Virtual Academy for Sustainability

WBGU
German Advisory Council on Global Change

Lecture 5: Technical and Economic Feasibility of the Transformation

Episode 1: Historical Dynamics, Possible Pathways and Investment Needs

Prof. Dr. Nebojsa Nakicenovic
IIASA and TU Wien (Austria)

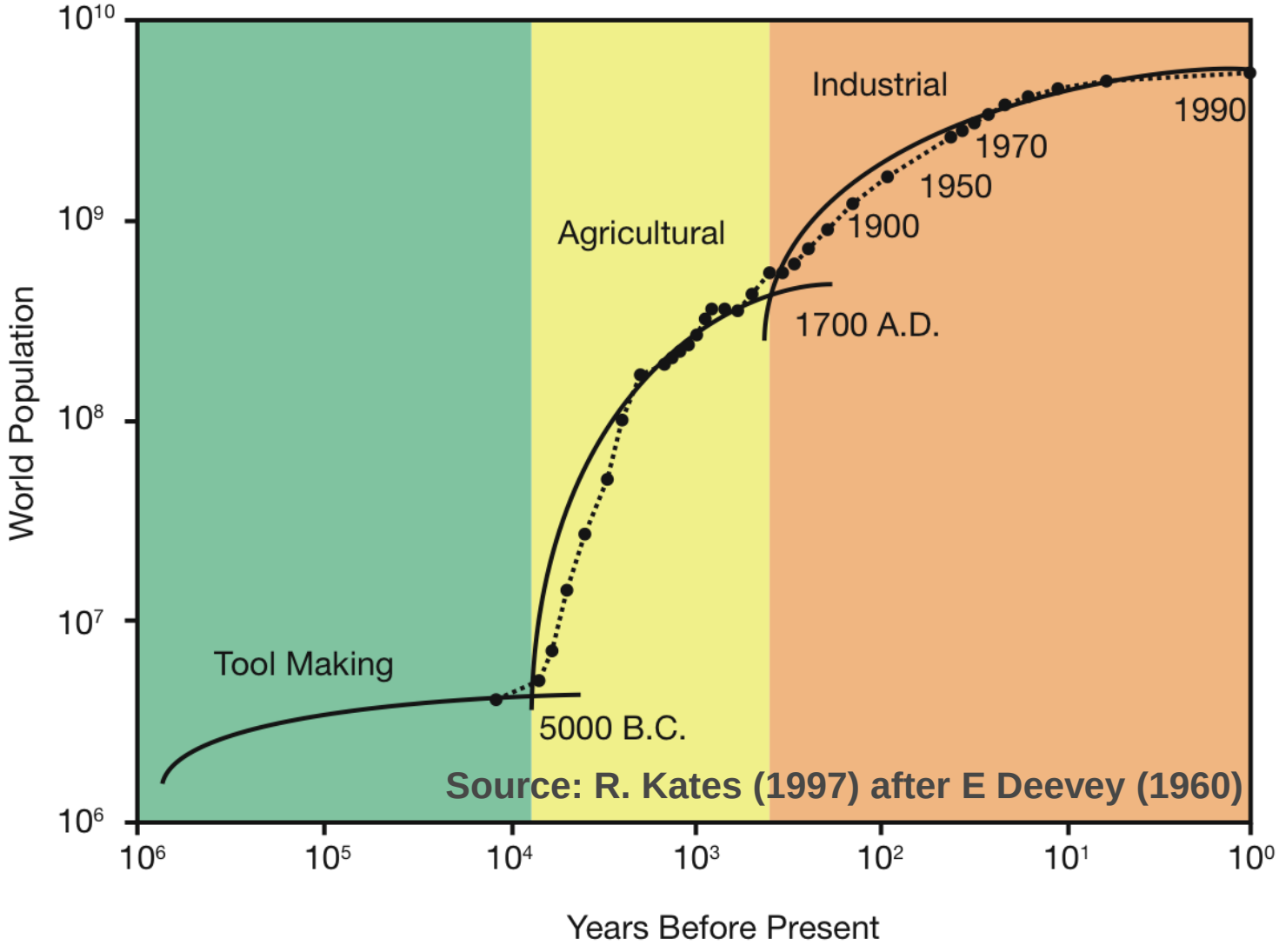
World in Transition: A Social Contract for Sustainability *supported by*

DBU
Deutsche Bundesstiftung Umwelt

- **Episode 1: Global Energy Transformation: Historical Dynamics, Possible Pathways and Investment Needs (Prof. Nakicenovic)**
- Episode 2: Global Energy Transformation: Challenges and Possible Solutions (Prof. Schmid)
- Episode 3: Interview

Learning Outcomes

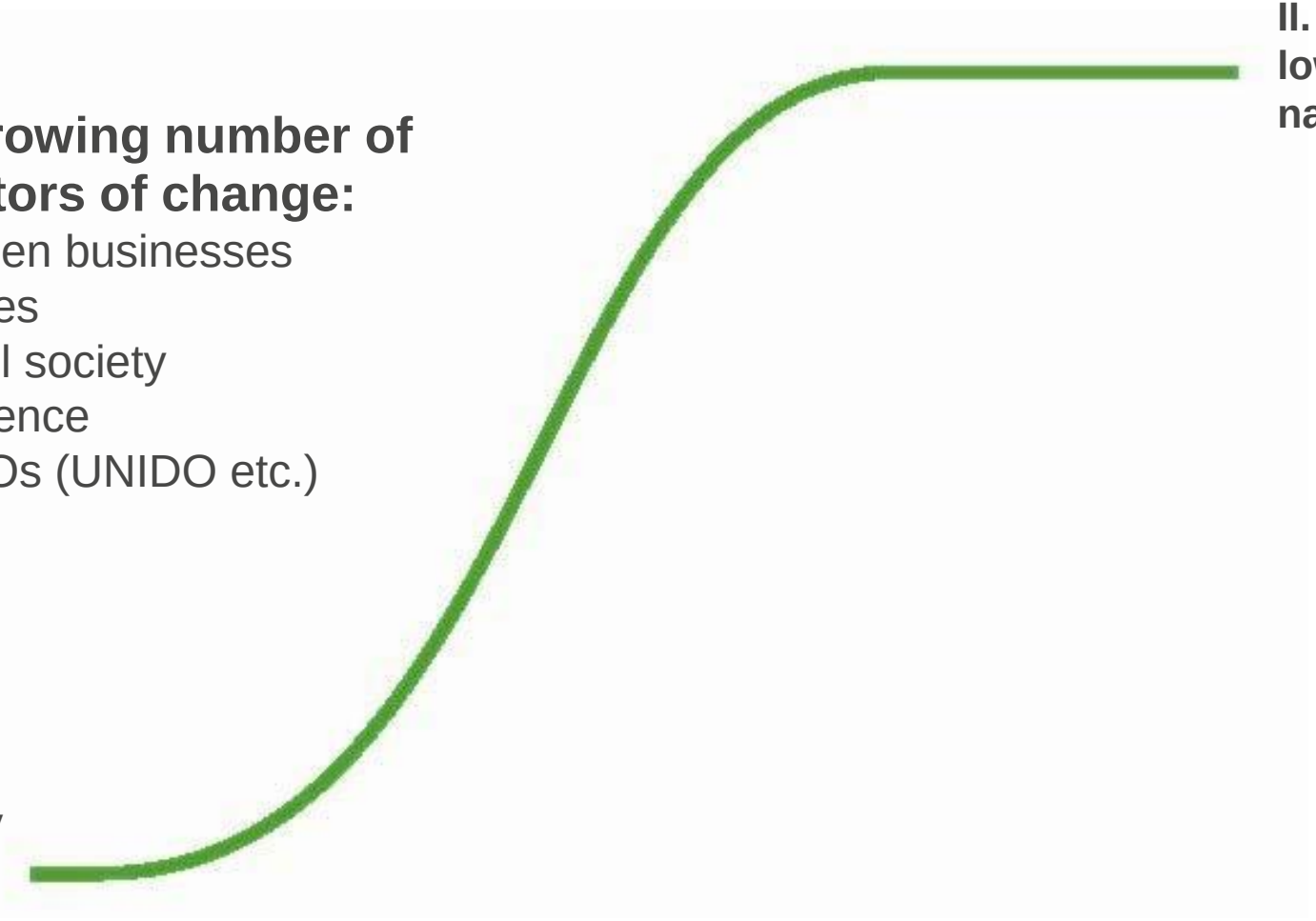
- Better understanding of the historical evolution and transformational change
- Improved perceptions of major energy challenges such as access and security
- Availability of fossil energy resources and renewable energy potentials in the world
- Range of technological options for transforming energy systems at all scales
- Investment requirements today and for transforming energy systems
- Potential co-benefits of transformation including development, security, environment


World Population
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
Industrial
1990
1970
1950
1900
Agricultural
1700 A.D.
Tool Making
5000 B.C.
Source: R. Kates (1997) after E Deevey (1960)
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
Years Before Present

”Decarbonization Revolution”

→ **Growing number of actors of change:**

- green businesses
- cities
- civil society
- science
- IGOs (UNIDO etc.)



II. Vision: low carbon narrative

I. Legitimacy of BAU eroding

Learning from the past

Vision – better future, normative perspectives

Abolition of slavery, Democracy, European Union

Crisis – “Gales of Creative Destruction”

The Great Depression, Structural adjustment programmers, financial market reforms after 2008

Technology – Rapid innovation diffusion

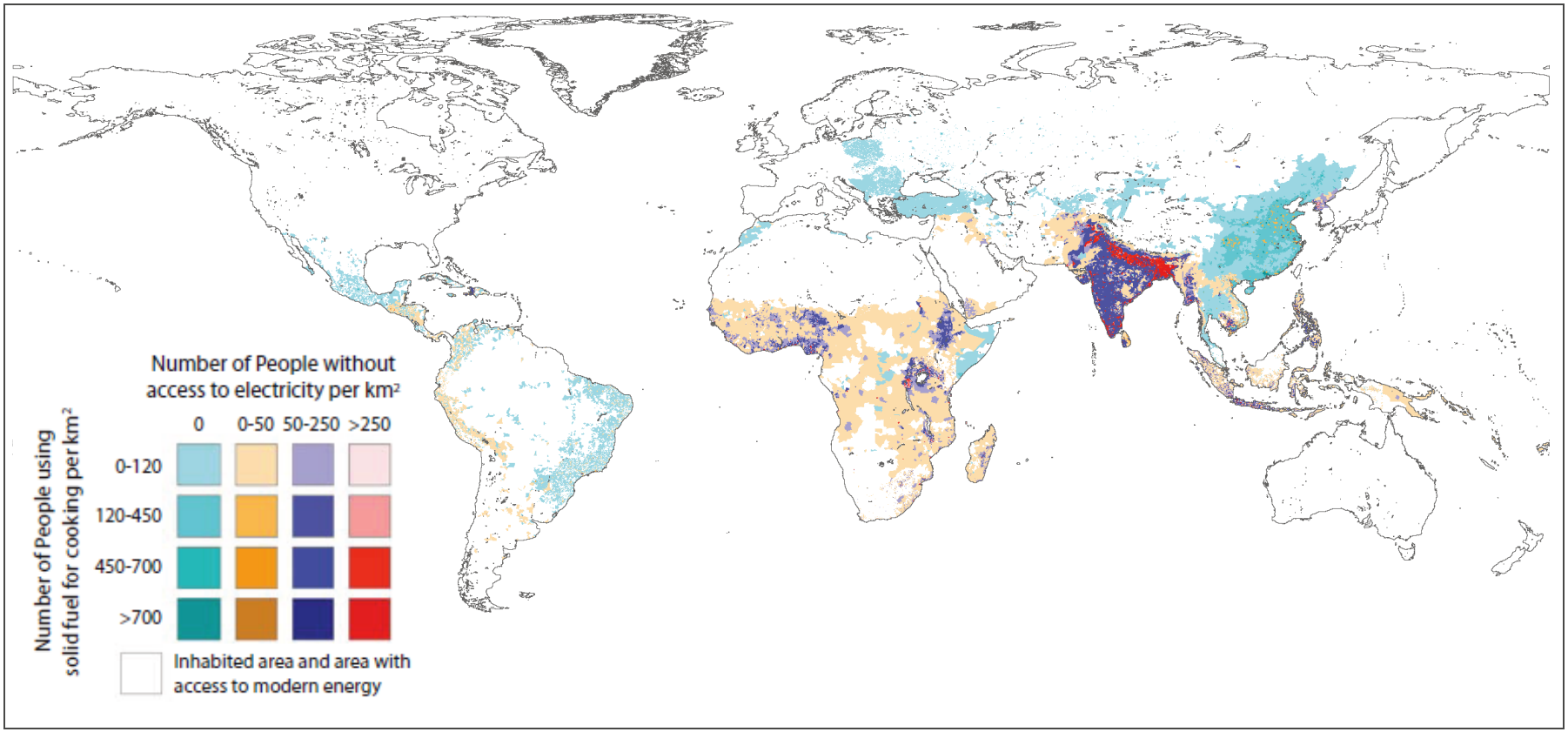
Substitution of carriages by cars, IT-revolution

Knowledge – research-driven, precautionary principle

Protection of the ozone layers, climate change mitigation

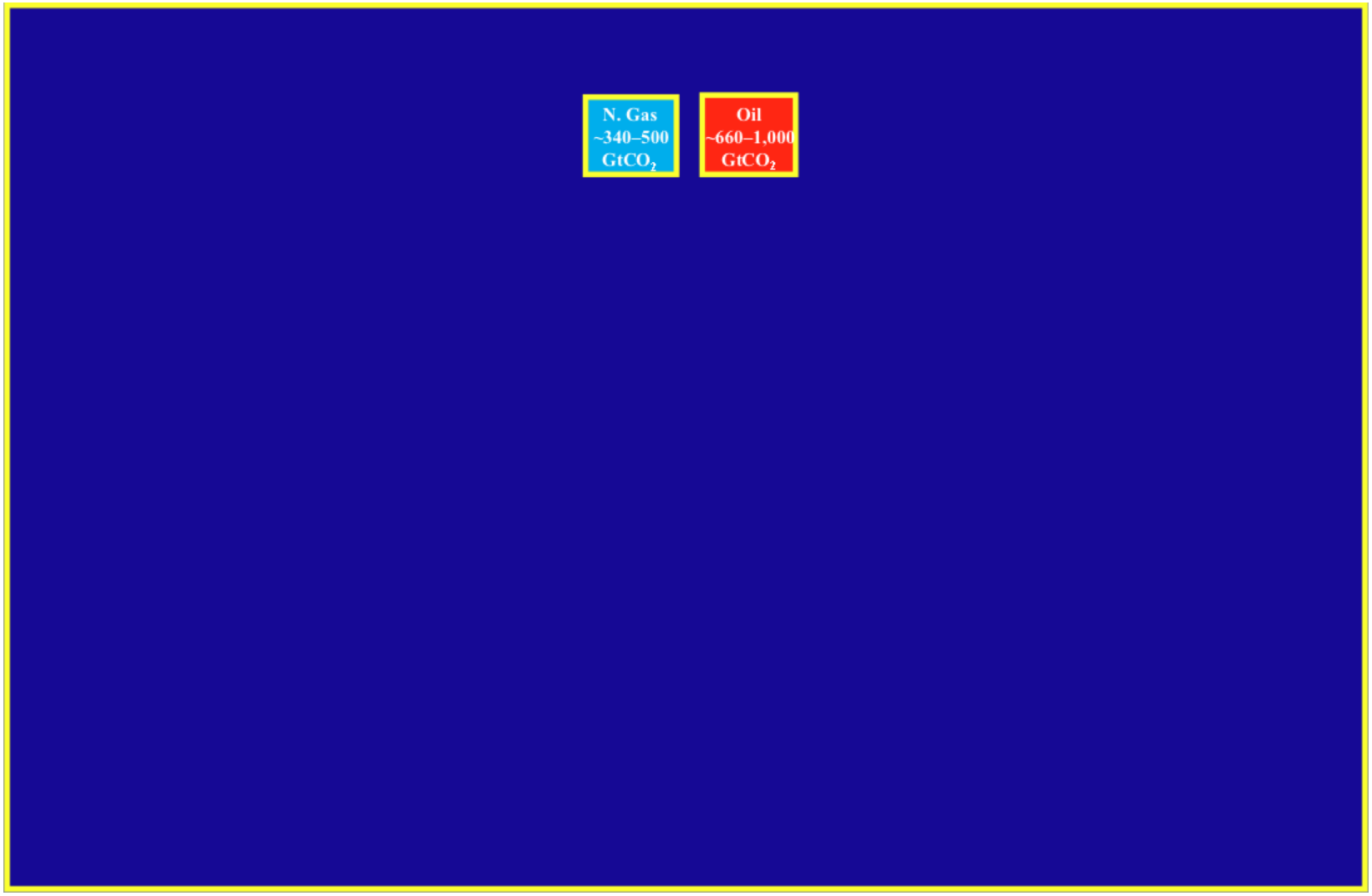
- The world is still on a carbon-intensive growth path with ever increasing GHG emissions
- 2° C stabilization requires a trend reversal of global emissions before 2020
- Global energy is based predominantly on fossil sources (more than 80%)
- 3 billion people lack access to modern forms of energy

