

Global Energy Assessment

The Role of Renewables

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- 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

Global Energy Assessment

Toward a Sustainable Future





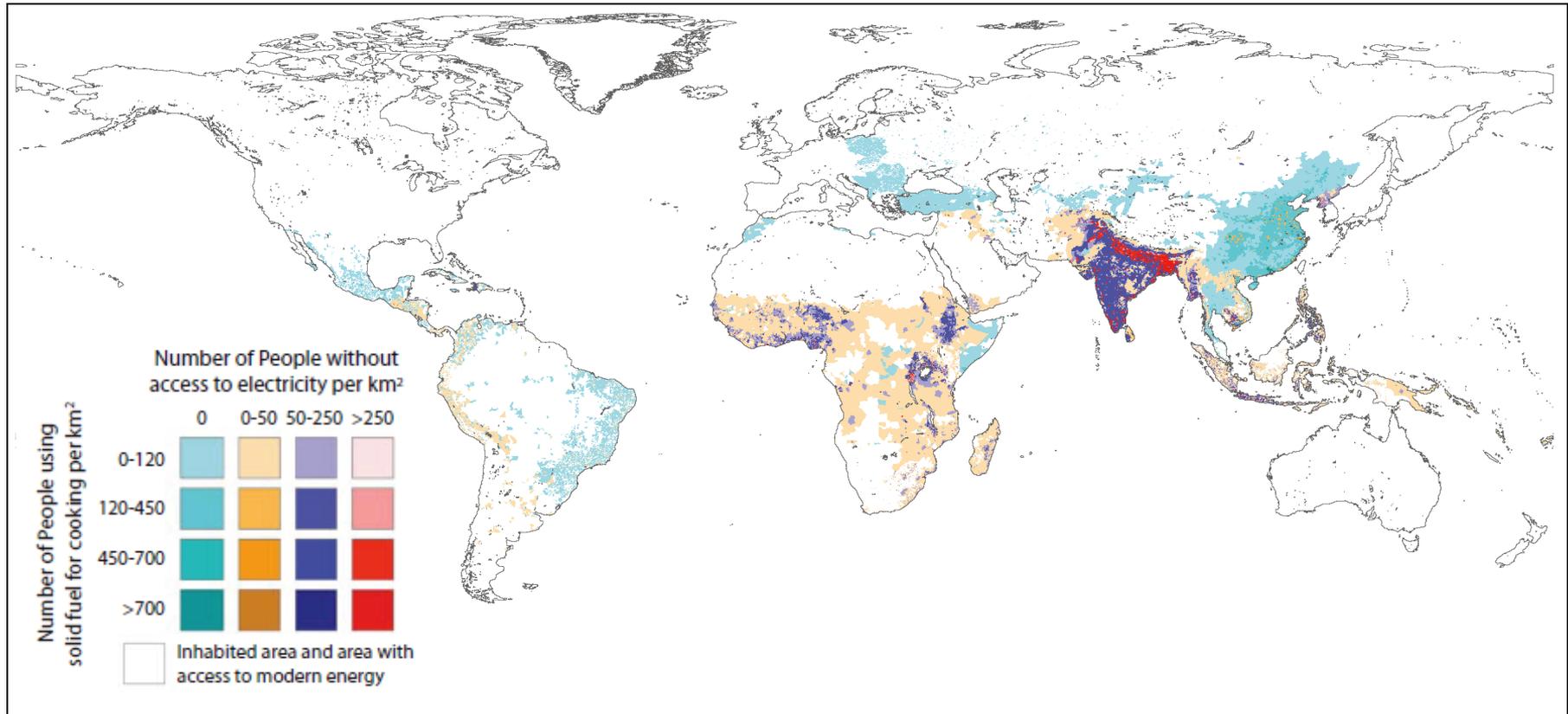
2012 INTERNATIONAL YEAR OF
SUSTAINABLE ENERGY
FOR ALL

2030 Energy Goals

- Universal Access to Modern Energy
- Double Energy Efficiency Improvement
- Double Renewable Share in Final Energy

