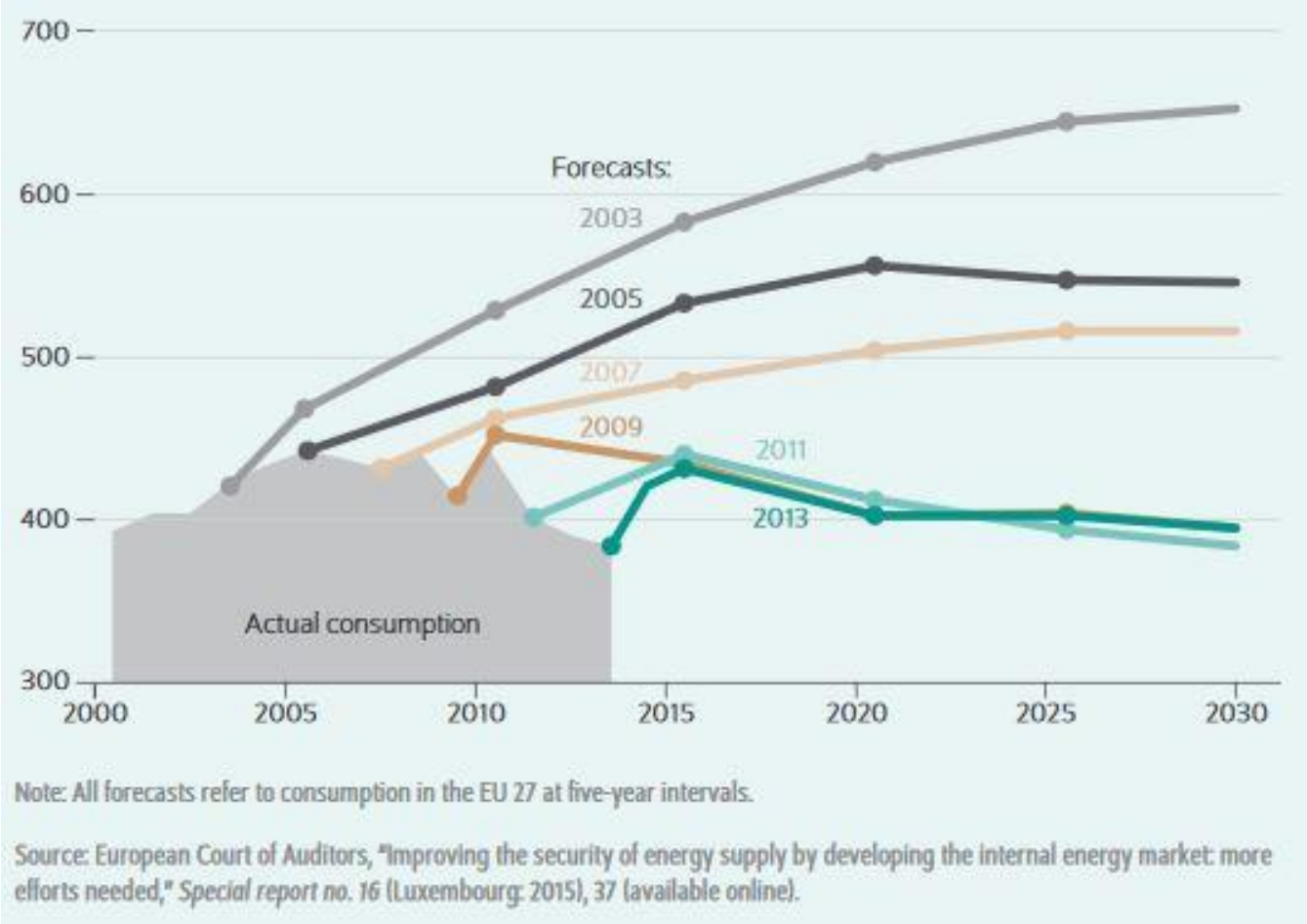
~ comprehensive linear optimization model determining lowest-cost energy mixes provided under some pre-determined constraints
~ Global Energy System Model (GENeSYS-MOD) is a top-down energy system model developed recently for scenario analysis
~ The model seeks to meet demands (exogenous) through a combination of technologies and trade between the different regions (17 nodes)