Final energy access (non-commercial share) in relation to population density

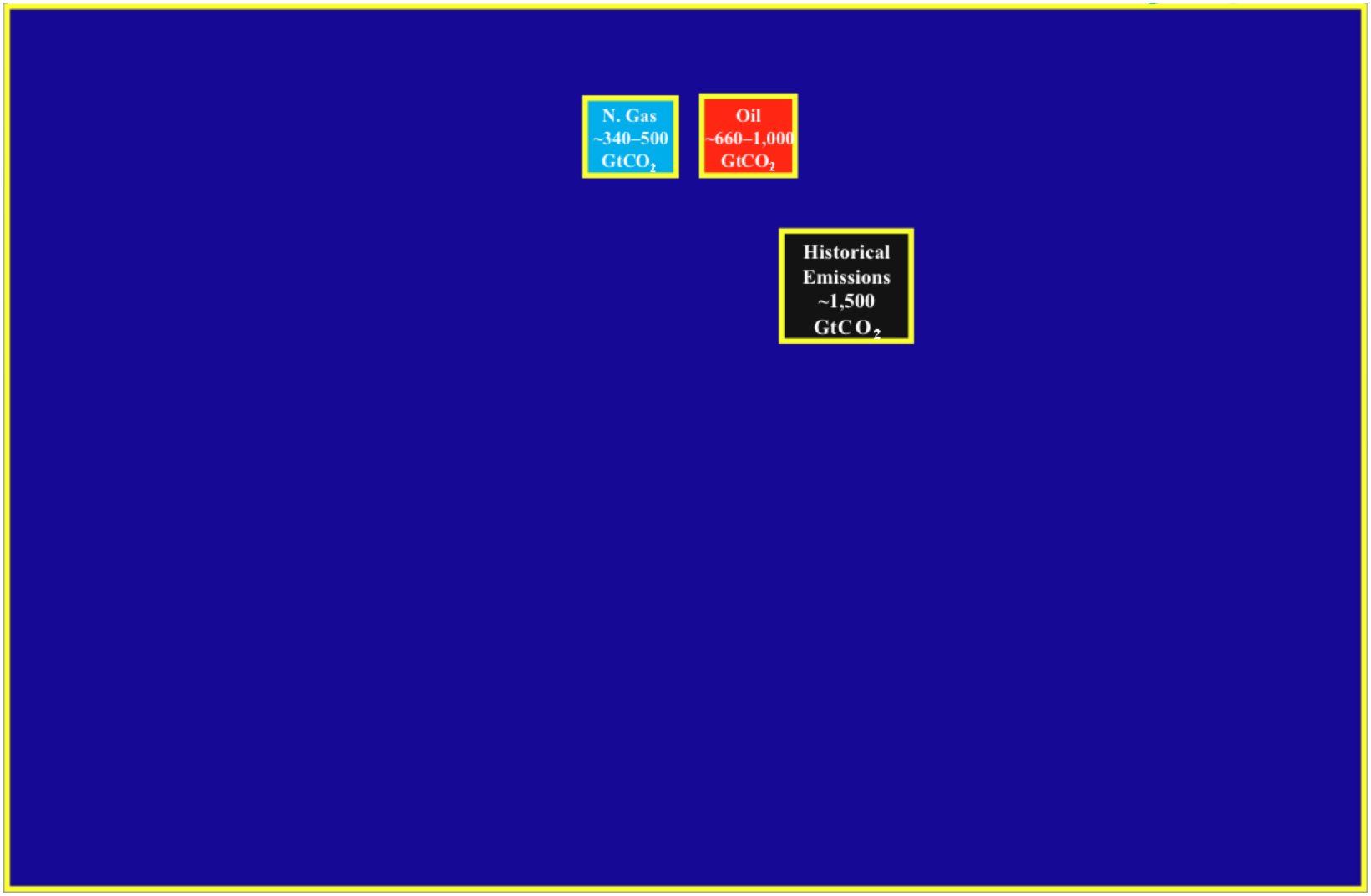


Source: Pachauri et al., 2012

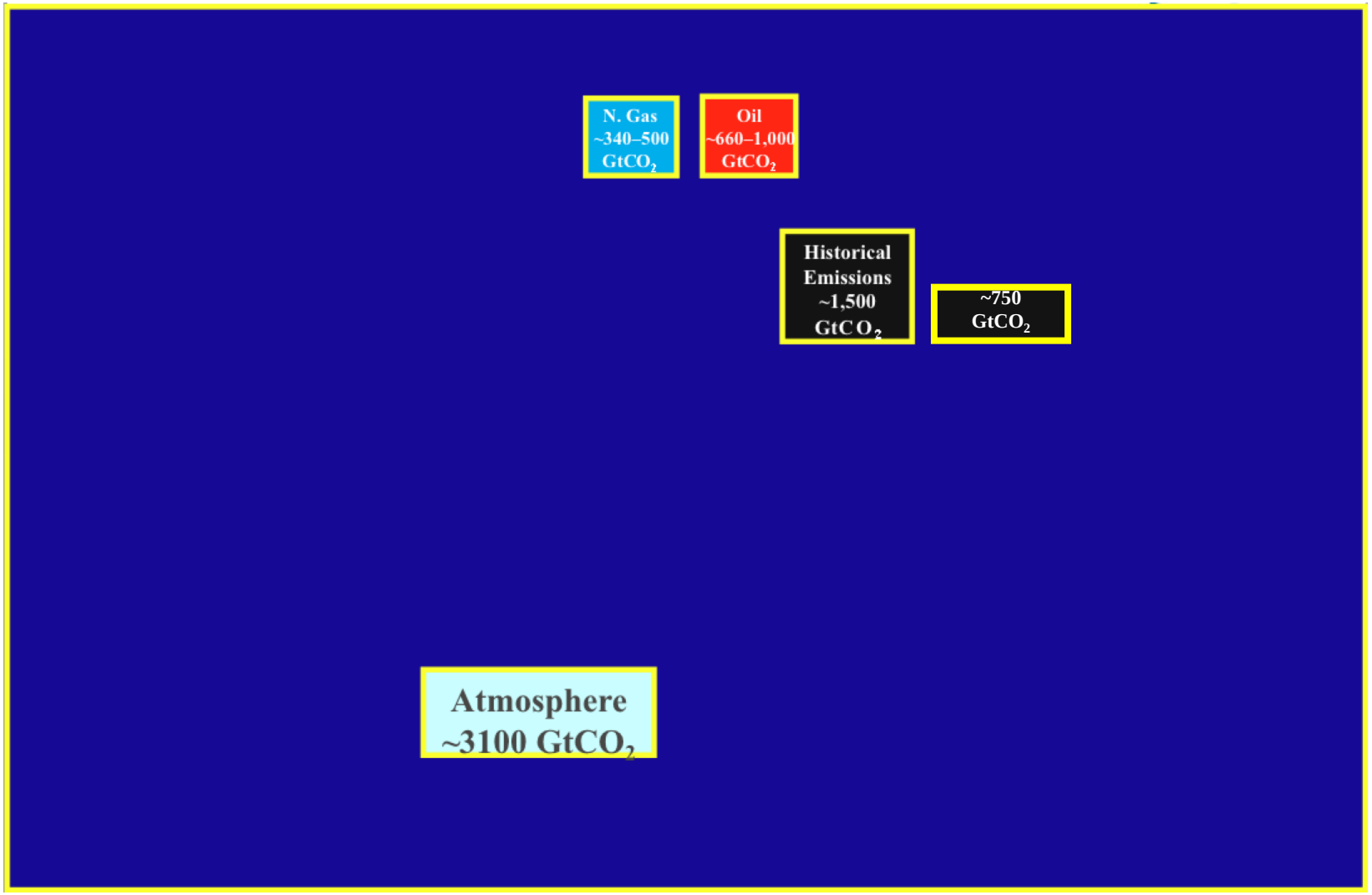
Global Carbon Pools



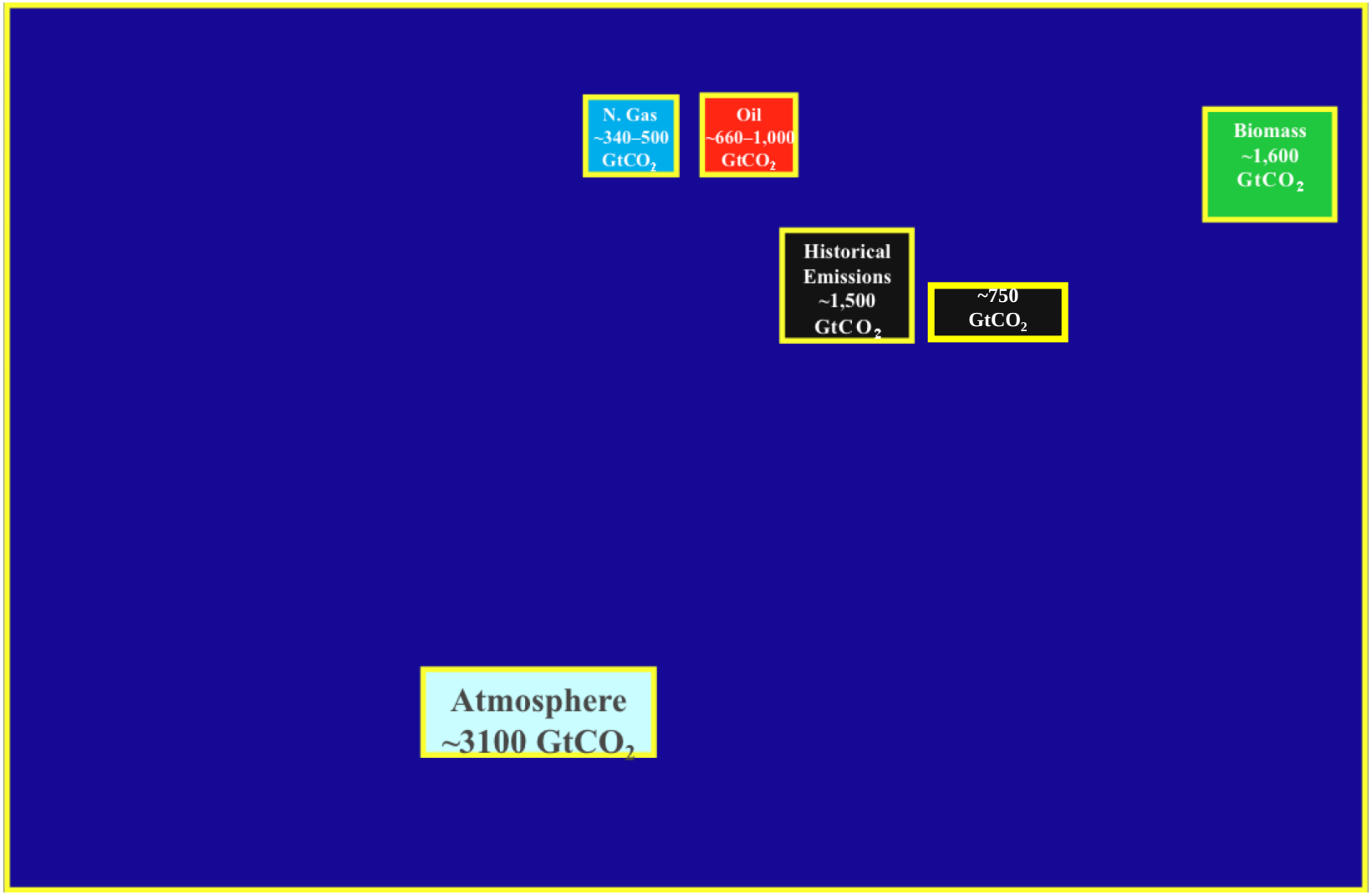
Global Carbon Pools



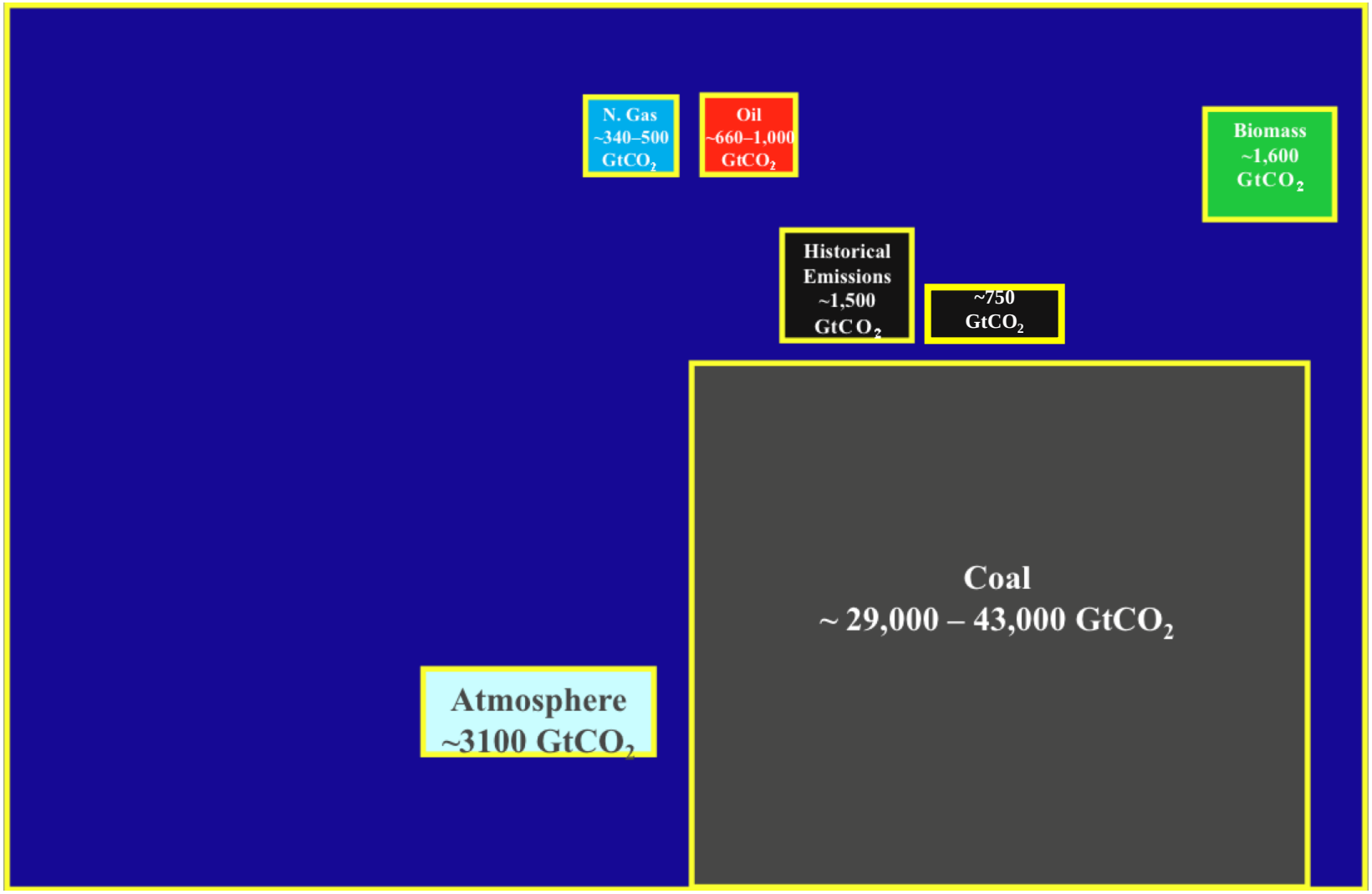
Global Carbon Pools