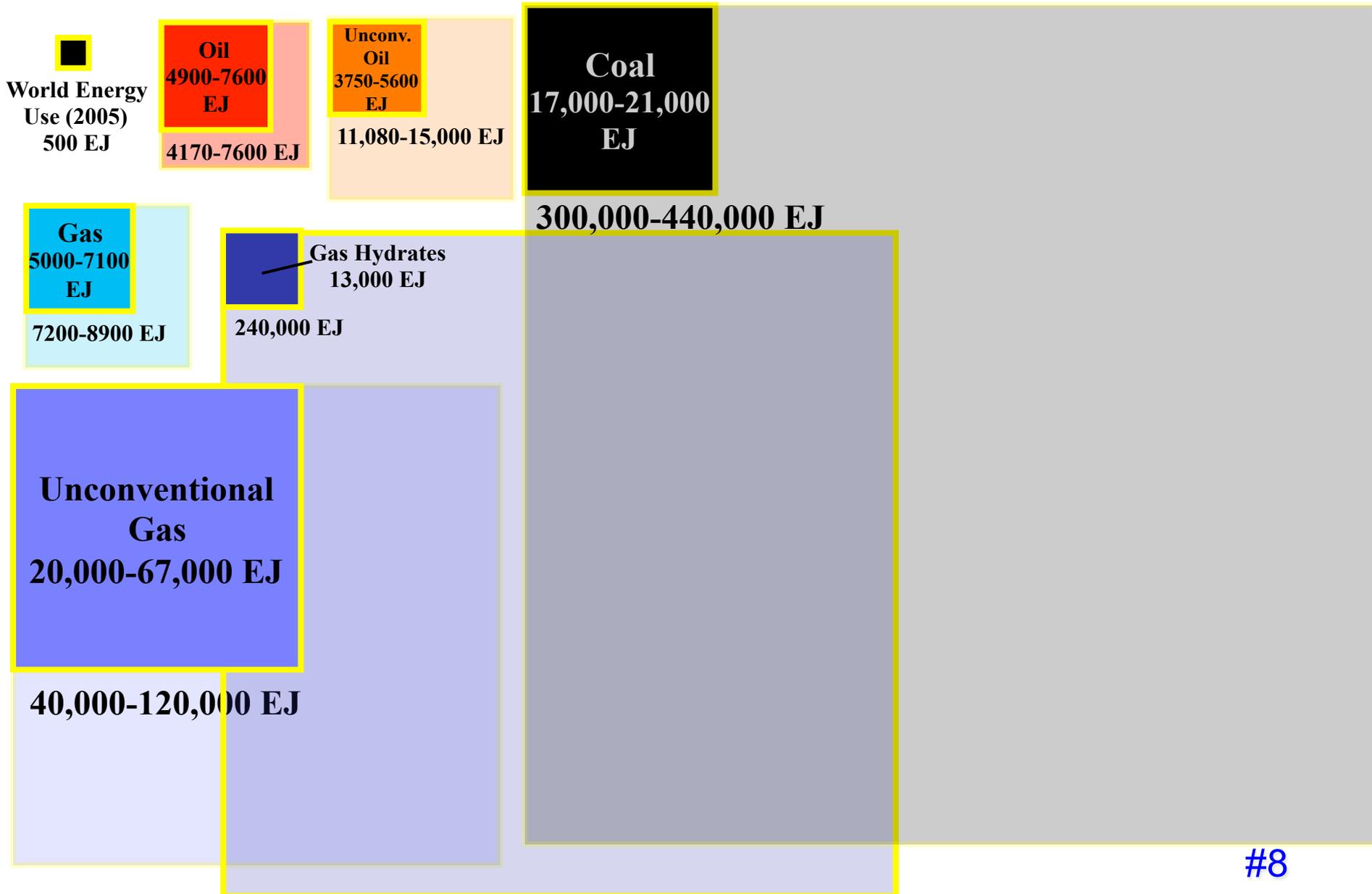
Aspirational & Ambitious but Achievable

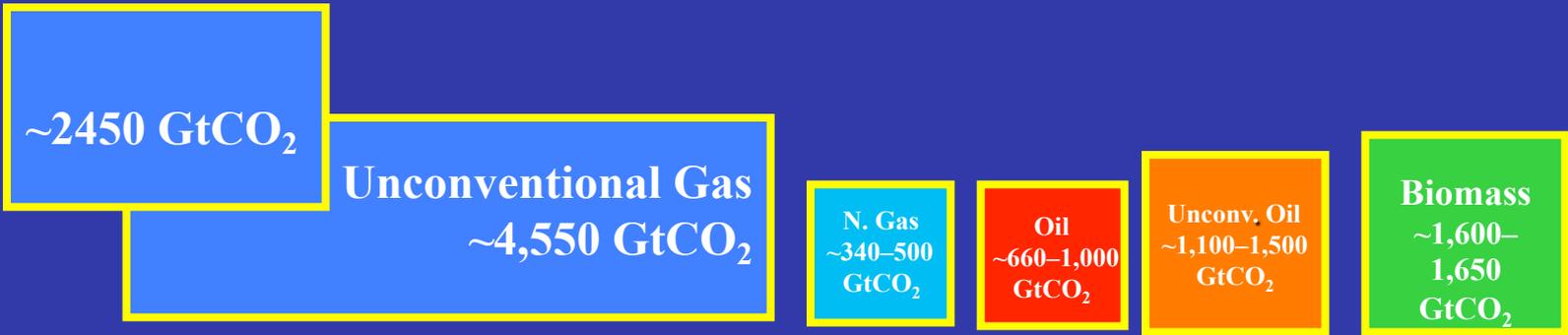
Final energy access (non-commercial share) in relation to population density