Primary Energy in Europe in 2°C scenario




Total Production [in PJ]
19K
18K
17K
16K
15K
14K
13K
12K
11K
10K
9K
8K
7K
6K
5K
4K
3K
2K
1K
2015
2020
2025
2030
2035
2040
2045
2050

Natural gas consumption in the EU 27 and the commission's EU reference forecasts 2000 – 2013 (in Mio.t of crude oil equivalents)



(Neumann et al. 2018)

3 The renaissance of natural gas as a “bridge fuel” – but methane can’t decarbonize

3.1 Narrative was developed by Jonathan Stern and is set by fossil fuel actors

~ devised and established by Jonathan Stern in 2017

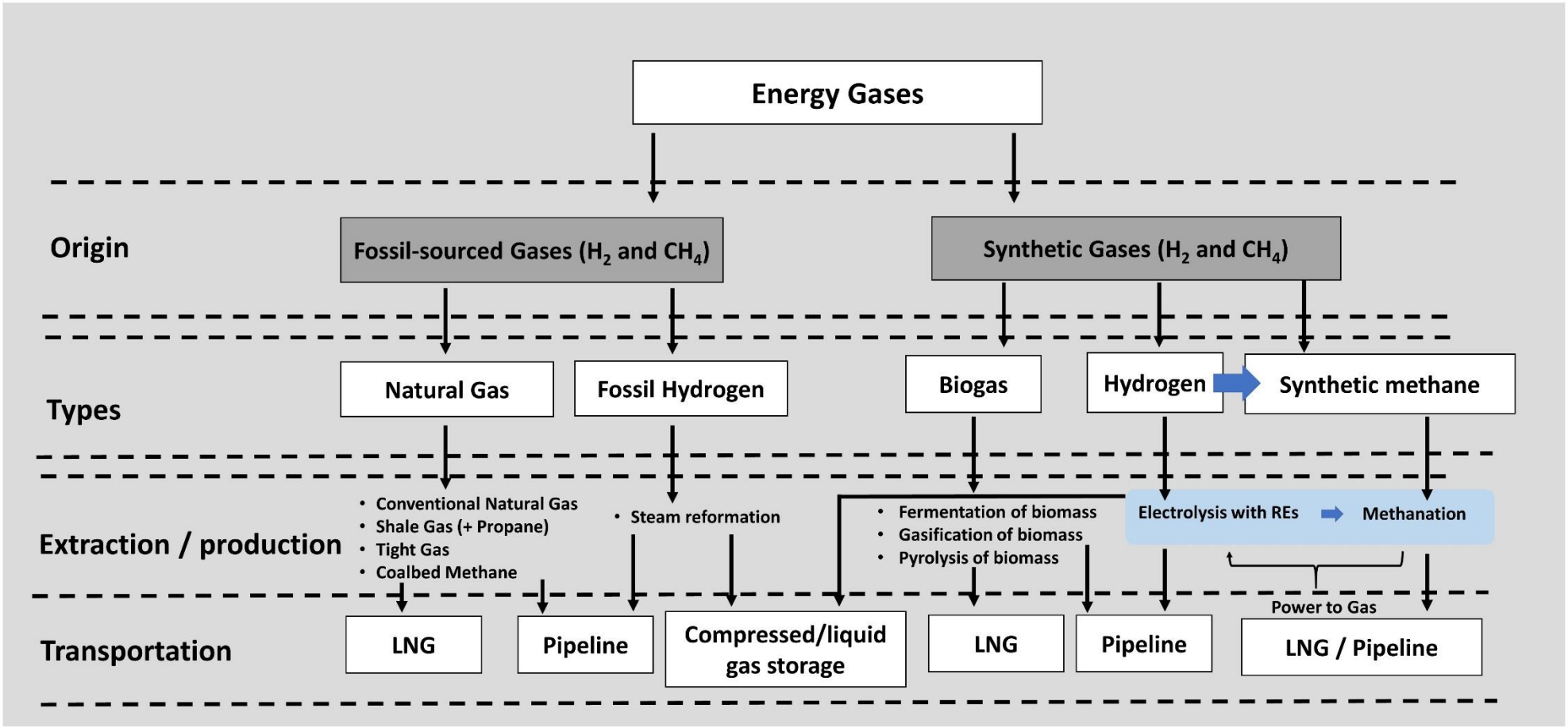
~ He analyzed the natural gas sector and described why fossil natural gas never had its “golden age” in the European energy system (forecasts always overestimated)

~ implemented by the fossil natural gas actors to secure their interests (mainly capital-intensive infrastructure) and was adopted in the political discourse

Source: Innogy 2019

Source: Zukunft ERDGAS e.V.