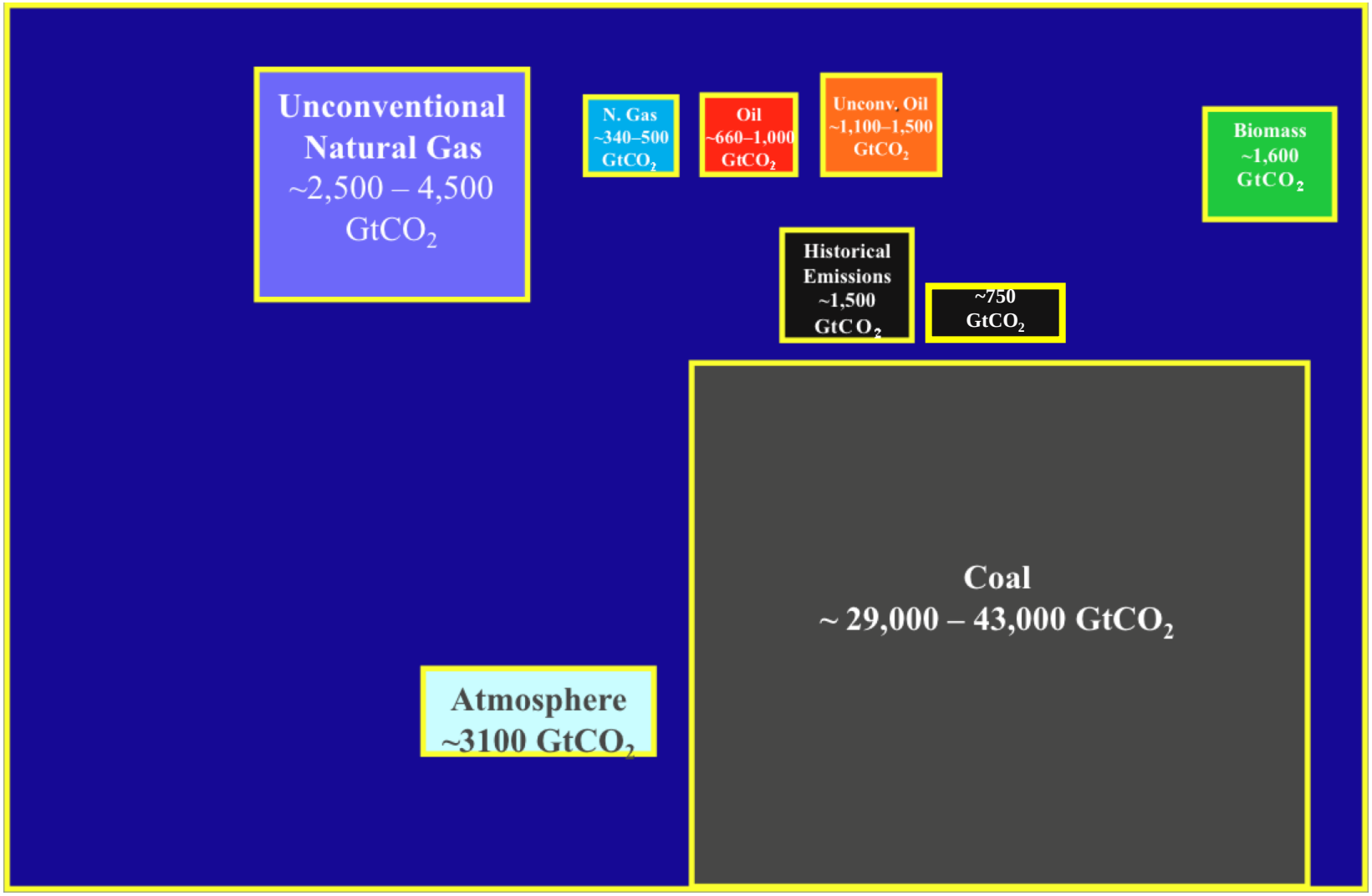
Global Carbon Pools



Global Carbon Pools



Global Carbon Pools



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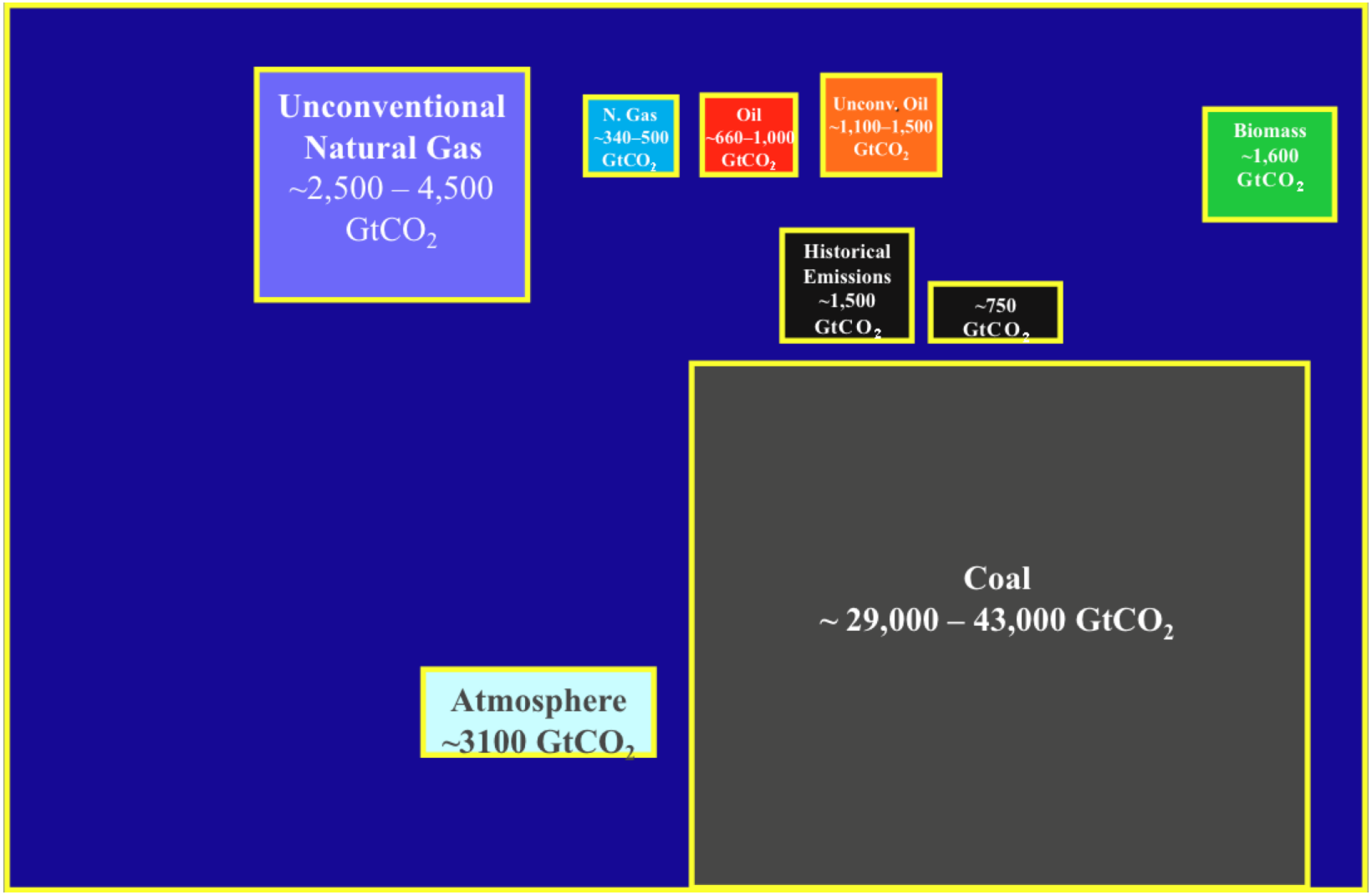
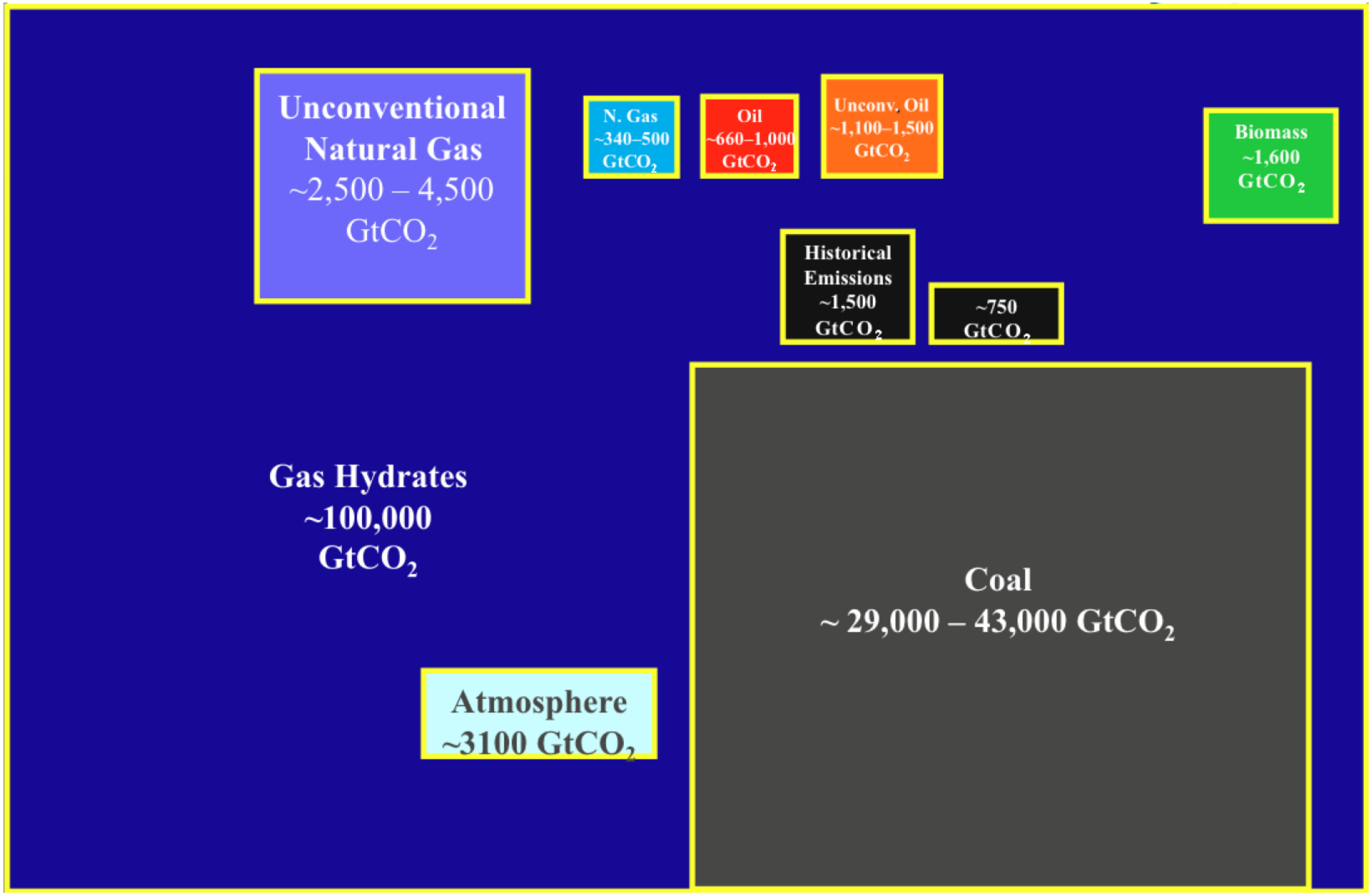
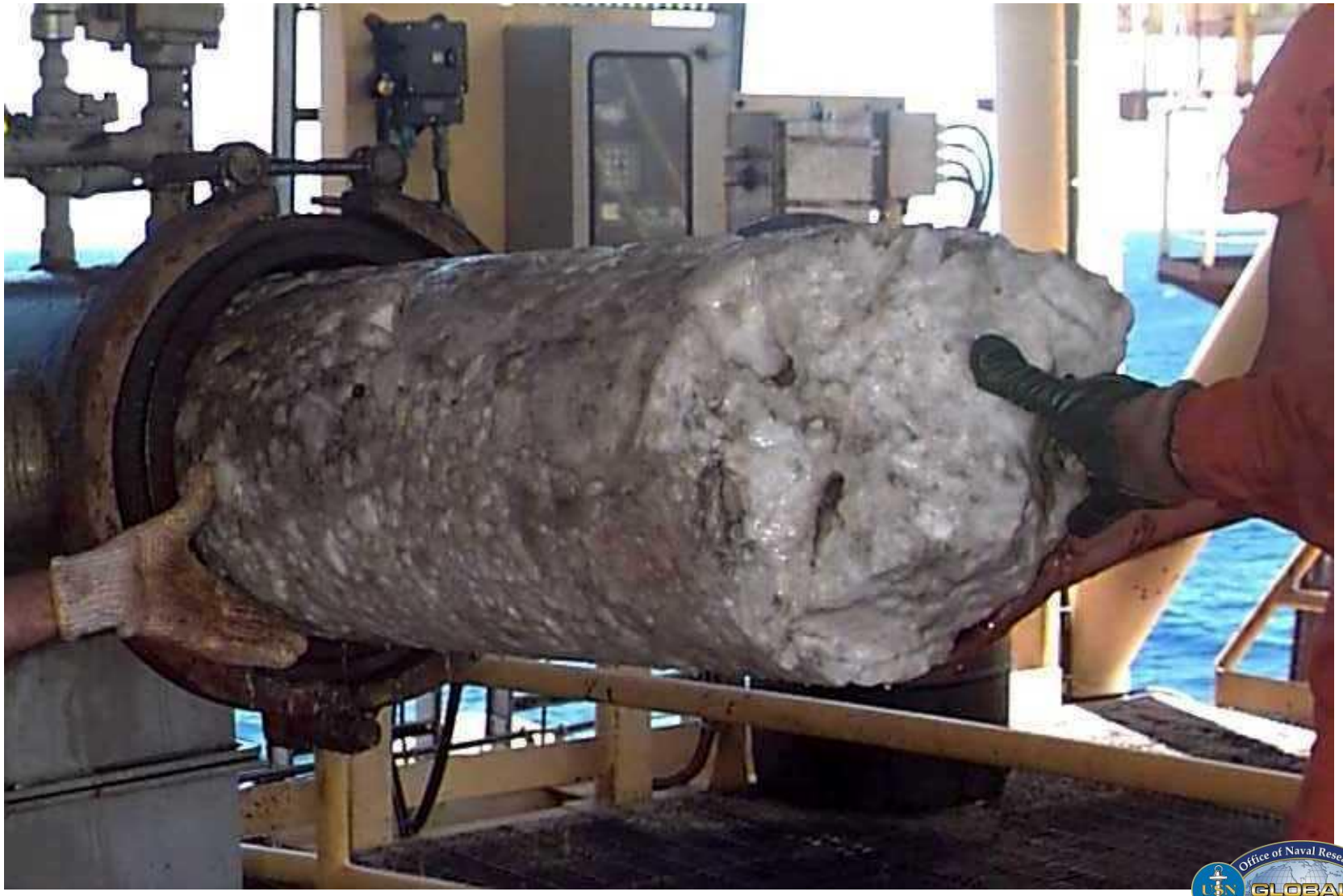


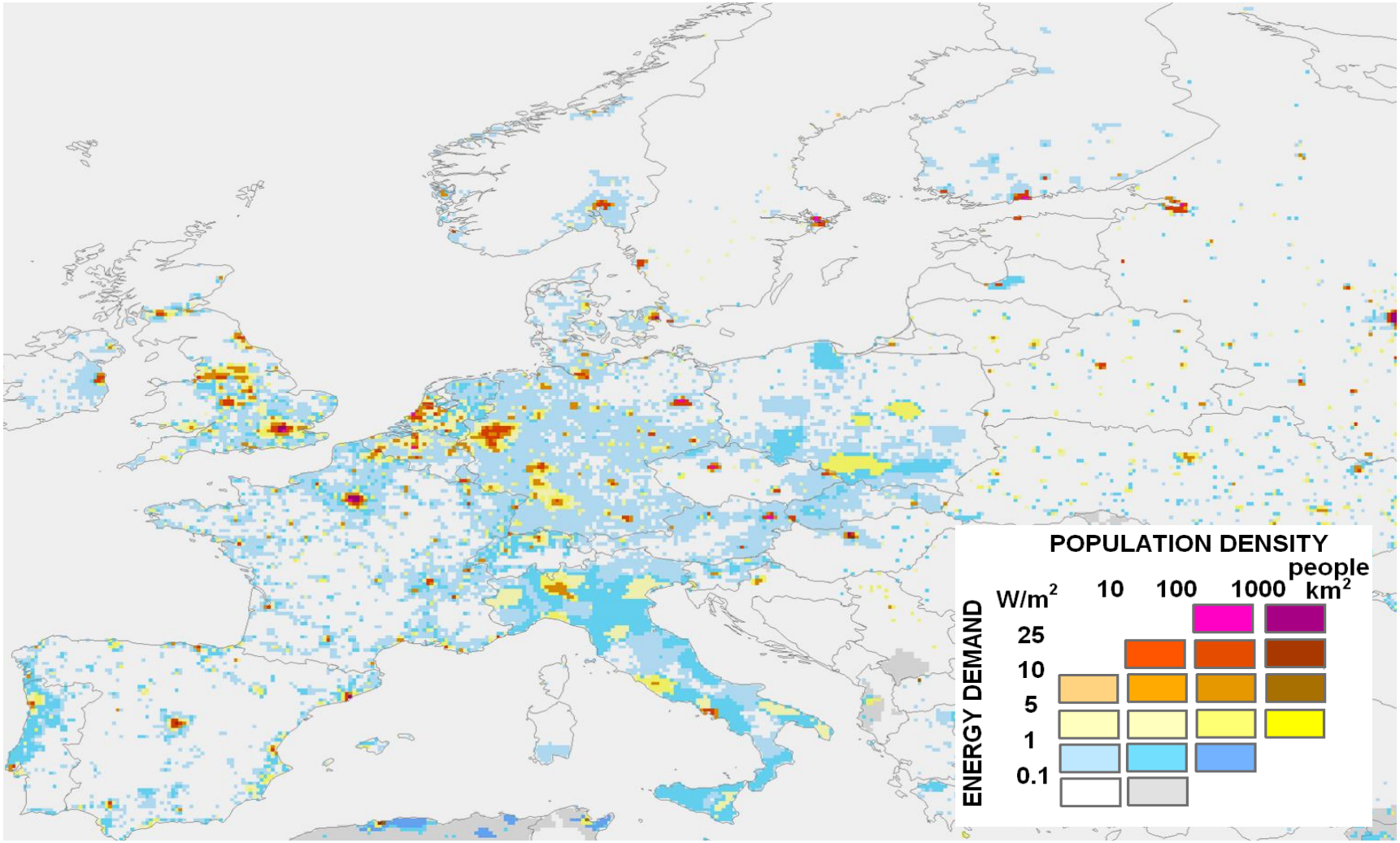
Global Carbon Pools



Gas Hydrate (Clathrate)