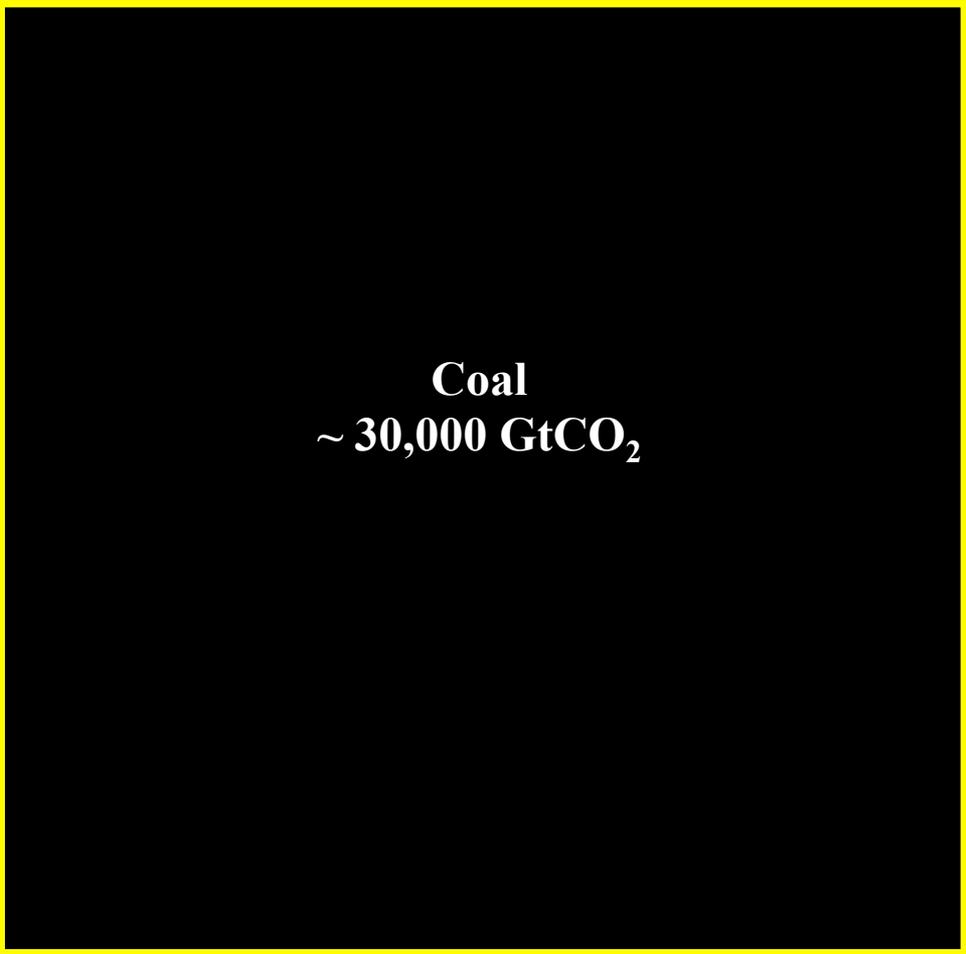
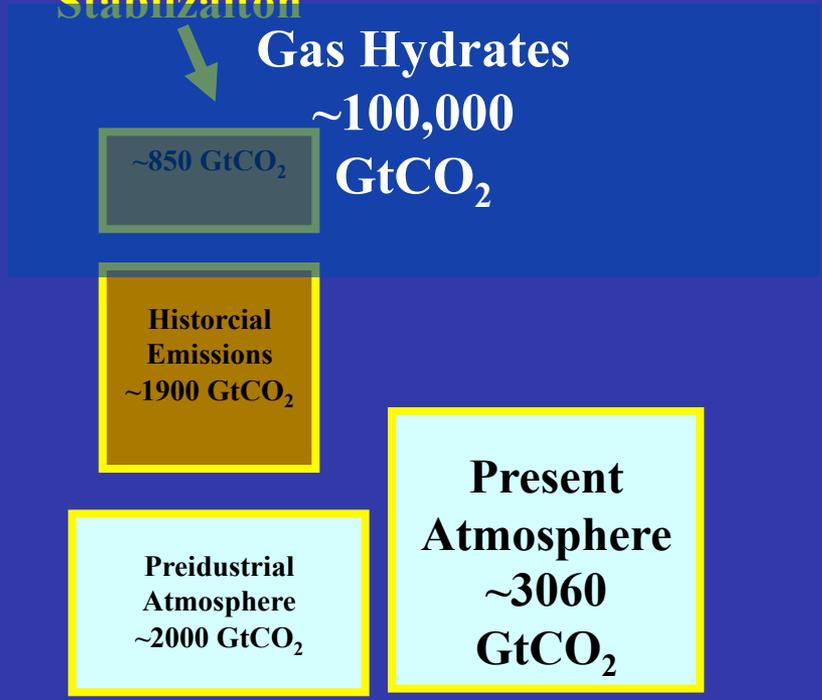
	Historical through 2005	Base year 2005	Reserves	Resources	Additional occurrences
	[EJ]	[EJ]	[EJ]	[EJ]	[EJ]
Conventional oil	6 069	147.9	4 900 - 7 610	4 170 - 6 150	
Unconventional oil	513	20.2	3 750 - 5 600	11 280 - 14 800	> 40 000
Conventional gas	3 087	89.8	5 000 - 7 100	7 200 - 8 900	
Unconventional gas	113	9.6	20 100 - 67 100	40 200 - 121 900	> 1 000 000
Coal	6 712	123.8	17 300 - 21 000	291 000 – 435 000	
Conventional uranium	1 218	24.7	2 400	7 400	
Unconventional uranium	34	n.a.		7 100	> 2 600 000

	Base year 2005	Technical potential	Annual flows
	[EJ]	[EJ/a]	[EJ/a]
Biomass, MSW, etc.	46.3	160 - 270	2200
Geothermal	2.3	810 - 1545	1 500
Hydro	11.7	50 - 60	200
Solar	0.5	62 000 -280 000	3 900 000
Wind	1.3	1 250 -2 250	110 000
Ocean	-	3 240 - 10 500	1 000 000