3.2 The problem with "renewable gases": Why there is no "green gas"



Source: Own illustration

~ Decarbonizing gas (e.g. CCTS, PtG with DAC or (Bio-)CCTS, blue hydrogen with CCOS) is based on ineffective (energy and costs) and immature technologies with no clear emissions benefits of the whole life cycle

~ PtG can't be run economically using excess electricity (Agora Energiewende and Agora Verkehrswende 2018; Drünert et al. 2019)

~ PtG with DAC technically possible but benefits for climate protection and costs are unclear (treated as CO_2-neutral)

"Methane remains methane, with all its effects on the climate, whether it comes from fossil sources or has been synthesized".

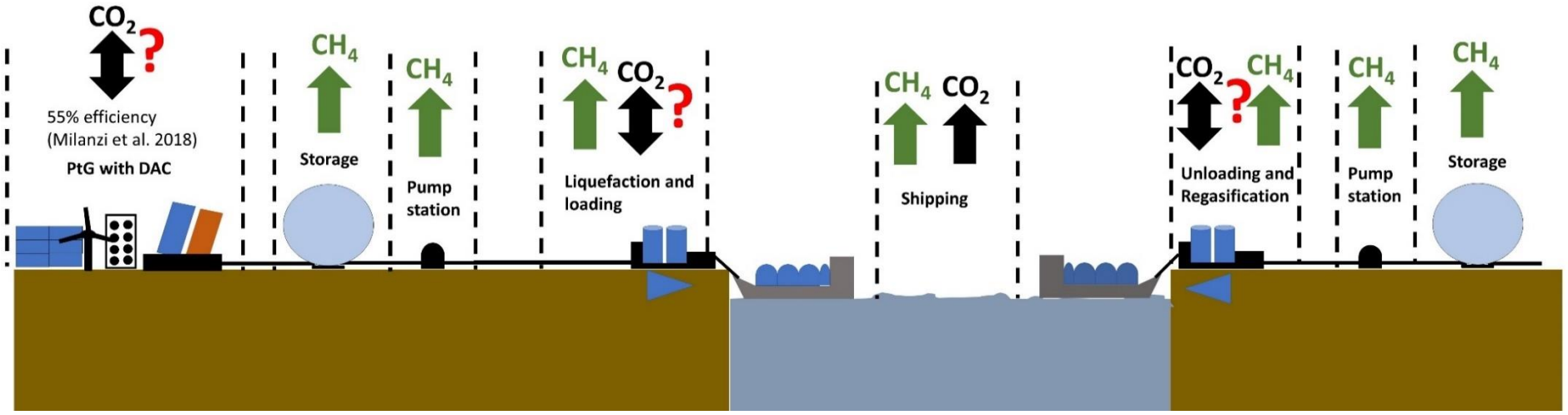
(Myhre et al. 2013; Nisbet et al. 2019; Alvarez et al. 2018; Cremonese and Gusev 2016; Agora Energiewende and Agora Verkehrswende 2018; Drünert et al. 2019; Shindell et al. 2012)

Methane

- GWP_{20} = 86 (105) (Myhre et al. 2013)
- App. 25% of climate change is methane related
- To achieve RCP2.6 pathway, annually reduction of 150 Mio.t (Nisbet et. 2019)
- Methane emissions from US natural gas sector were underestimated by 60% (Alvarez et al. 2018)
- Transparent and independent global measurement data is needed

"if losses exceed app. 2.7%, then the positive climate effect compared to coal is obsolete" (Cremonese and Gusev 2016)

Direct methane emissions threw:
flares, venting, leakages, ventilations (intentionally and unintentionally)



Own illustration

3.3 Take decarbonization serious: Adopt 20-year perspective on GWP for assessing greenhouse gas effects

~ To avoid tipping points and try to ensure intergenerational justice

"The average global mean temperature will "increase by 1.5 degrees by about 2030 and 2 degrees by 2045" regardless of the development of the CO_2-emissions, if methane and black carbon emissions are not immediately reduced significantly" (Shindell et al. 2012)