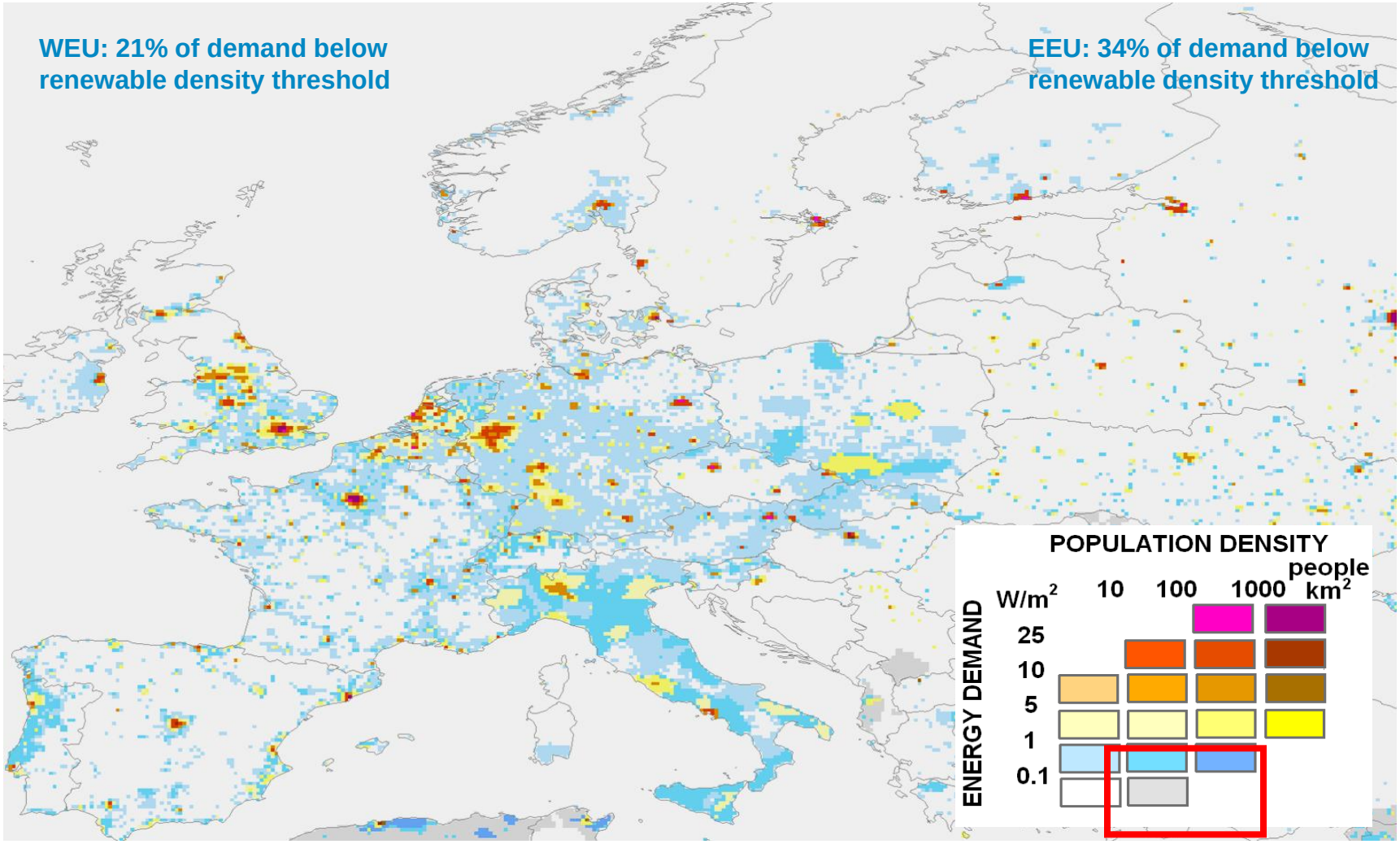


Europe Population vs. Energy Density



Source: Gubler et al., 2012

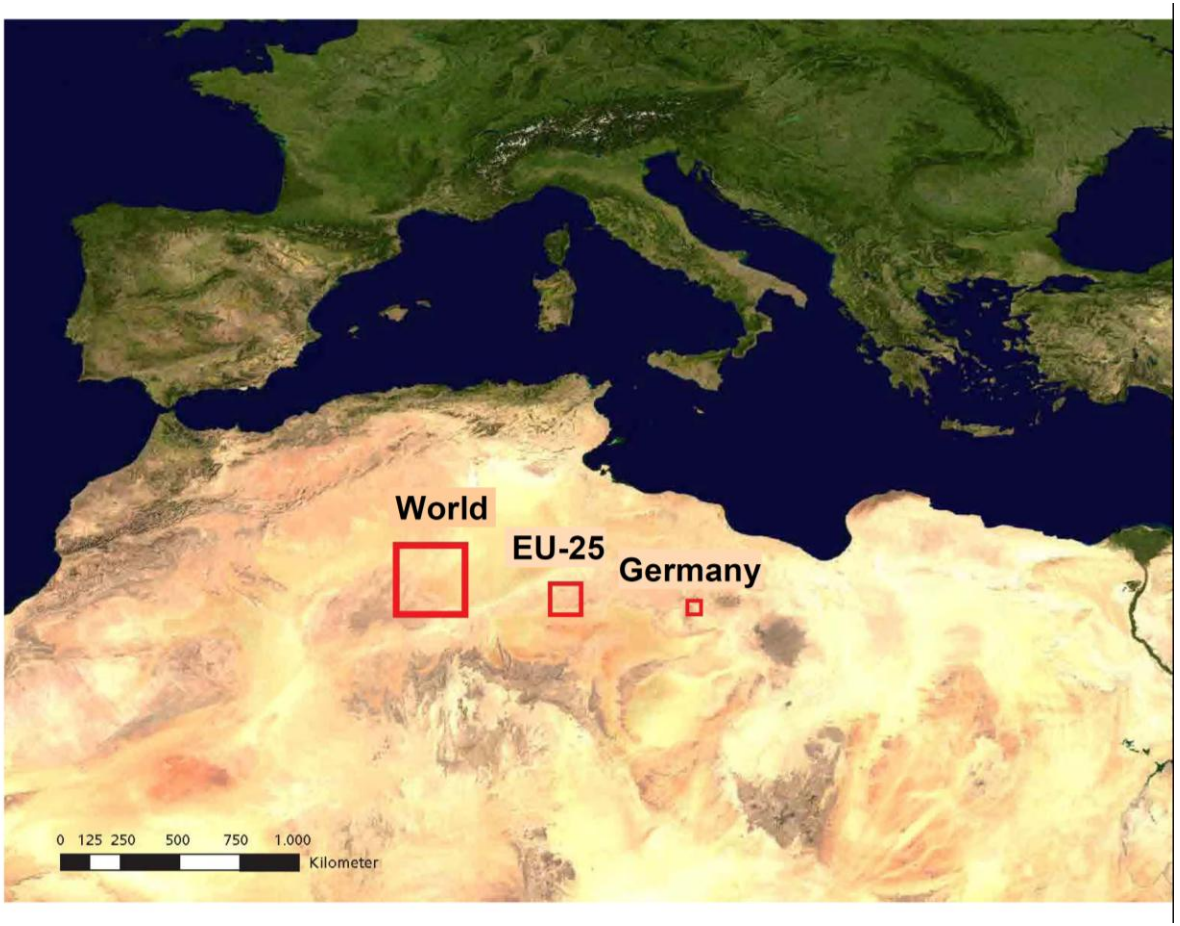
Europe Population vs. Energy Density



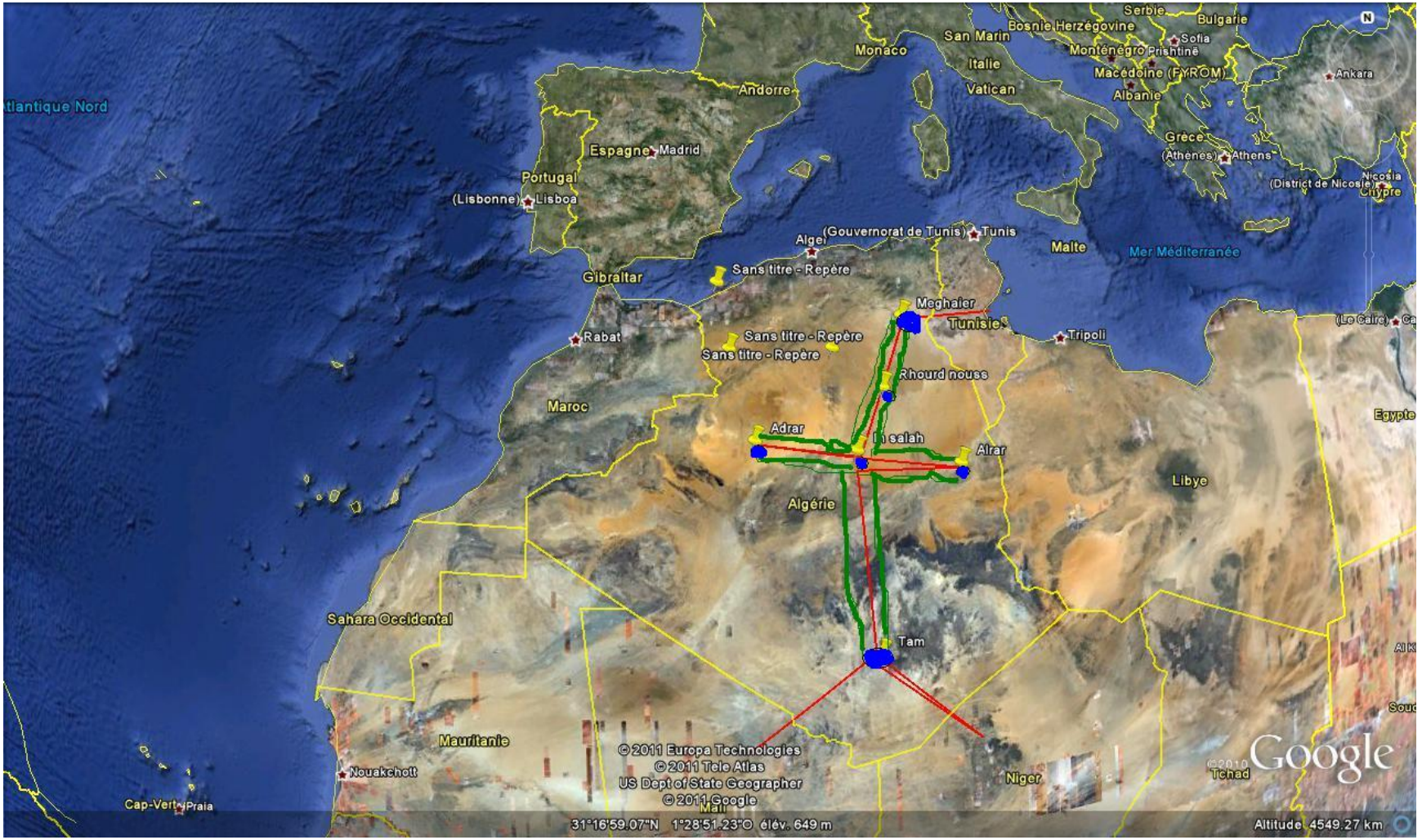
Source: Gubler et al., 2012

Required desert area for the sustainable supply of electricity

World 300 x 300 km²
EU-25 150 x 150 km²
Germany 50 x 50 km²

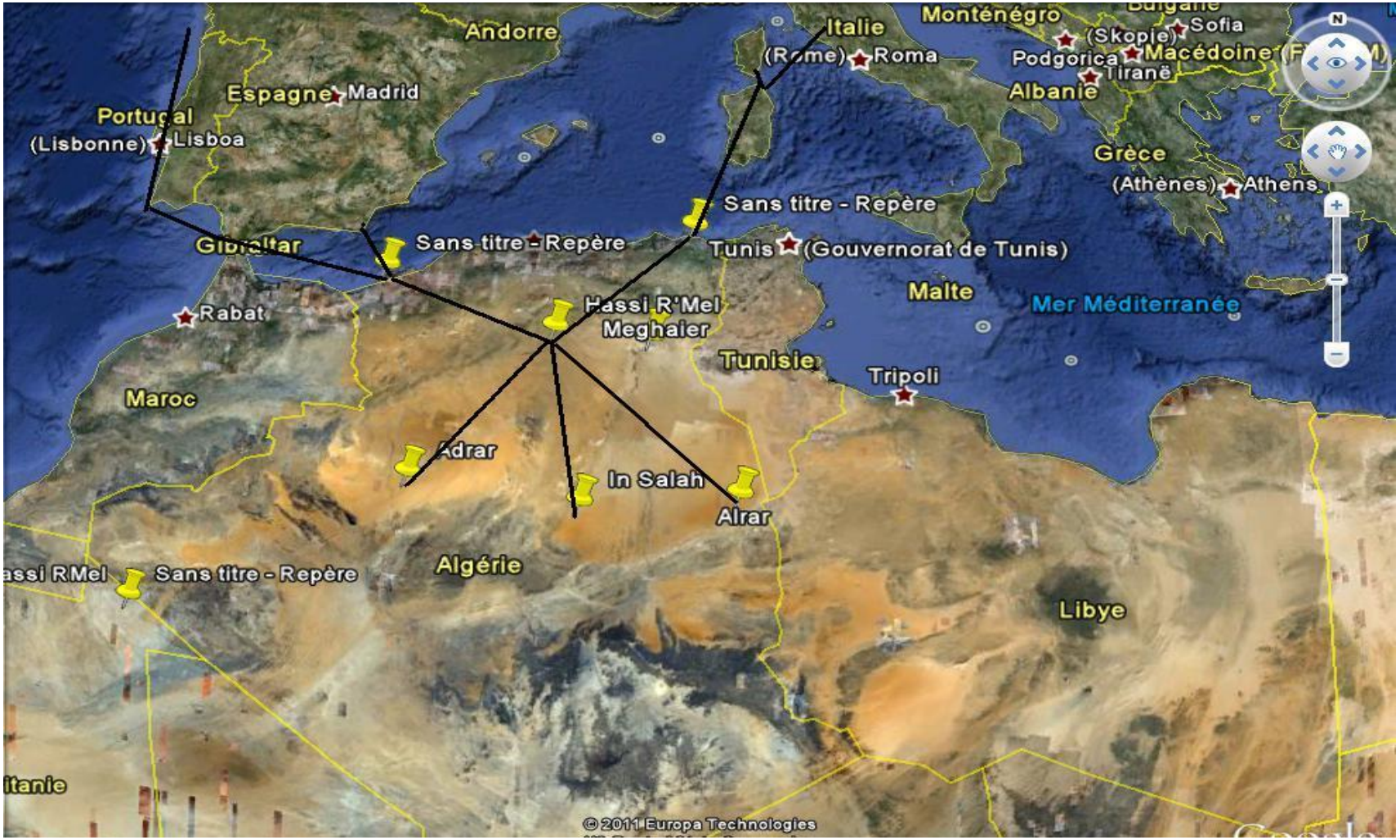


Source: DLR Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft



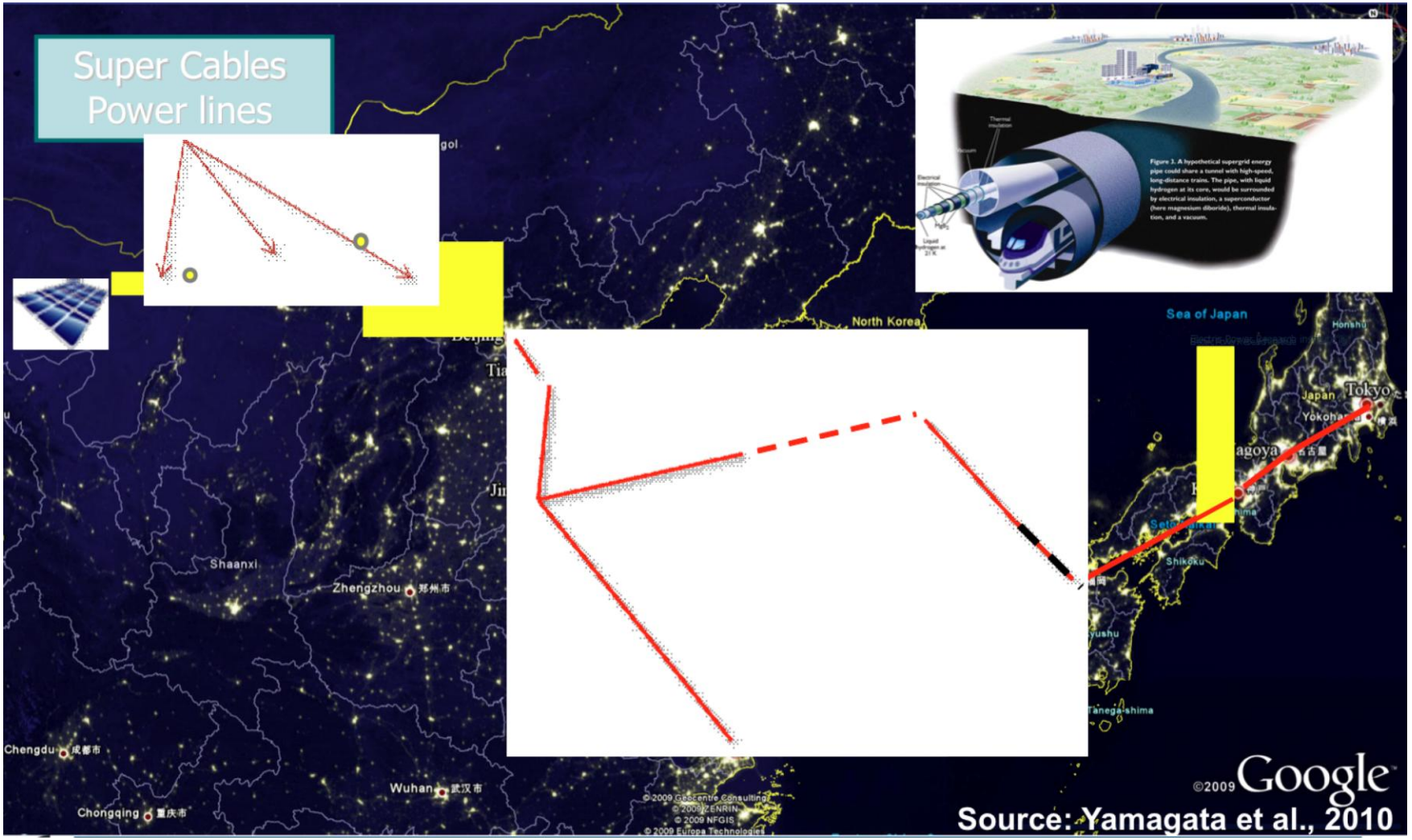
Source: Hasani et al., 2011

Energy for Europe (Desertec)



Source: Hasani et al., 2011

Asian “Supergrid”



WBGU

Before reconstruction

over 150 kWh/(m²a)

-90%

Reconstruction according to the passive house principle

15 kWh/(m²a)

Source: Fraunhofer-Institut für Bauphysik (IBP), 2012

Framework conditions

Challenges:

- Achieving universal energy access in the world