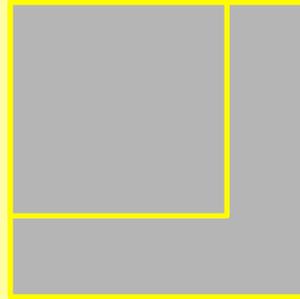


Cumulative Emissions for 2°C Stabilization





Biomass
160-270 EJ/yr



Geothermal
810-1545 EJ/yr

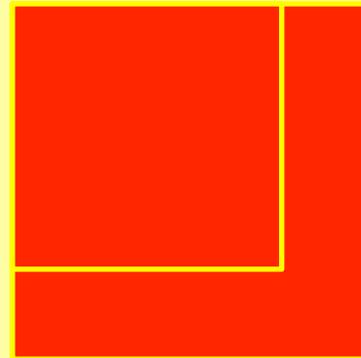


World Energy Use (2005)
500 EJ

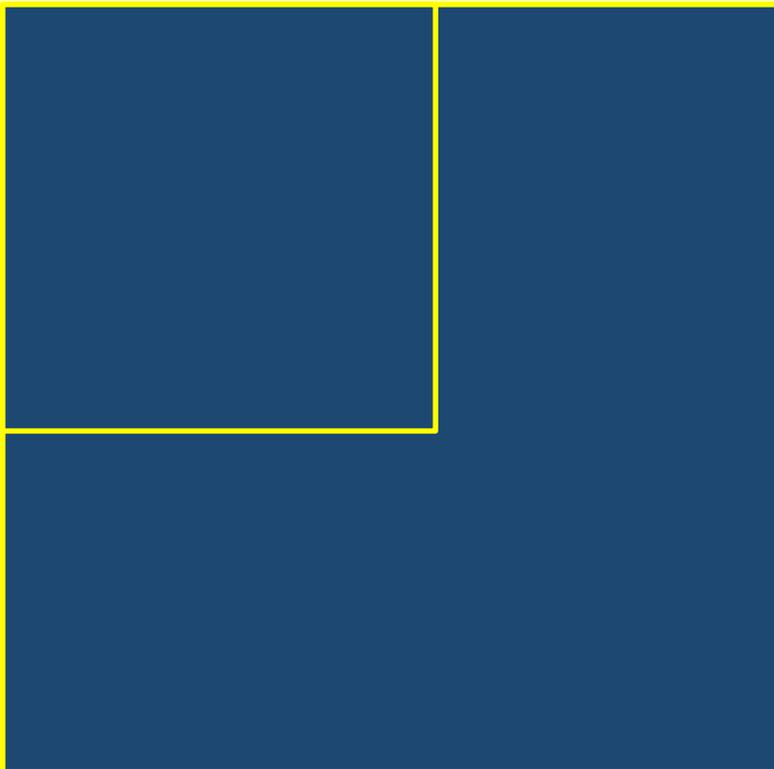


Hydro
50-60 EJ/yr

Solar
62,000-280,000 EJ/yr



Wind
1250-2250 EJ/yr

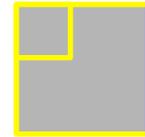


Ocean
3240-10,500 EJ/yr

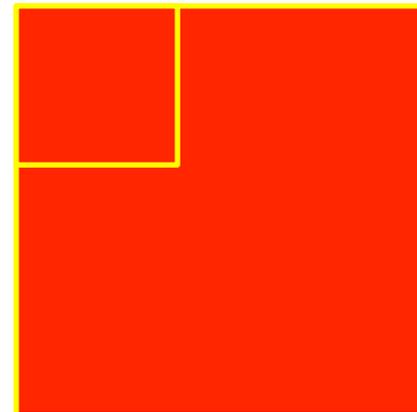
Supply Pathway by 2050 and 2100