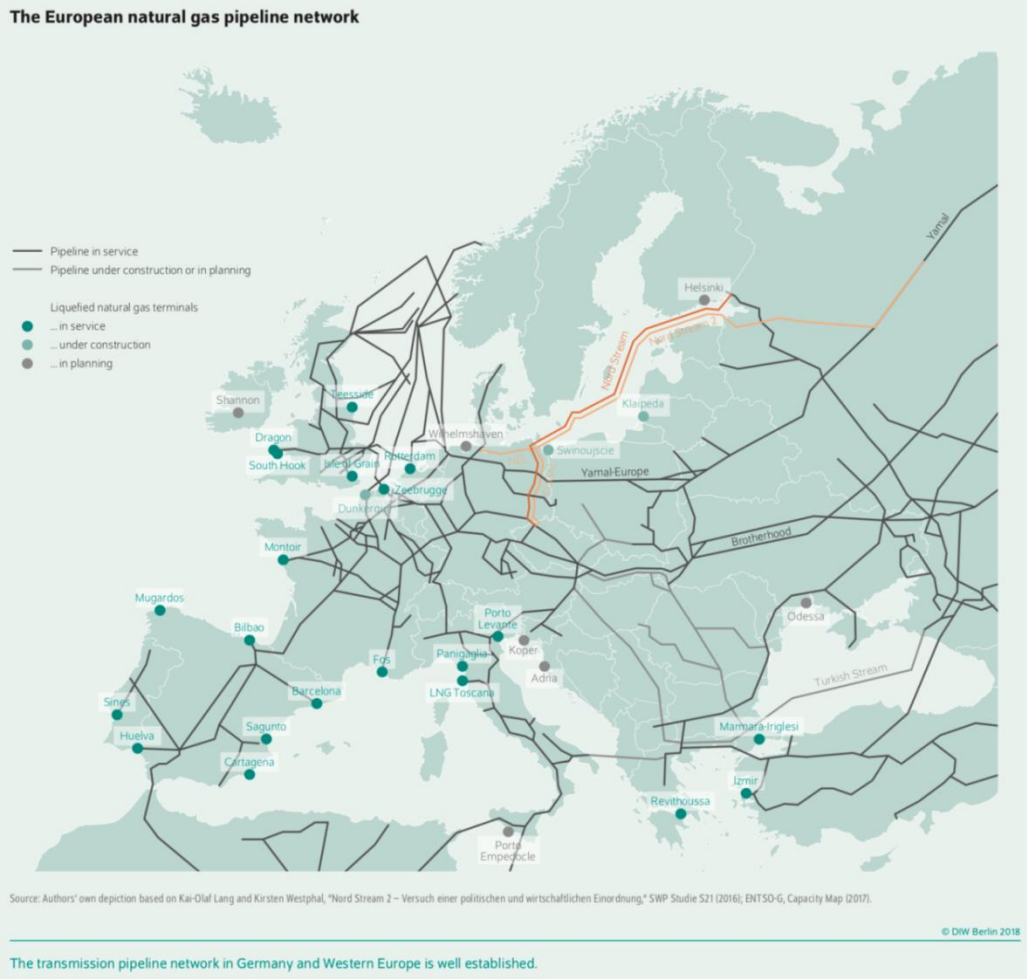
~ Narrative of green gas is used for the justification of the continuation and expansion of fossil natural gas infrastructure

Hypothesis:

"The further use or further investments in gas infrastructure is not compatible with the Paris climate targets and makes the necessary transformation to a no-carbon-no-nuclear energy system more difficult or even prevents it because of strengthening the carbon lock-in effects. We need a natural gas exit strategy and need to avoid every measure which is not energiewende-beneficial".