- Decarbonization of energy systems until 2050

Preconditions:

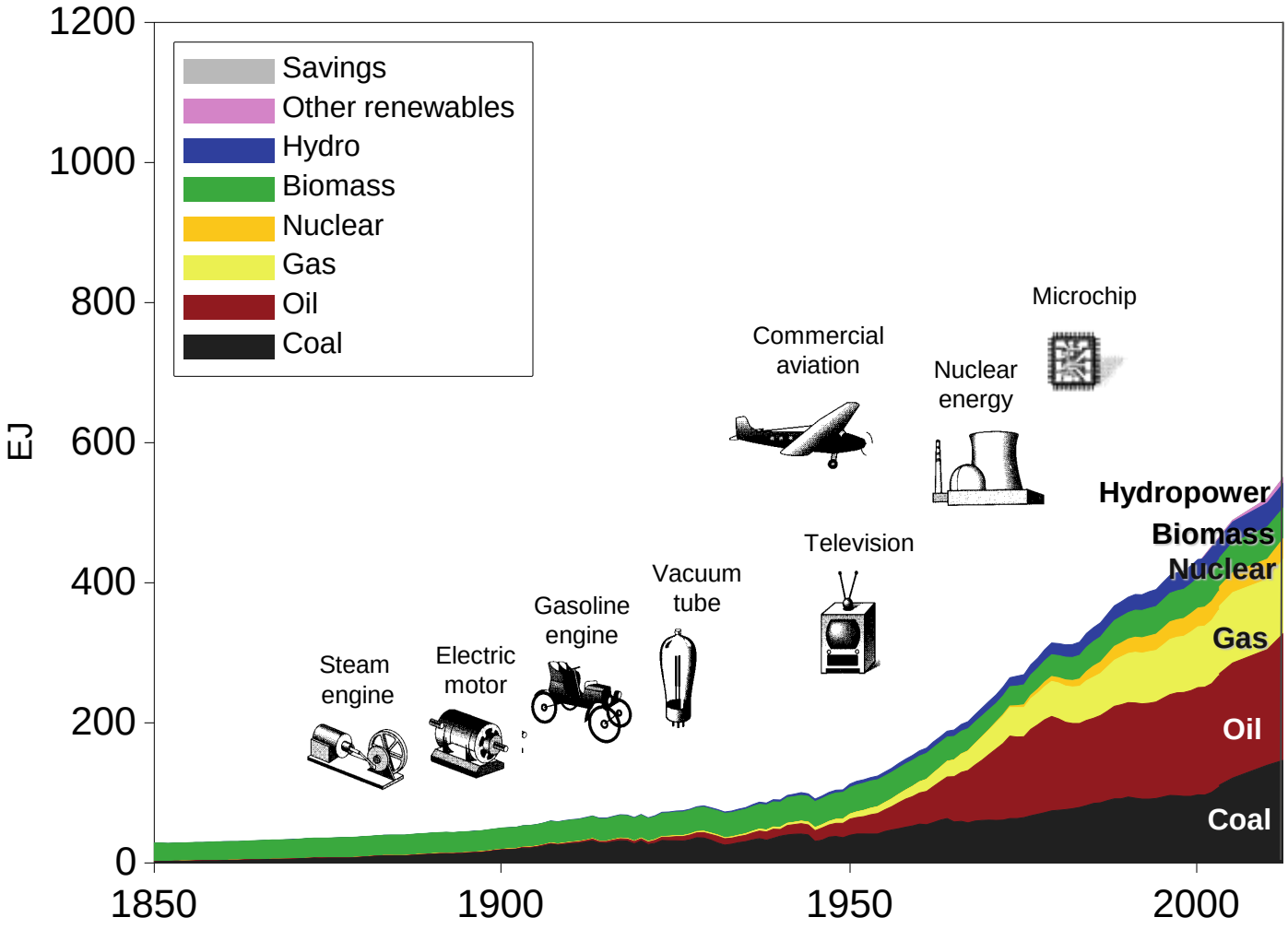
- The global primary energy demand should not increase significantly beyond the current levels
- Drastic improvements in energy efficiency (halving the global of CO2 intensity of energy)
- Behavioral and lifestyles changes necessary

2012 INTERNATIONAL YEAR OF
SUSTAINABLE ENERGY
FOR ALL

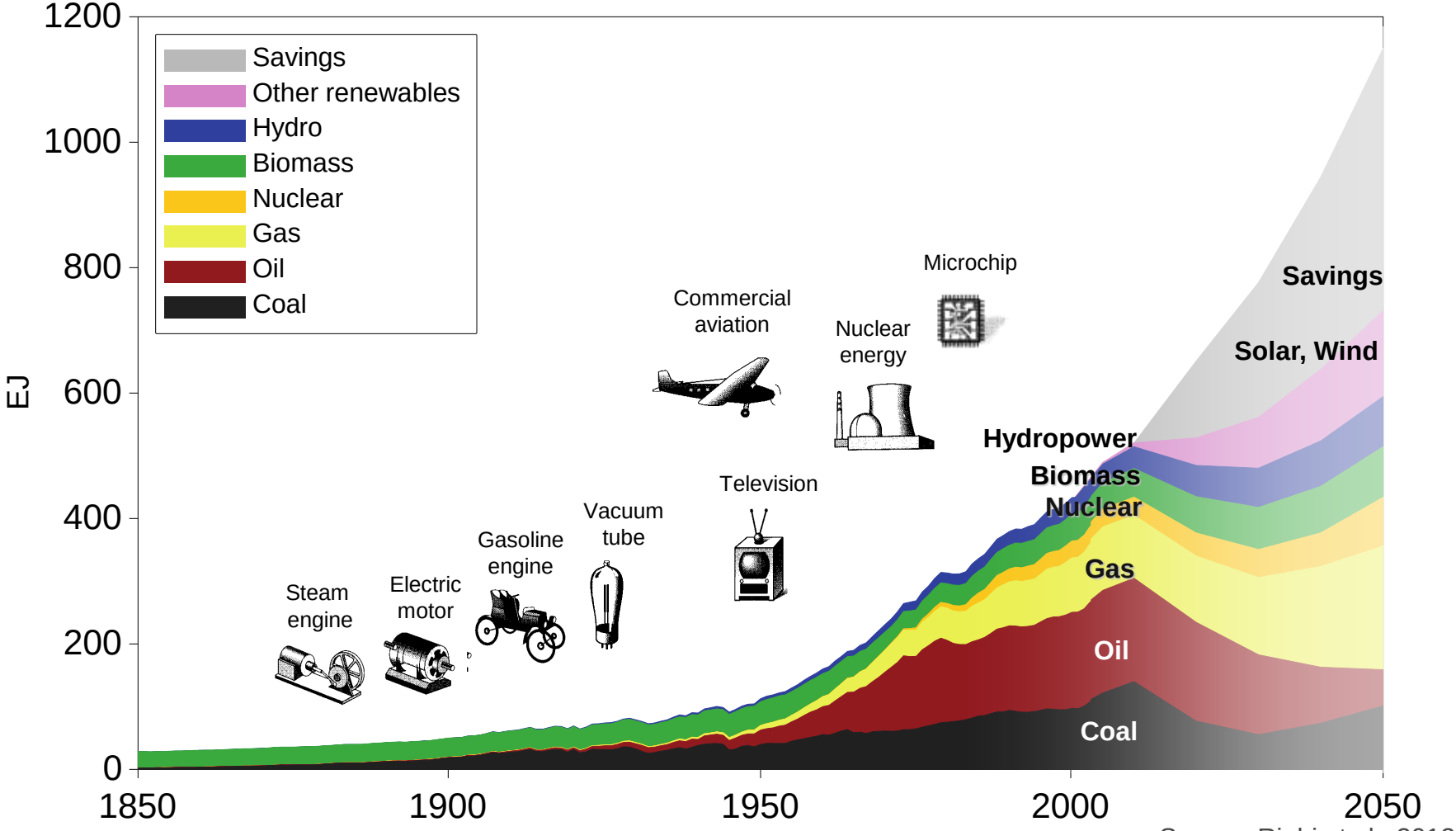
2030 Energy Goals

- Universal Access to Modern Energy
- Double Energy Efficiency Improvement
- Double Renewable Share in Final Energy
- Aspirational & Ambitious but Achievable

Global Primary Energy

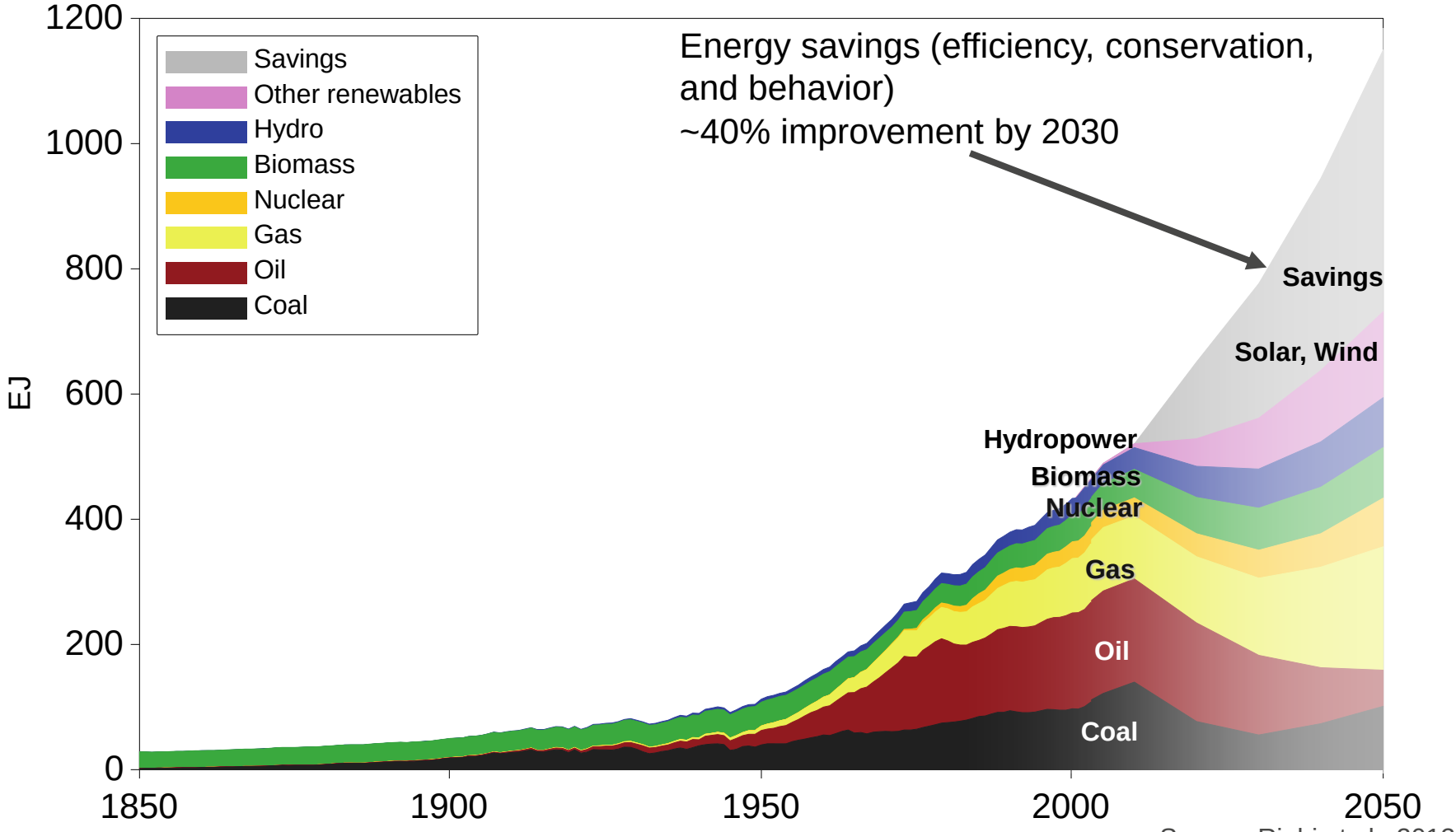


Limited Bioenergy and Intermittent REN



Source: Riahi et al., 2012

Limited Bioenergy and Intermittent REN



Source: Riahi et al., 2012

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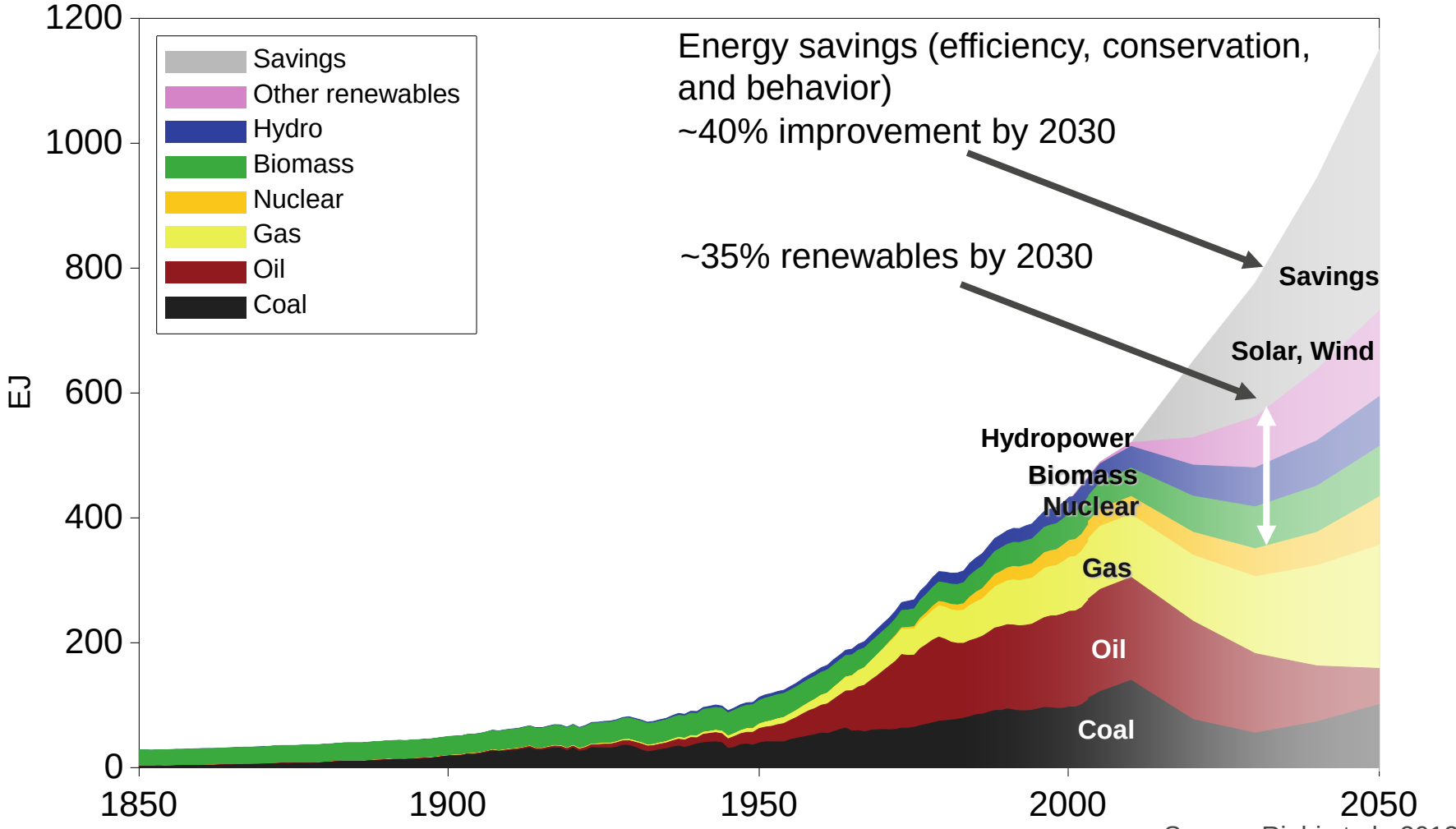