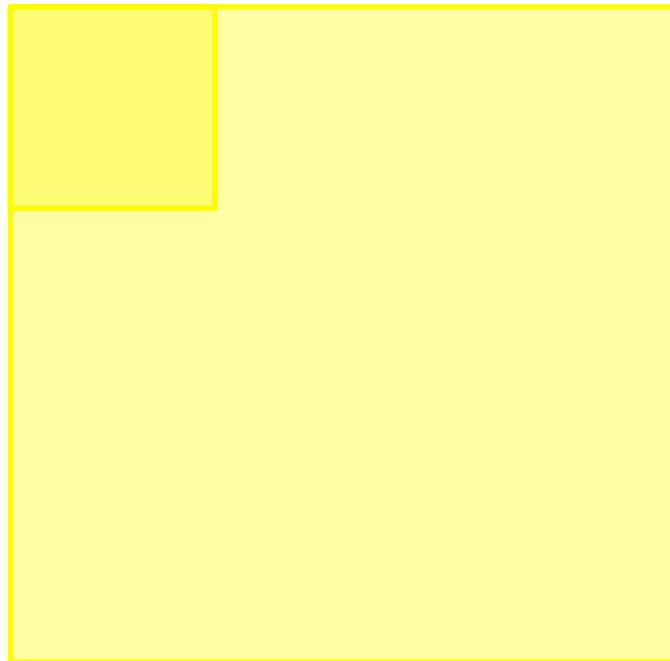
World Energy Use (2005)
500 EJ



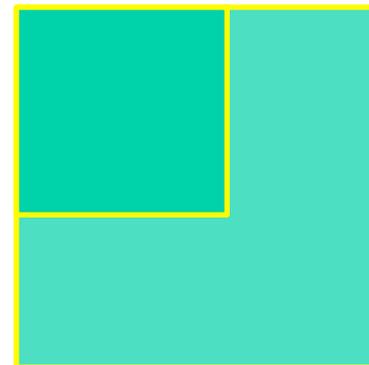
Geothermal
50-299 EJ



Wind
450-2984 EJ



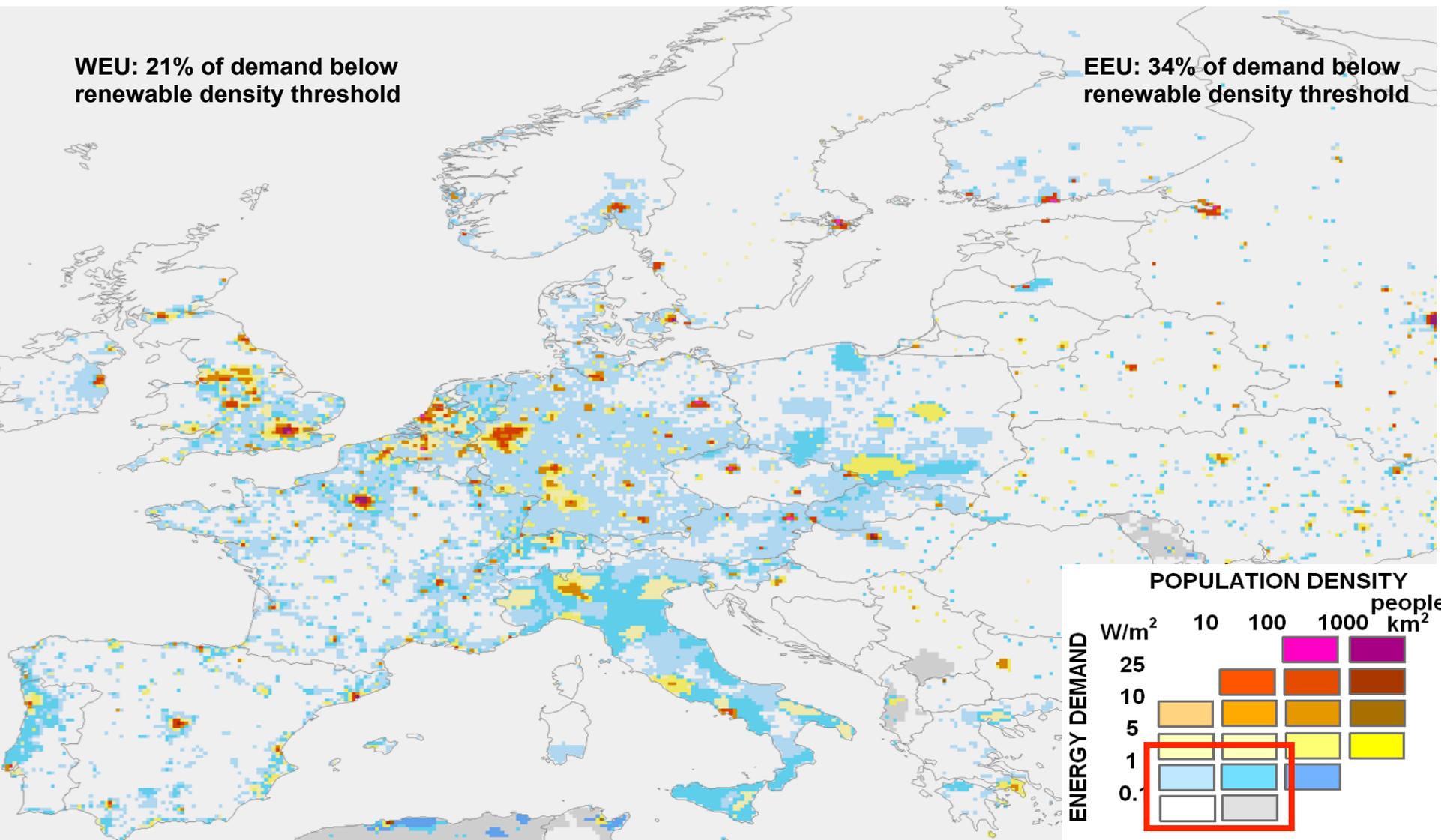
Solar
381-3865 EJ



Hydro
765-2314 EJ

WEU: 21% of demand below renewable density threshold

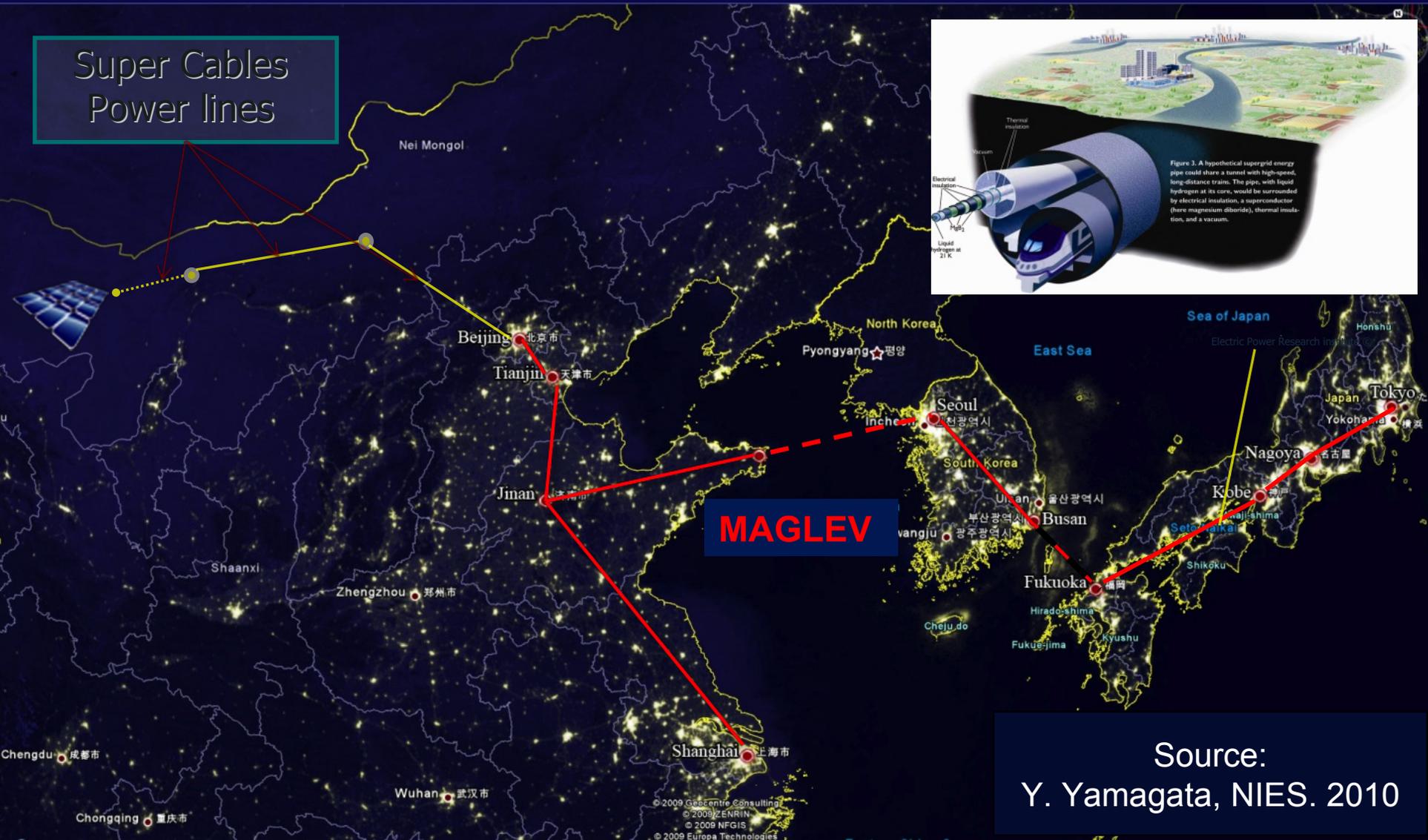
EEU: 34% of demand below renewable density threshold





Potential Synergies between New Energy and Transport Infrastructures: Asian "Supergrid"