4 “Stranded assets“

4.1 North Stream 2

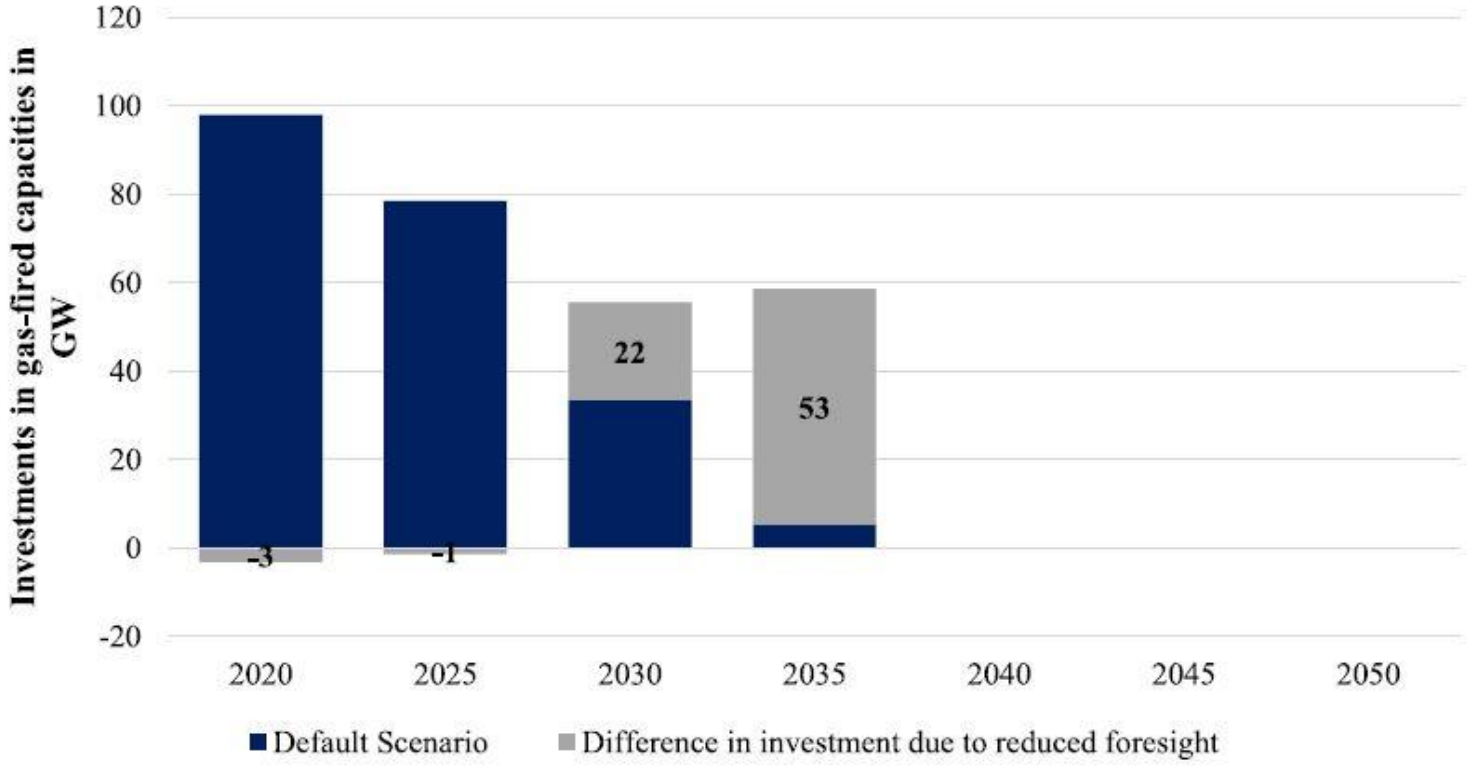


4.2 LNG-terminals (in Germany) unlikely

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

4.3 Stranded investments in natural gas power plants

(Gerbaulet et al. 2019)