Source: Riahi et al., 2012

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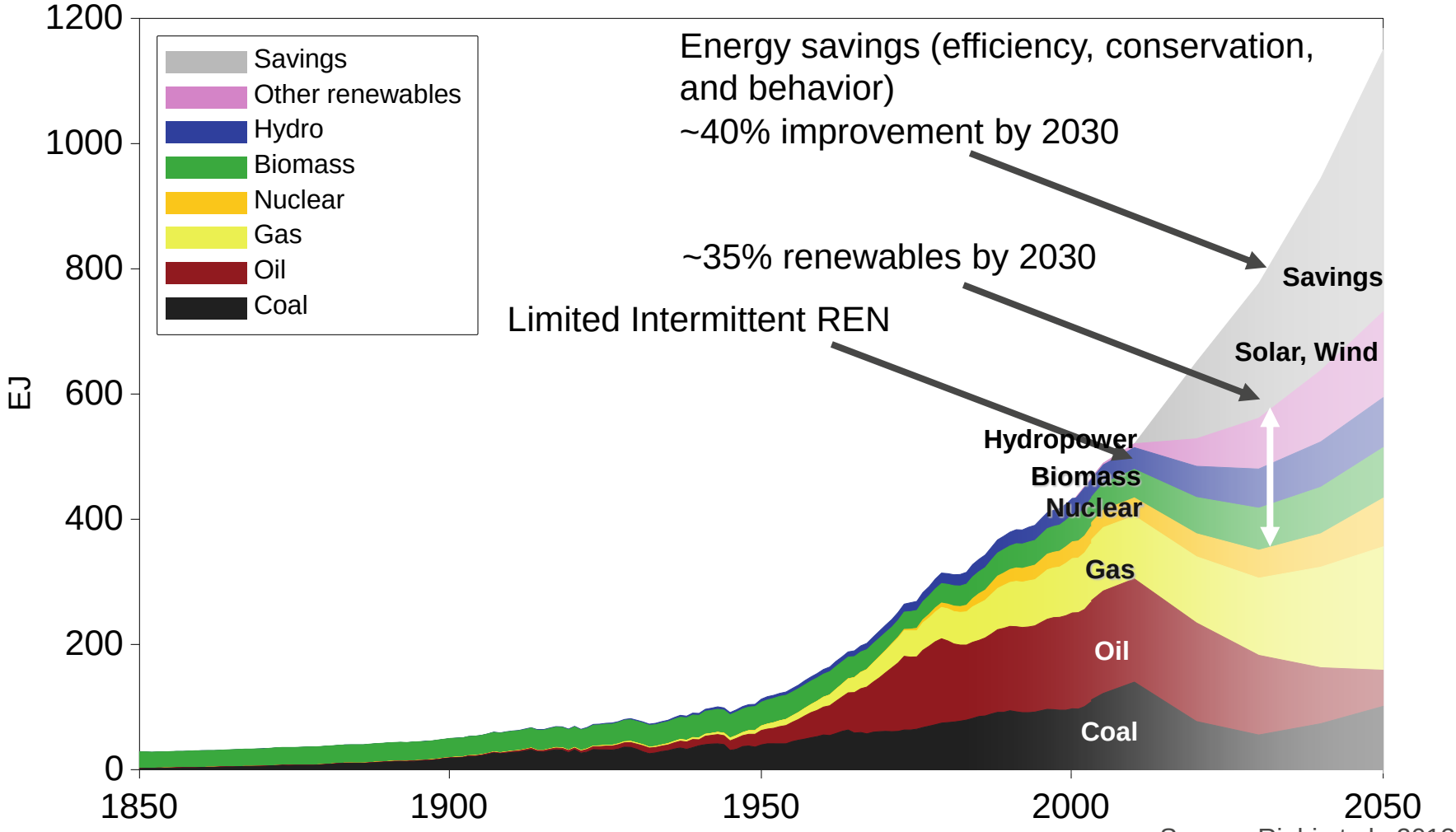

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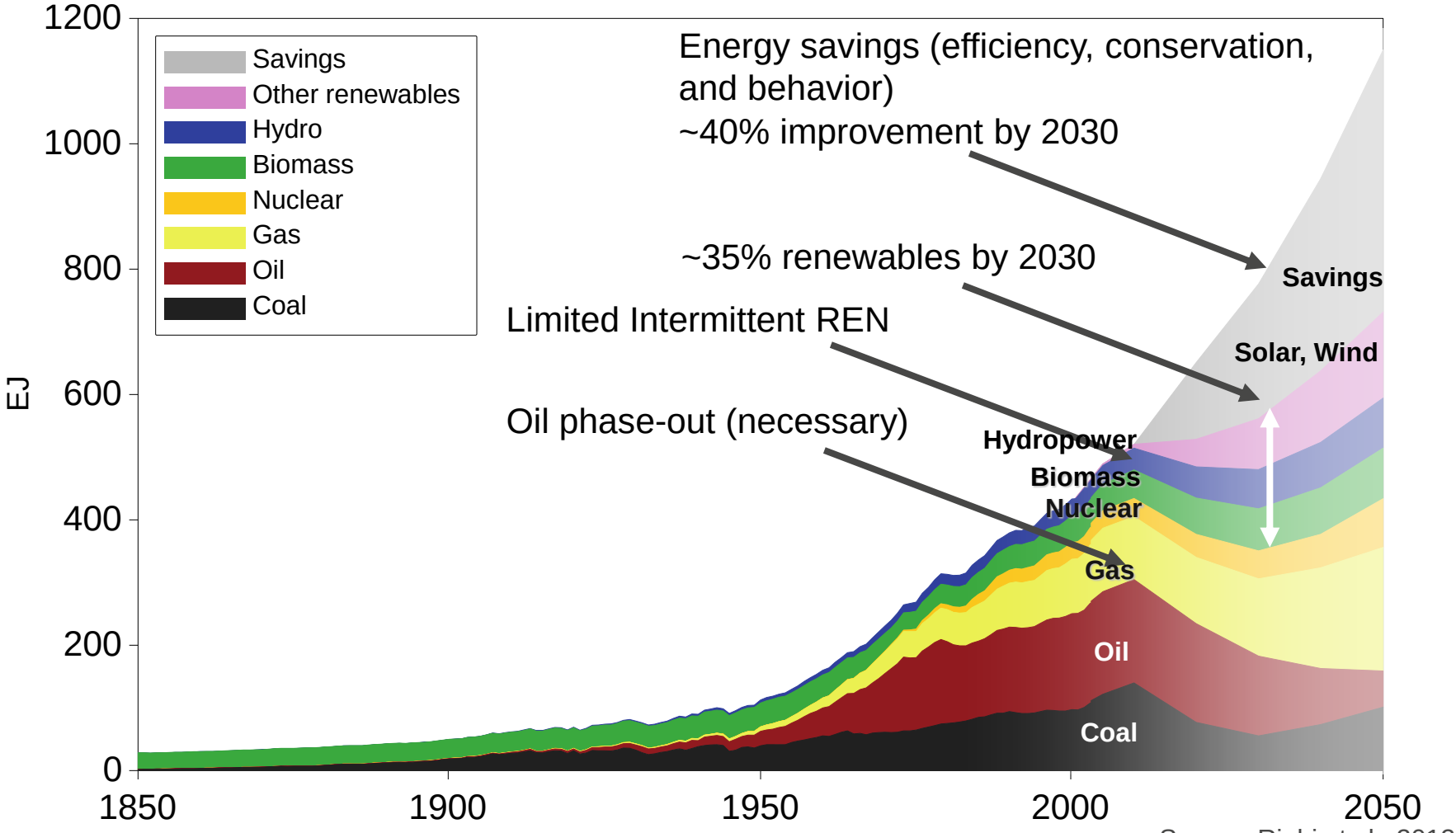

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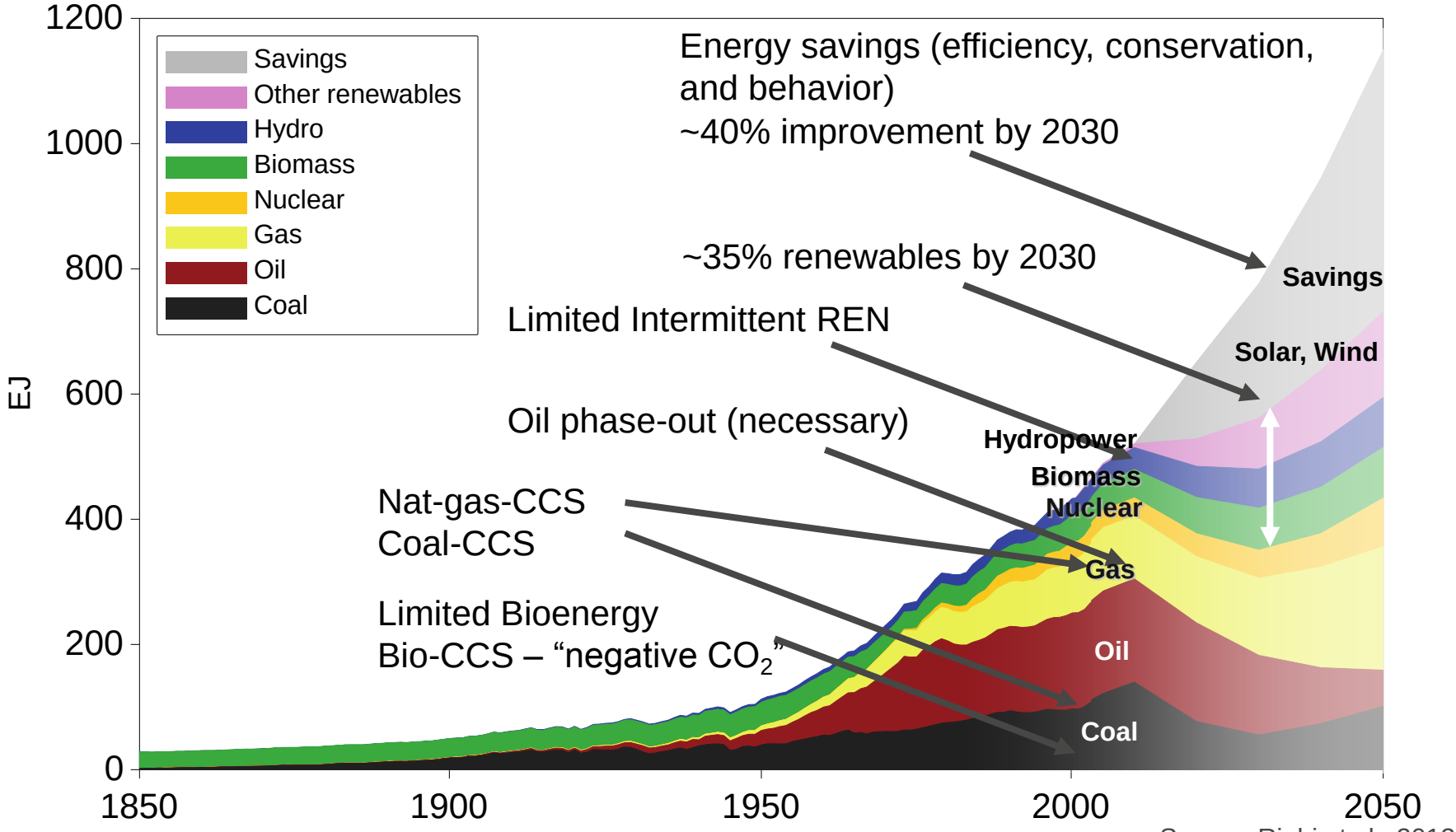
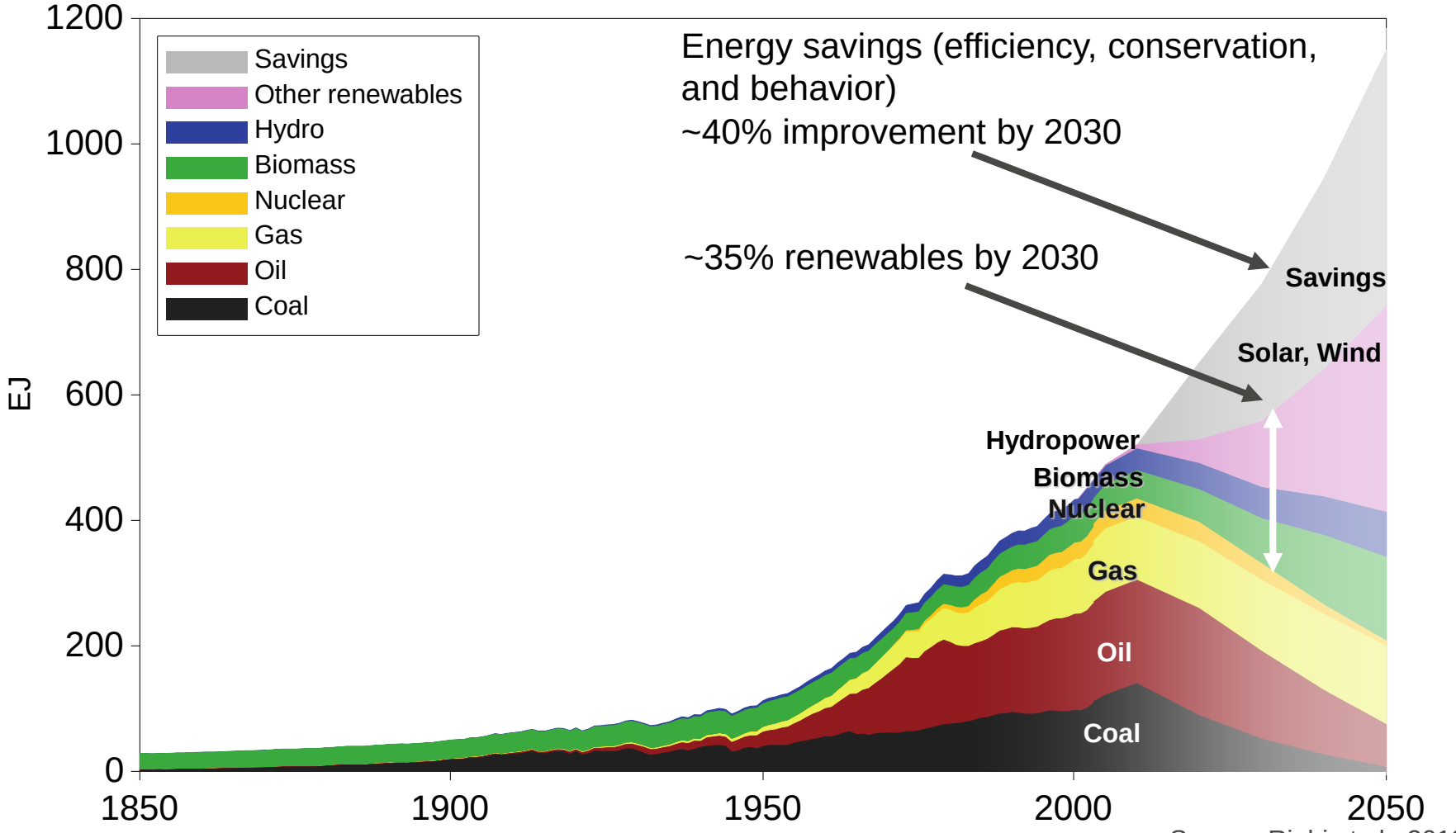