Super Cables
Power lines



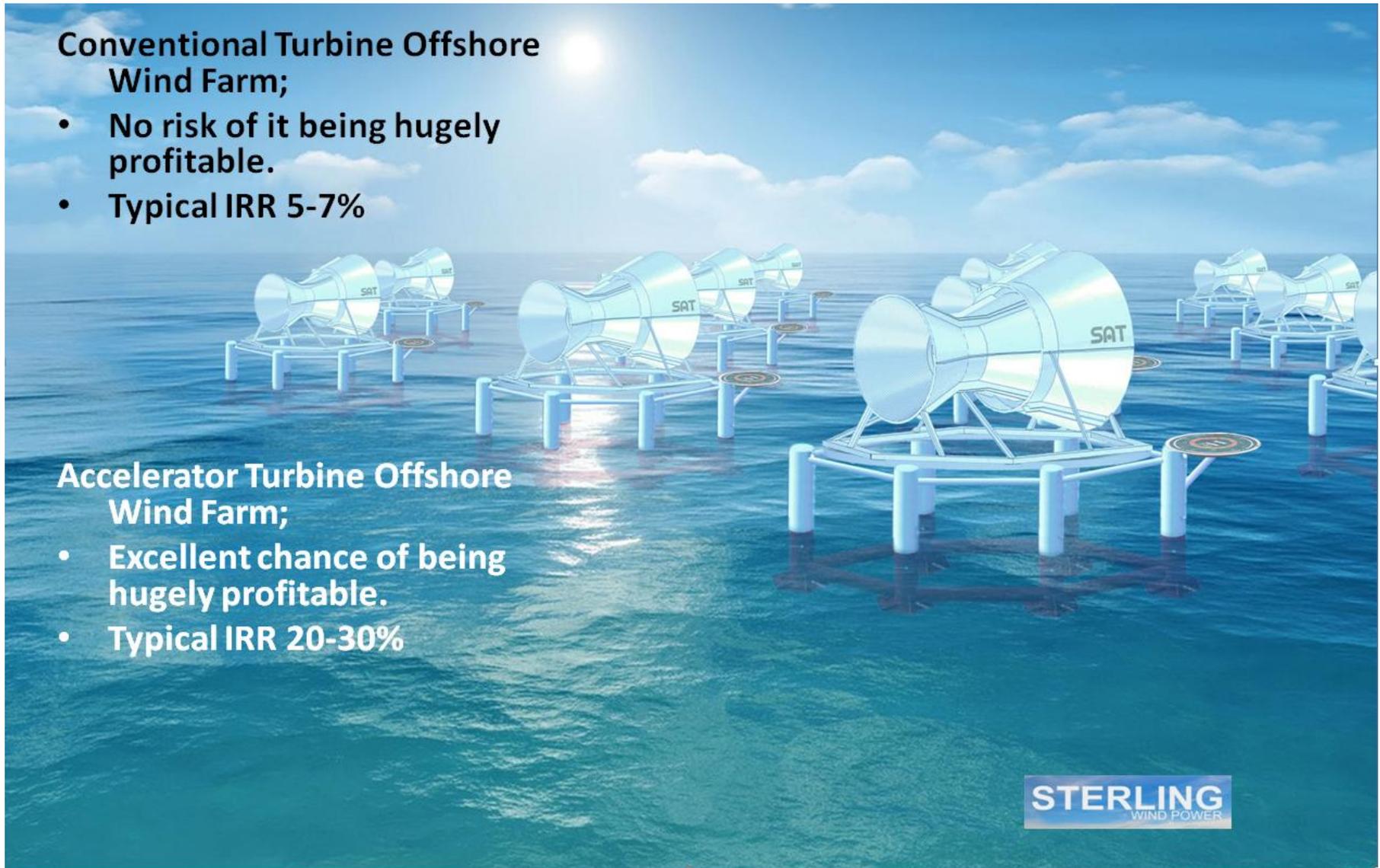
Source:
Y. Yamagata, NIES. 2010

Conventional Turbine Offshore Wind Farm;

- No risk of it being hugely profitable.
- Typical IRR 5-7%

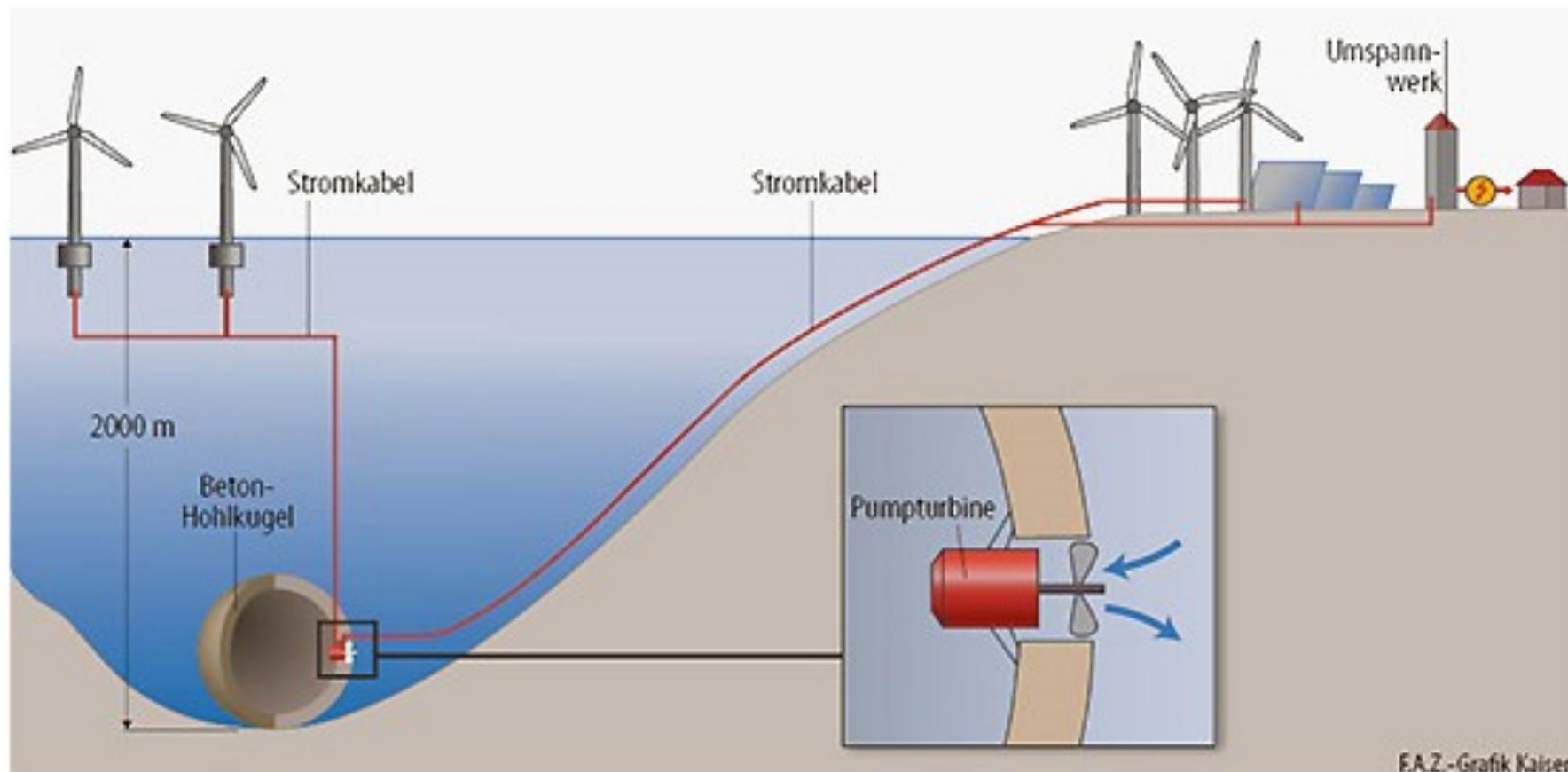
Accelerator Turbine Offshore Wind Farm;