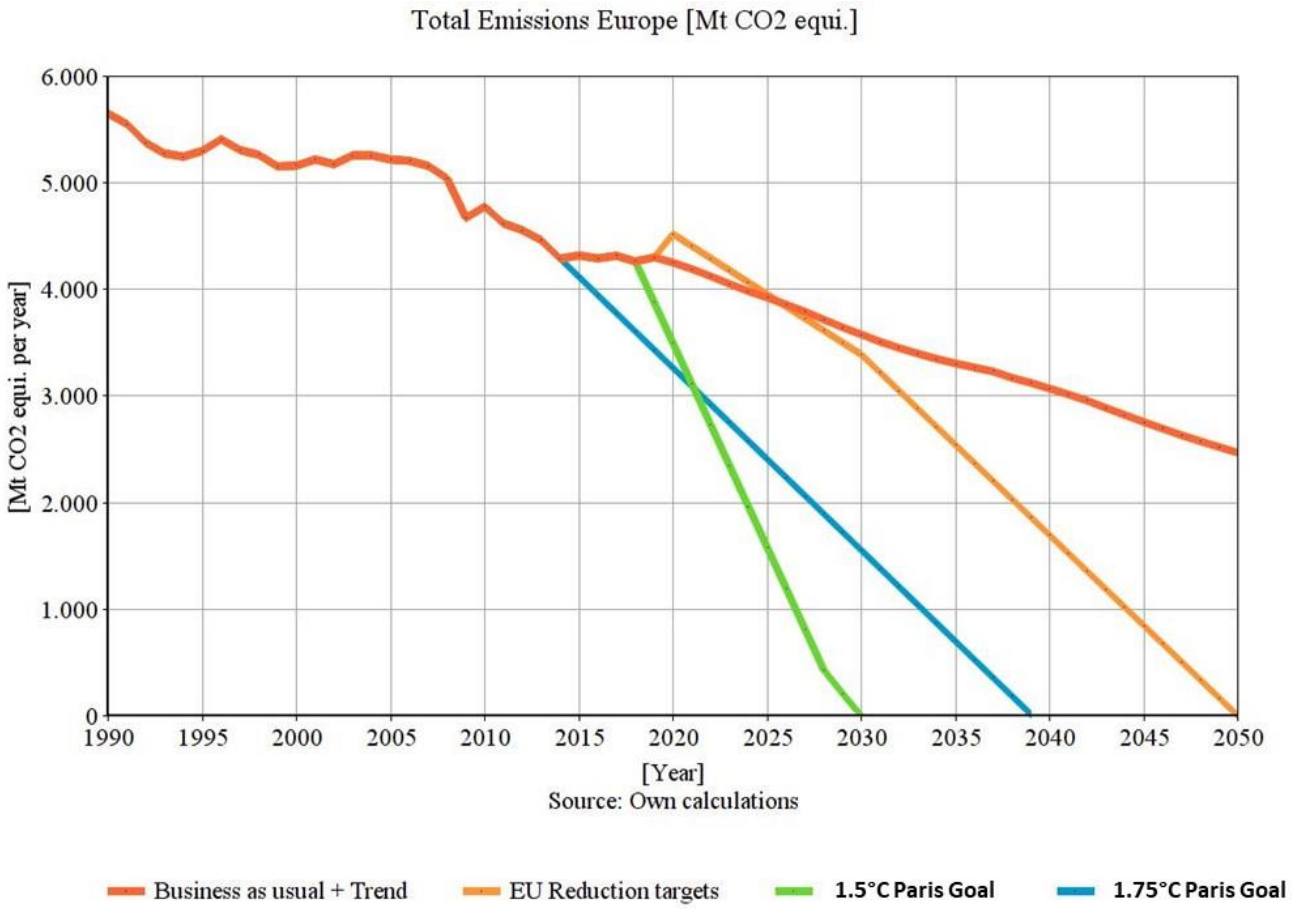
Investment differences for gas power plants in *Reduced Foresight* scenario vs. *Default Scenario* from 2020 to 2050 in Europe.