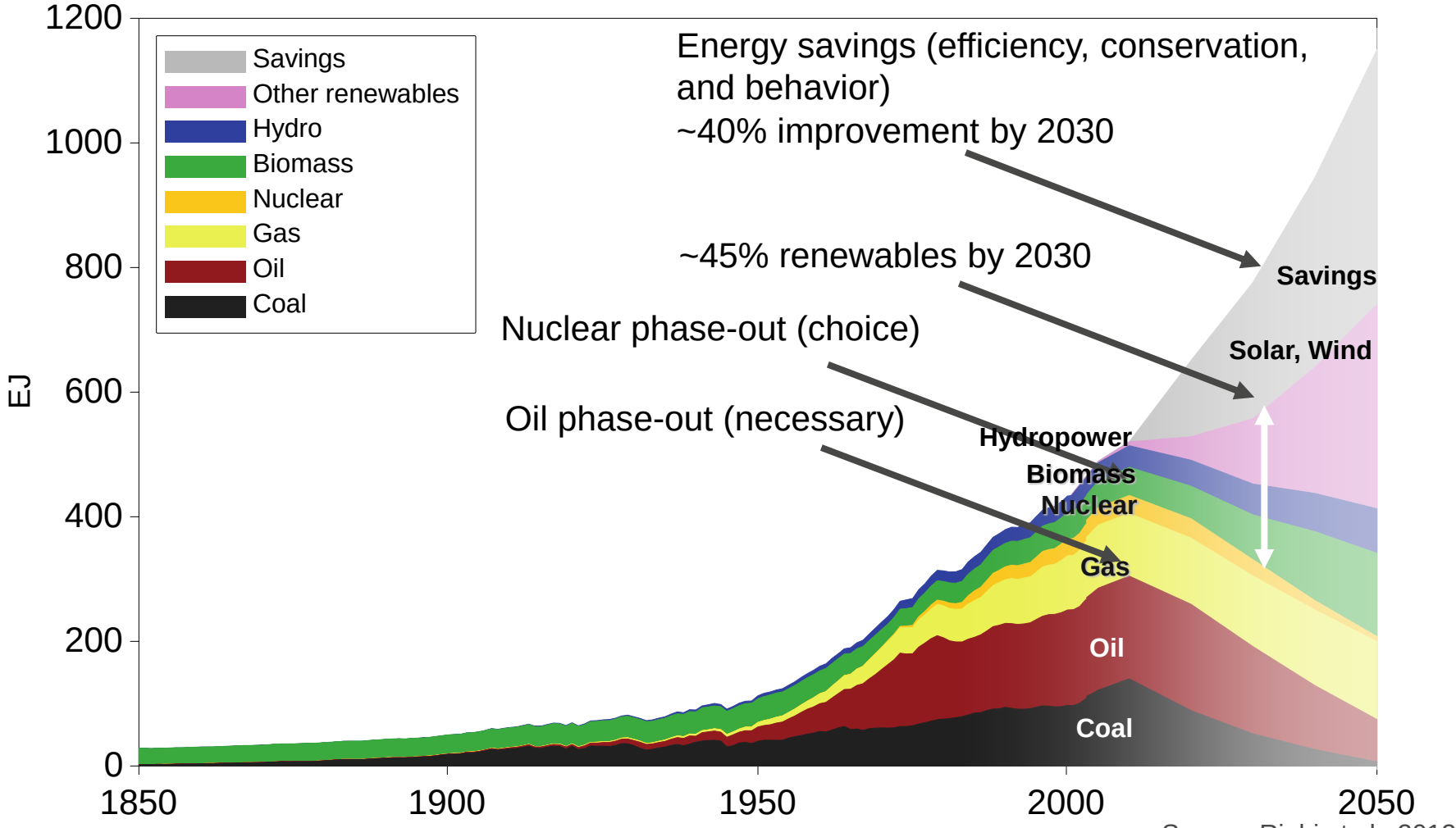
Source: Riahi et al., 2012

Nuclear and CCS Moratorium



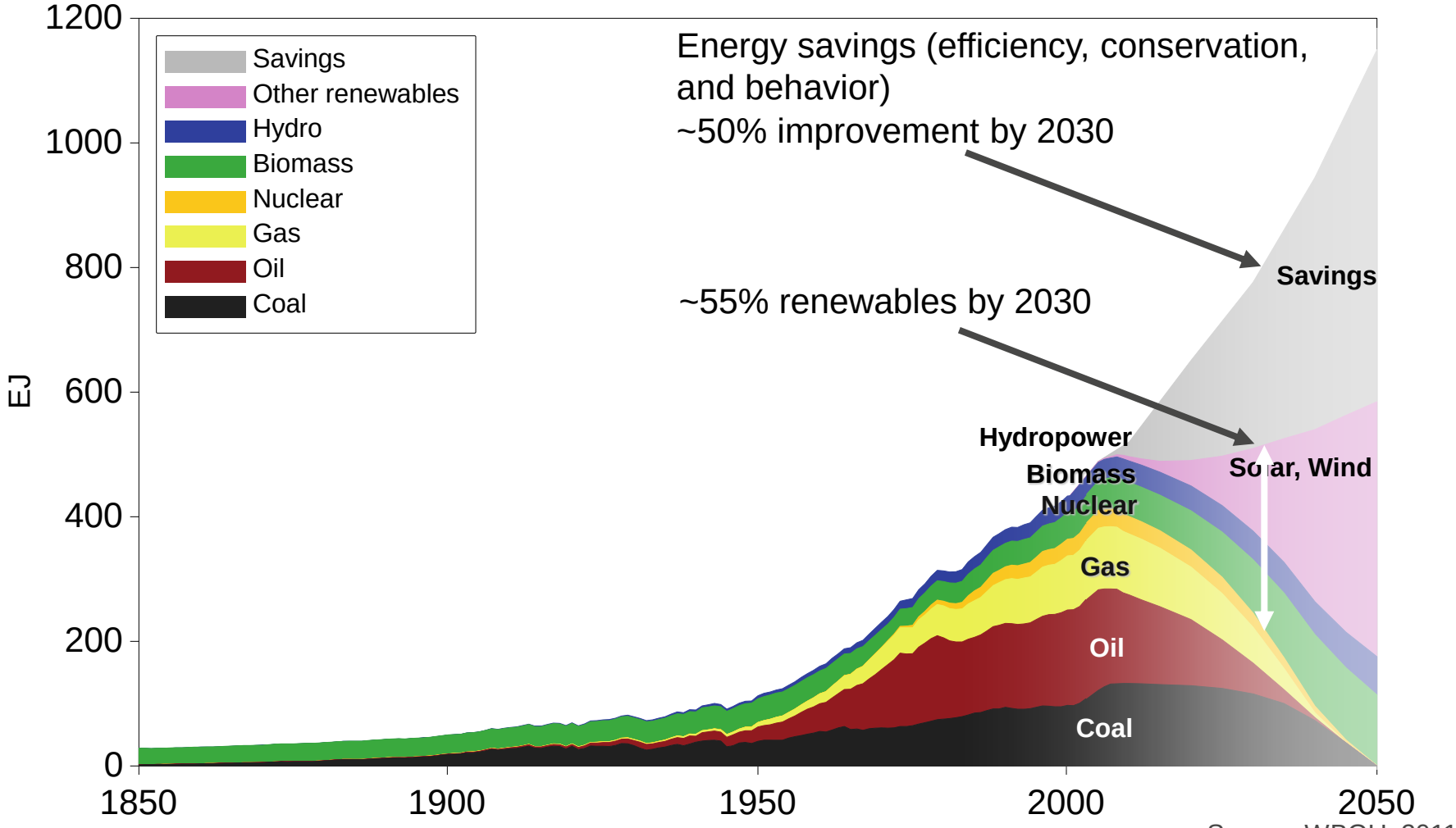
Source: Riahi et al., 2012

Nuclear and CCS Moratorium



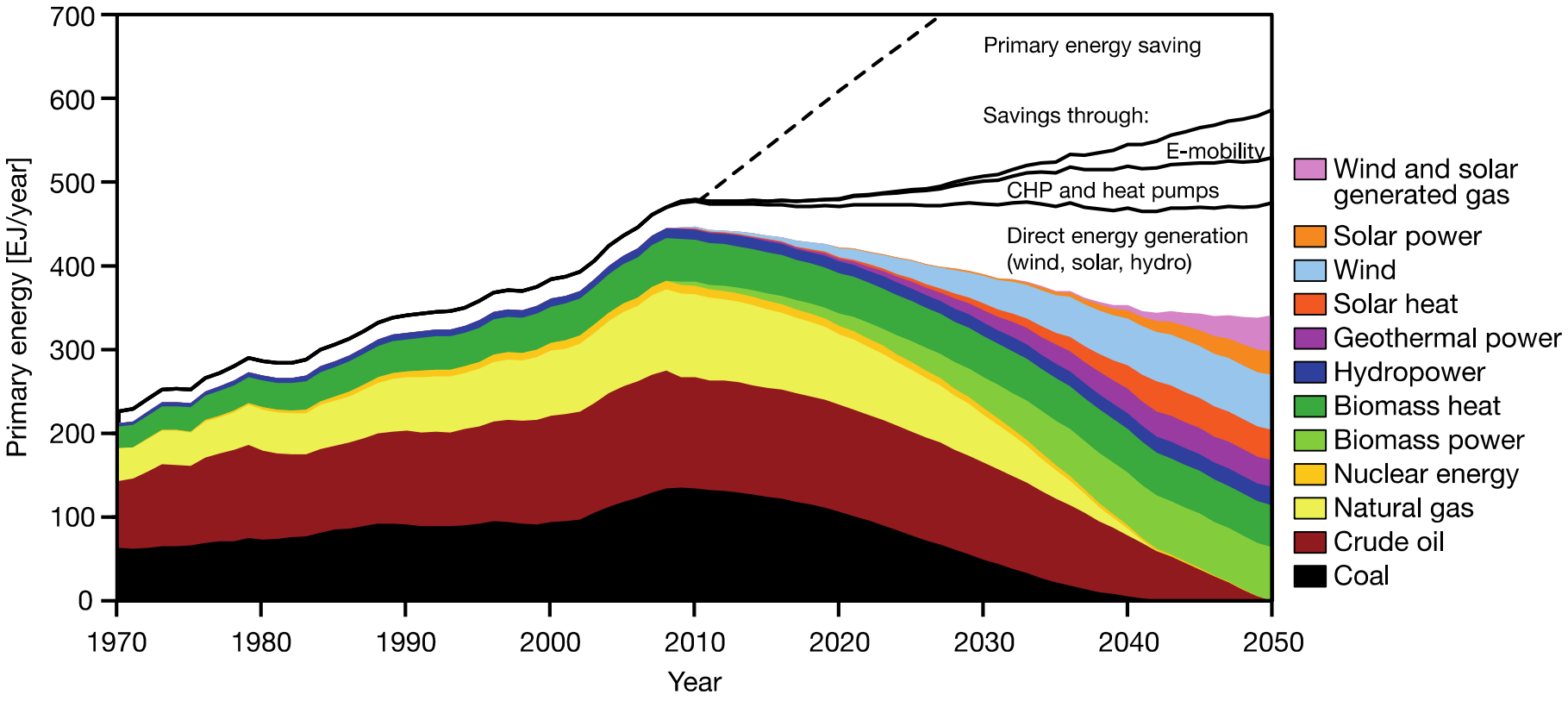
Source: Riahi et al., 2012

WBGU Exemplary Pathway



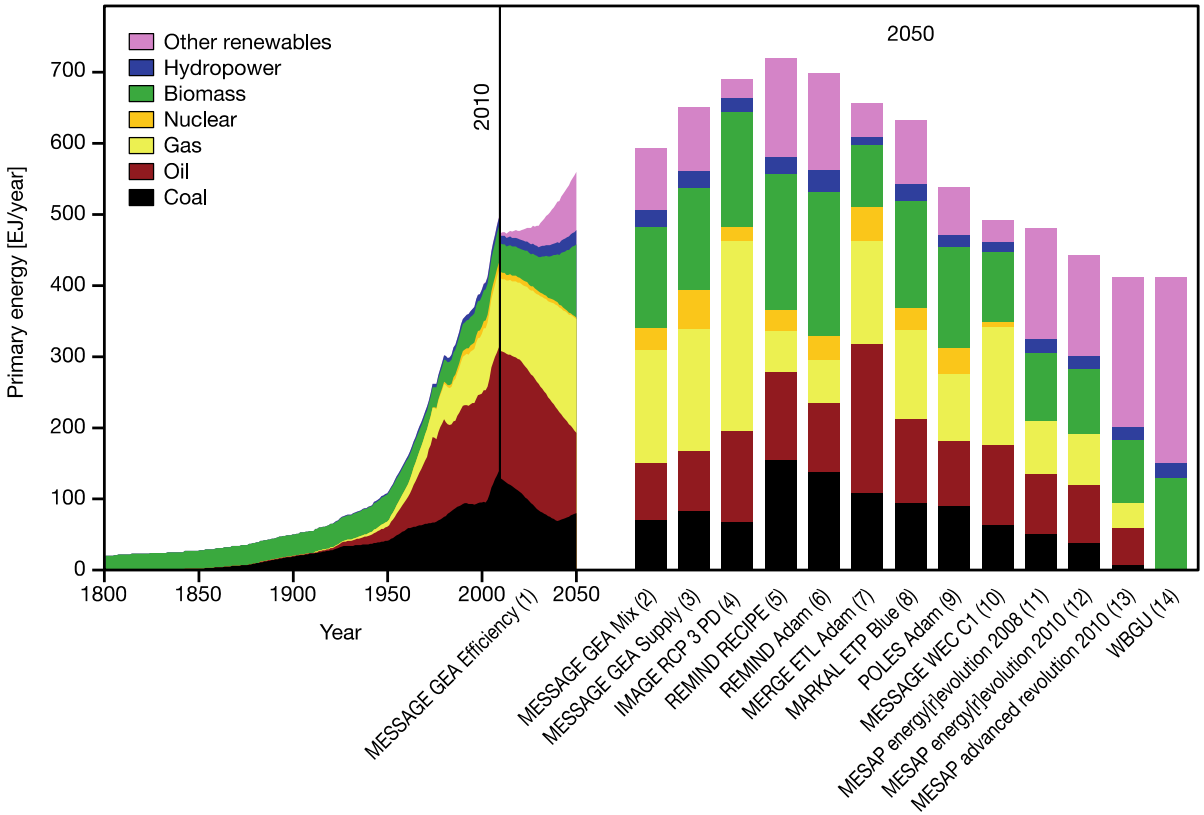
Source: WBGU, 2011

WBGU Exemplary Pathway



Source: WBGU, 2011

Alternative Stabilization Pathways



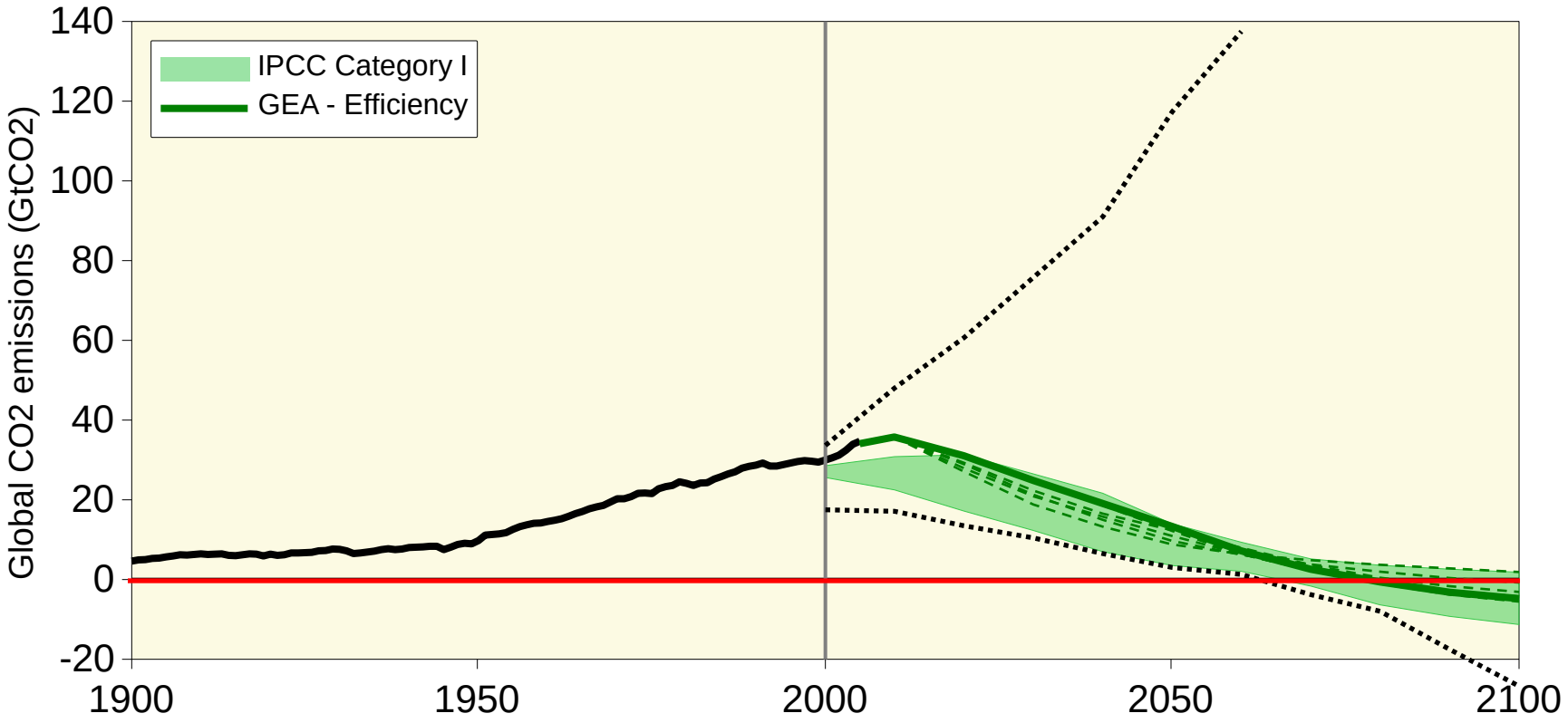
Source: WBGU, based on data from Nakicenovic et al.,1998; EREC und Greenpeace, 2008, 2010; IEA, 2008b; Edenhofer et al., 2009a, 2010; IIASA, 2009; GEA, 2012