- Excellent chance of being hugely profitable.
- Typical IRR 20-30%

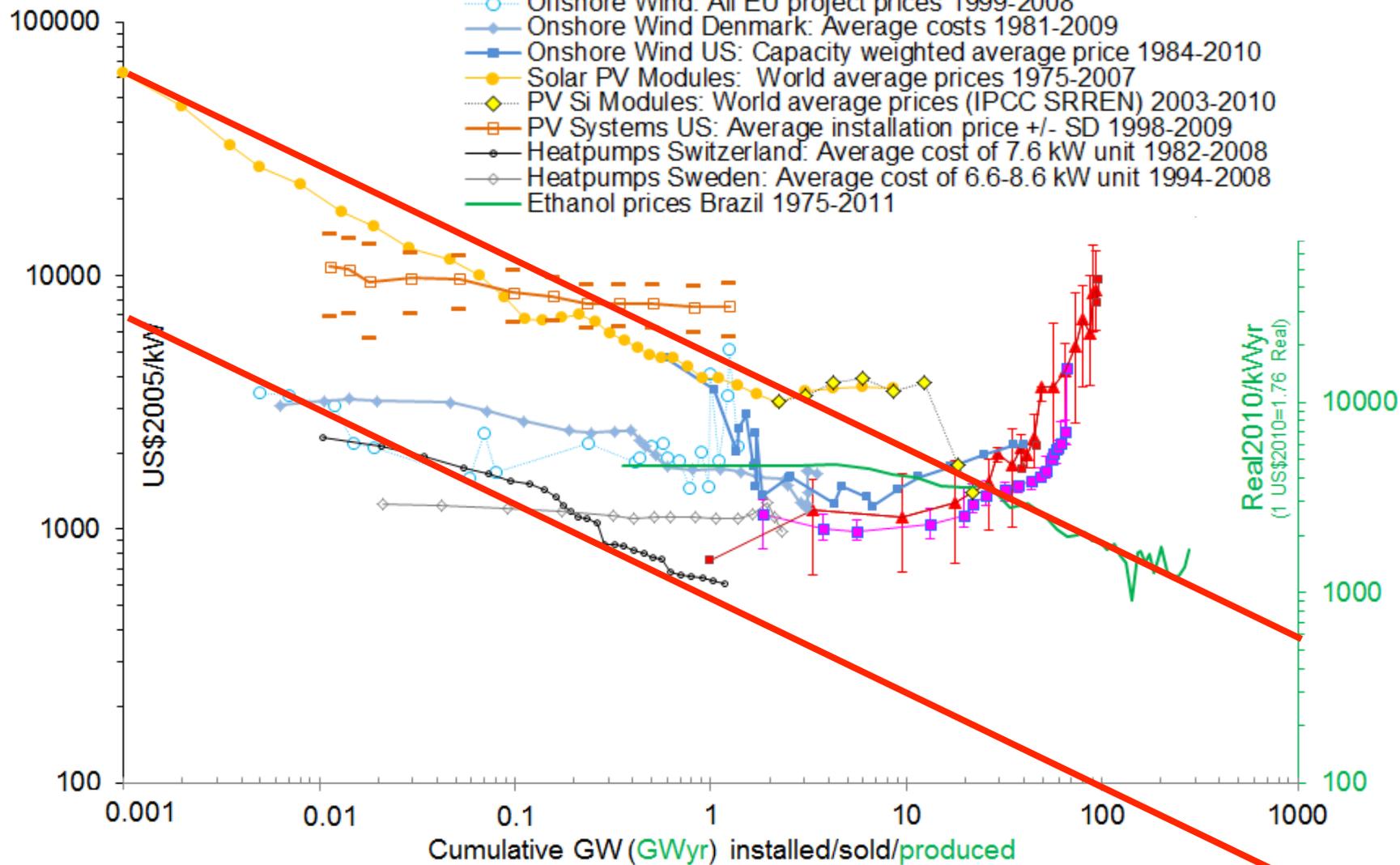