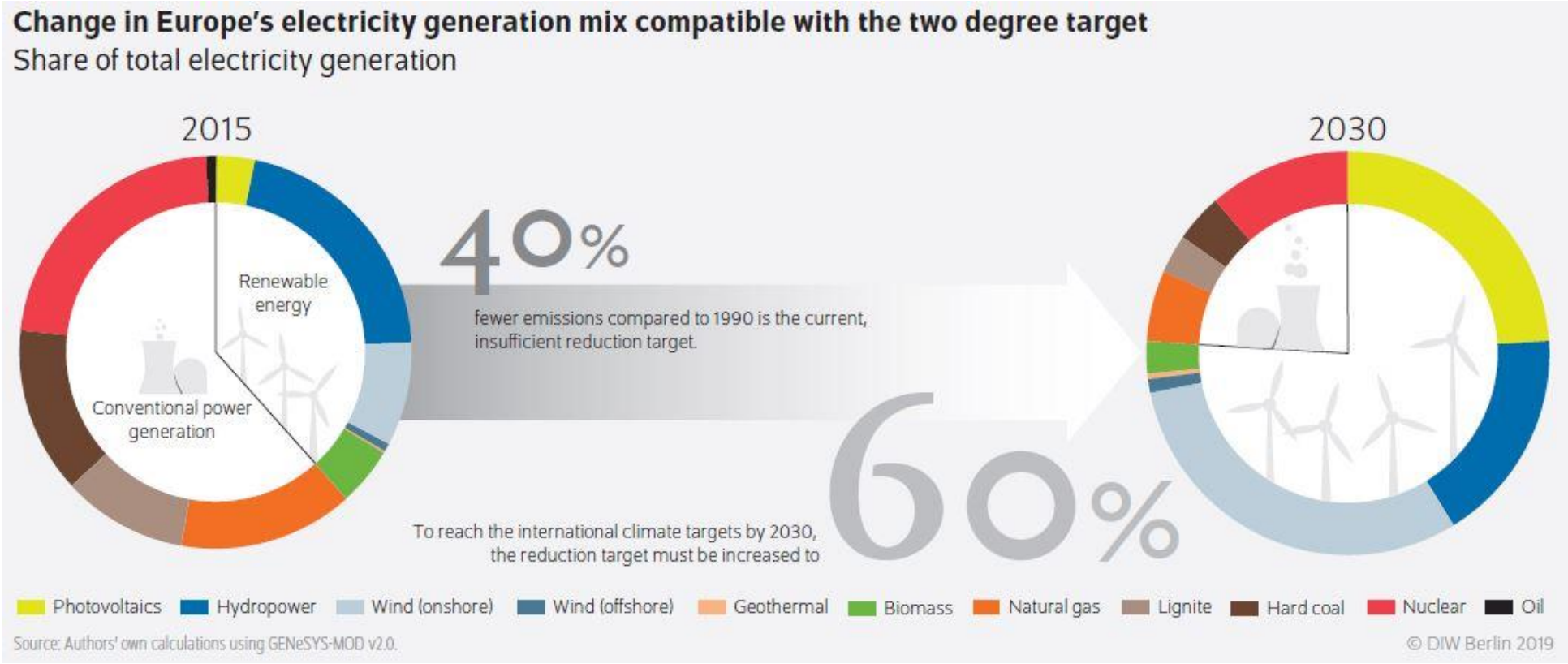
~Investments in gas power plants (and infrastructure) after 2035 are possibly stranded

~ The only question is: phase out of natural gas until 2030 or 2040?