Framework conditions

- Vigorous efficiency improvement
- Accelerated development of renewable energy
- Nuclear energy phase-out
- CCS as a transitional option
- CO2-sequestration with biomass as option for the future

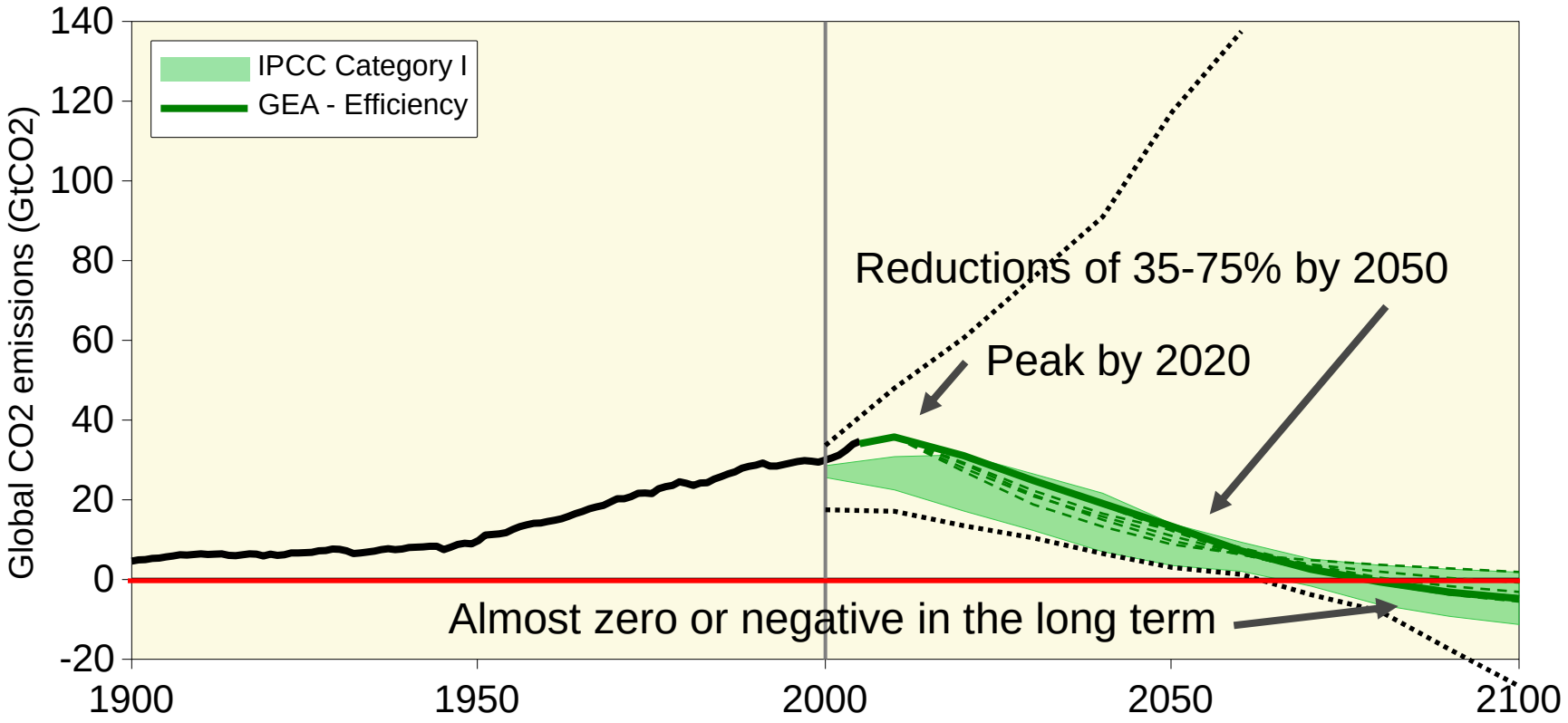
- Urbanization: high energy demand in cities
- Land-use: forest protection and climate-friendly agriculture essential

Global CO_2-eq Emissions



Source: Riahi et al., 2012

Global CO_2-eq Emissions



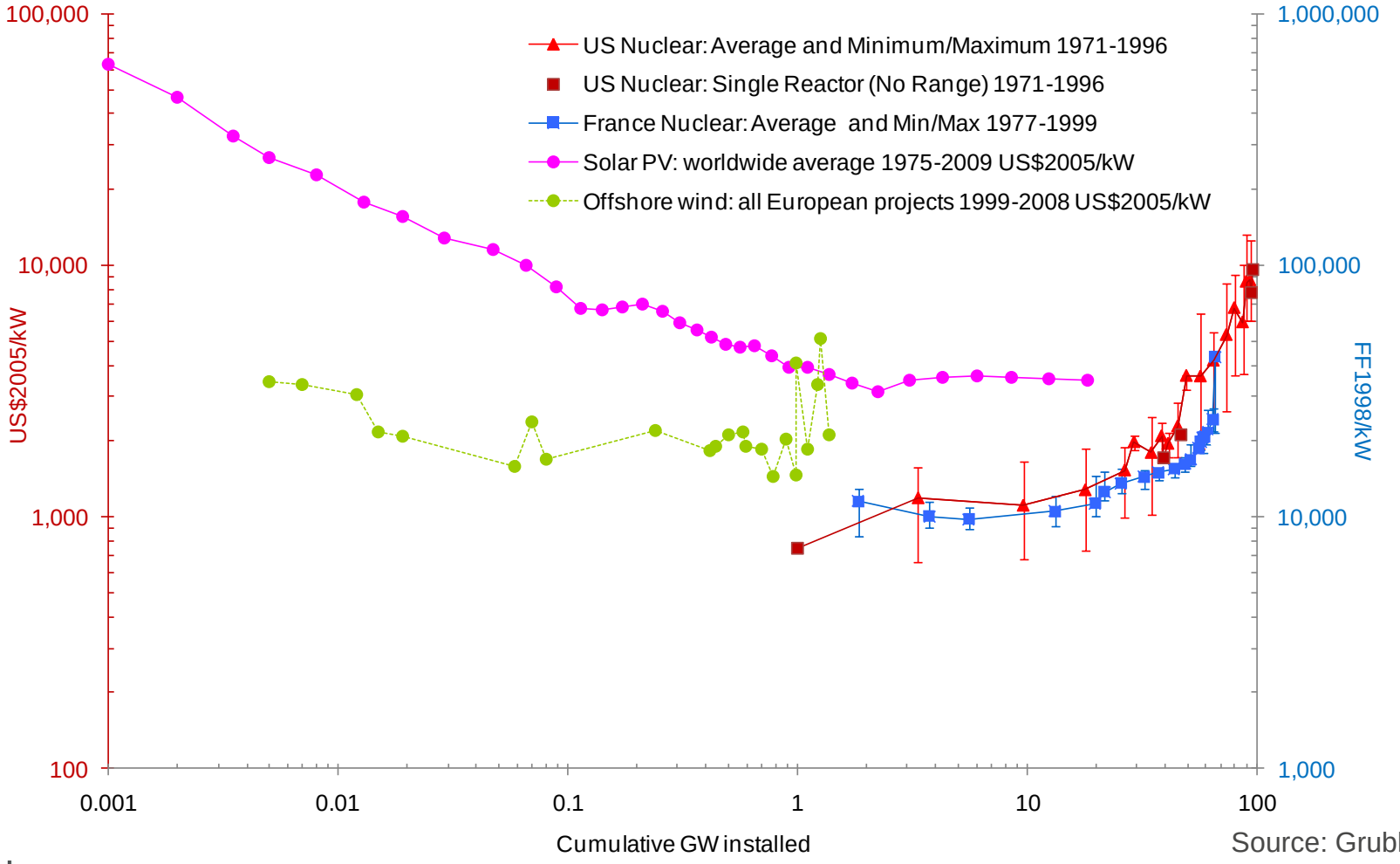
Source: Riahi et al., 2012

Global Energy Investments

Annual Energy Investments	Innovation RD&D [billion US$2005] 2010	Markets Formation [billion US$2005] 2010	Present Investments [billion US$2005] 2010	Investment for SE4All [billion US$2005] 2010 - 2030
Efficiency	>> 8	~ 5	200	258 - 365
Renewables	> 12	~ 20	200	259 - 406
Access	< 1	< 1	~ 9	36 - 41
Total	> 50	< 150	1250	1260 - 1680

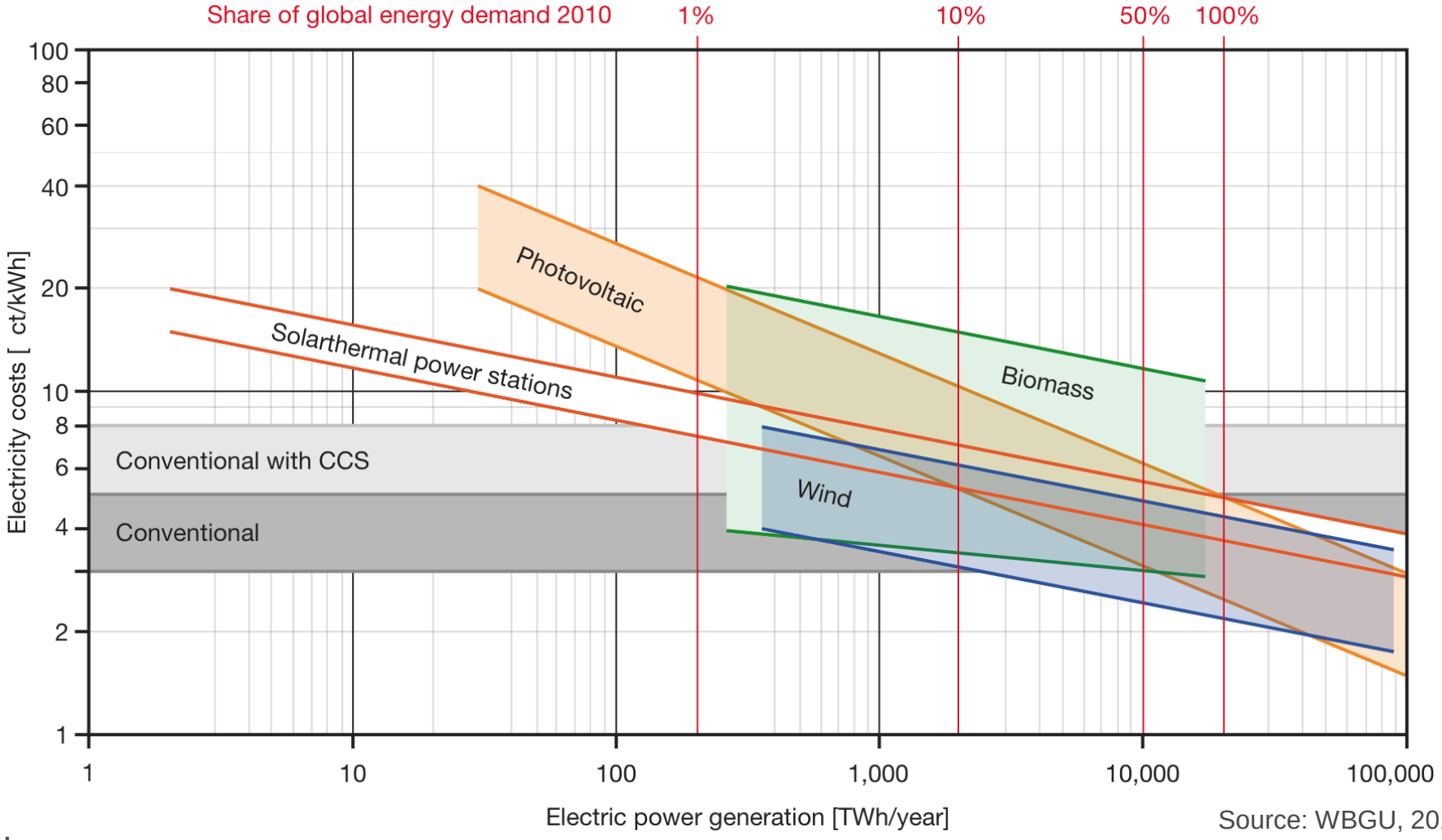
Source: Grubler et al., 2012

Photovoltaics, Offshore Wind and Nuclear



Source: Grubler et al., 2012

for Electricity from Renewables



Source: WBGU, 2011

- The goal is to secure planetary life-support systems.
- The social contract is for the proactive state with improved participation of civil society at local, national and global levels of cooperation.
- The proactive state is to actively set priorities for sustainability and involve increased participation of the civil society in decision-making.

Exercises for Self-Study

1. What are some of the reasons why costs of new and advanced technologies may decline with cumulative experience?

2. Why is it important to limit global mean temperature change to 2° C above the preindustrial level and not 1.5 or 3° C?

3. Discuss why it is important to achieve transformation of global, regional and local energy systems toward sustainable futures.

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Basic reading

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Further reading

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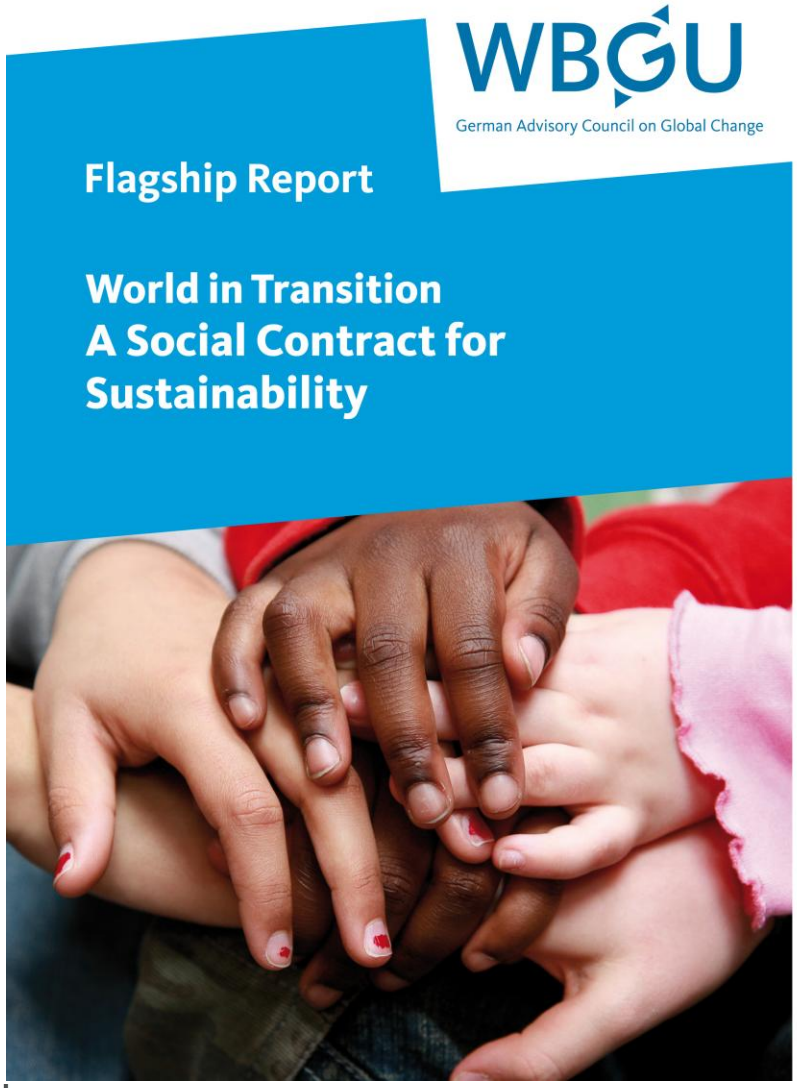

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