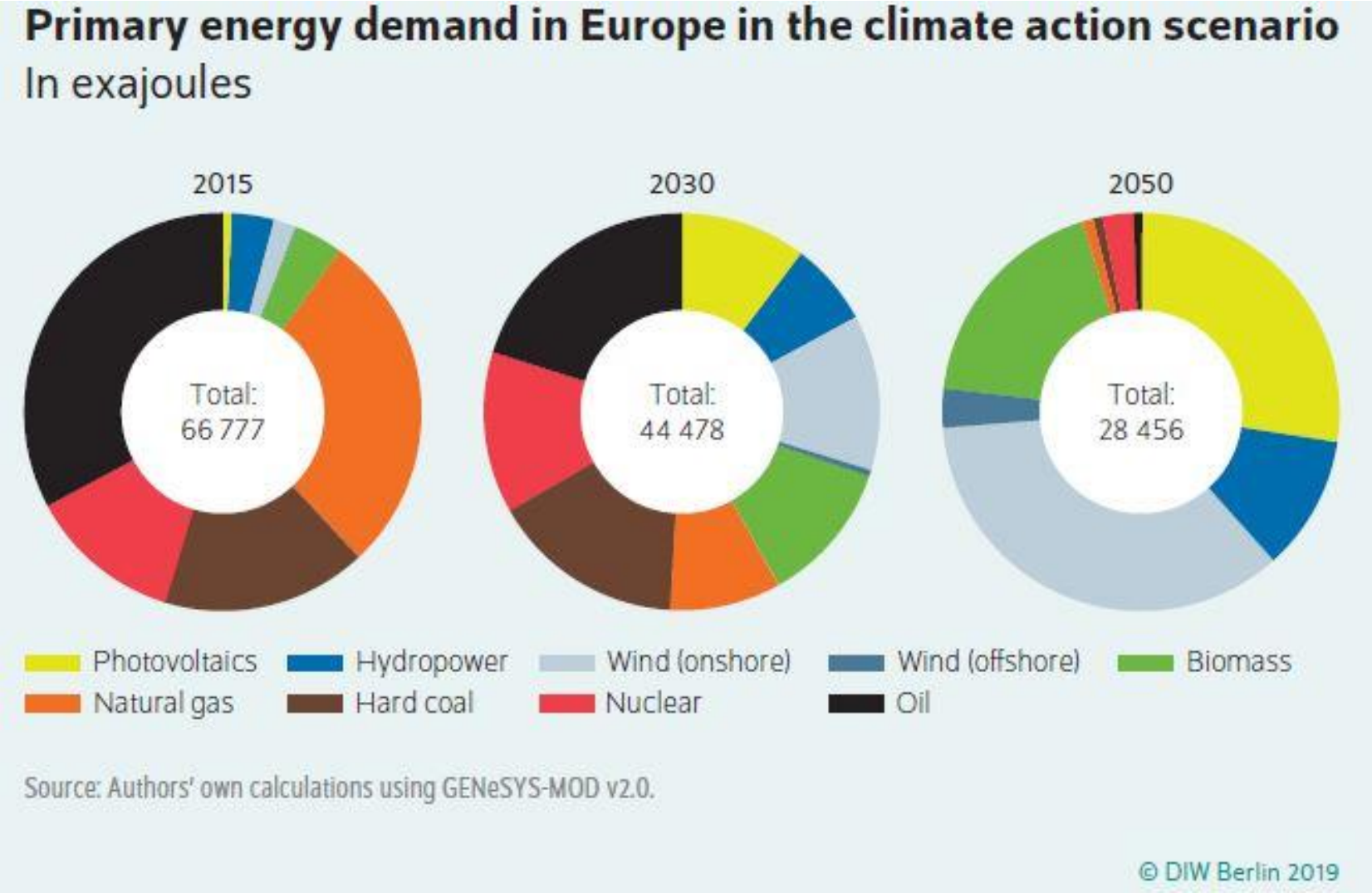
5 The no-carbon energy transformation in Europe and its implications for the natural gas industry

5.1 Take the Paris Agreement serious: CO_2-budgets instead of CO_2 reduction targets





~ To achieve at least the 2°C target from Paris Agreement, Europe must increase its contribution to climate change mitigation: The 2030 target for the electricity sector must be raised from 40% to 60% greenhouse gas reduction



(Oei, Hainsch, and Löffler 2019),

6 Change the narrative

6.1 Natural gas is no longer a “bridge“

~ Previous “bridge technologies“:

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

~ “Yesterday“: Lignite (Debriv Bundesverband Braunkohle 2012)

~ Today: Fossil natural gas (Zukunft Erdgas e.V. 2018)

7 Draft research topic and questions

100% renewables in the transport (industrial) sector without synthetic fuels – sufficiency strategies to meet the goal

~ The remaining quantities of gas from the relevant low-carbon scenarios are mostly to be found in the transport sector and the industrial sector

~ CCTS and LNG-imports of synthesized gases are presumed

~ Development of sufficiency strategies to compensate the remaining fossil fuels

~ Strategies for decarbonizing the mentioned sectors

Main messages / conclusions

1. Just like 24 years ago, from socialism to capitalist market economies, 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

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

3. Investing into 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

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

5. Suggest changing the narrative: From "bridge technology" to "natural gas exit" in Europe (and perhaps elsewhere)

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CO_2-Budgets, 1.5°C: We are following the methodology from Rahmstorf (2019), who calculates the remaining CO2-budget of the limits for 1.5°C global warming (420Gt from 2019 (Rogelj u. a. 2018, 108)) back to 2016 (Paris Agreement; 500 Gt since 2016 and divides it by the total population of the earth (EU 6.9% of the world population) which gives a remaining budget of 21.627 Mt from 2019 (with 12.873 Gt from 2016-2019)
WB41: Based on a global residual budget of 890 Gt CO2 in 2015, a remaining carbon budget of 51.60 Gt CO2 for Europe is calculated based on the population figure.