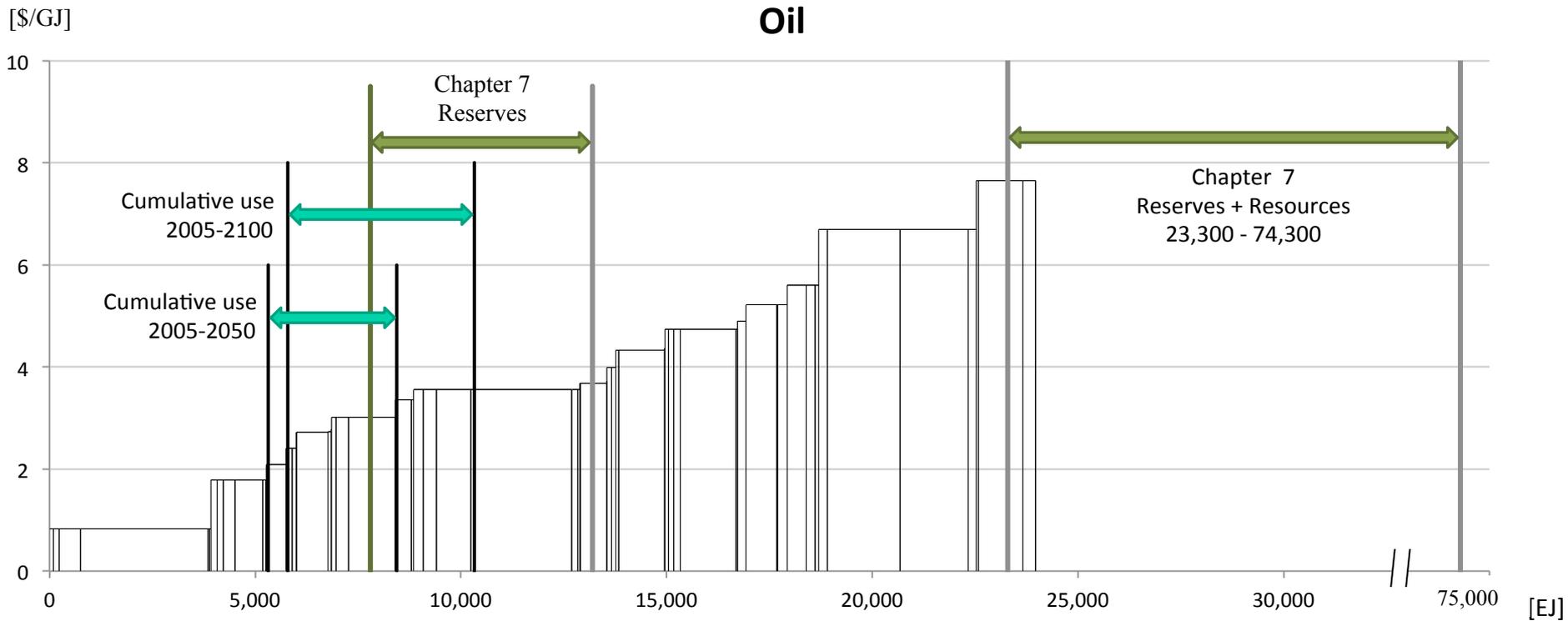
STERLING
WIND POWER

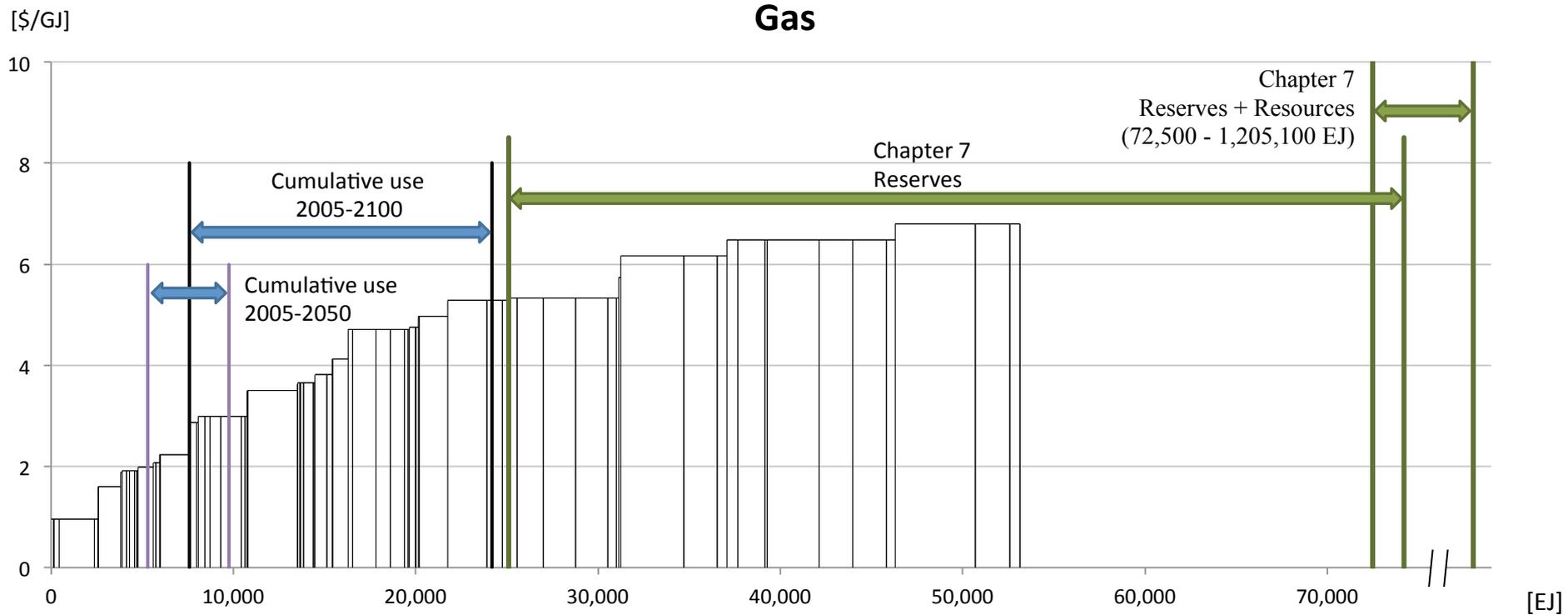
~ 30m sphere @ 2000m ≈ 60MWh



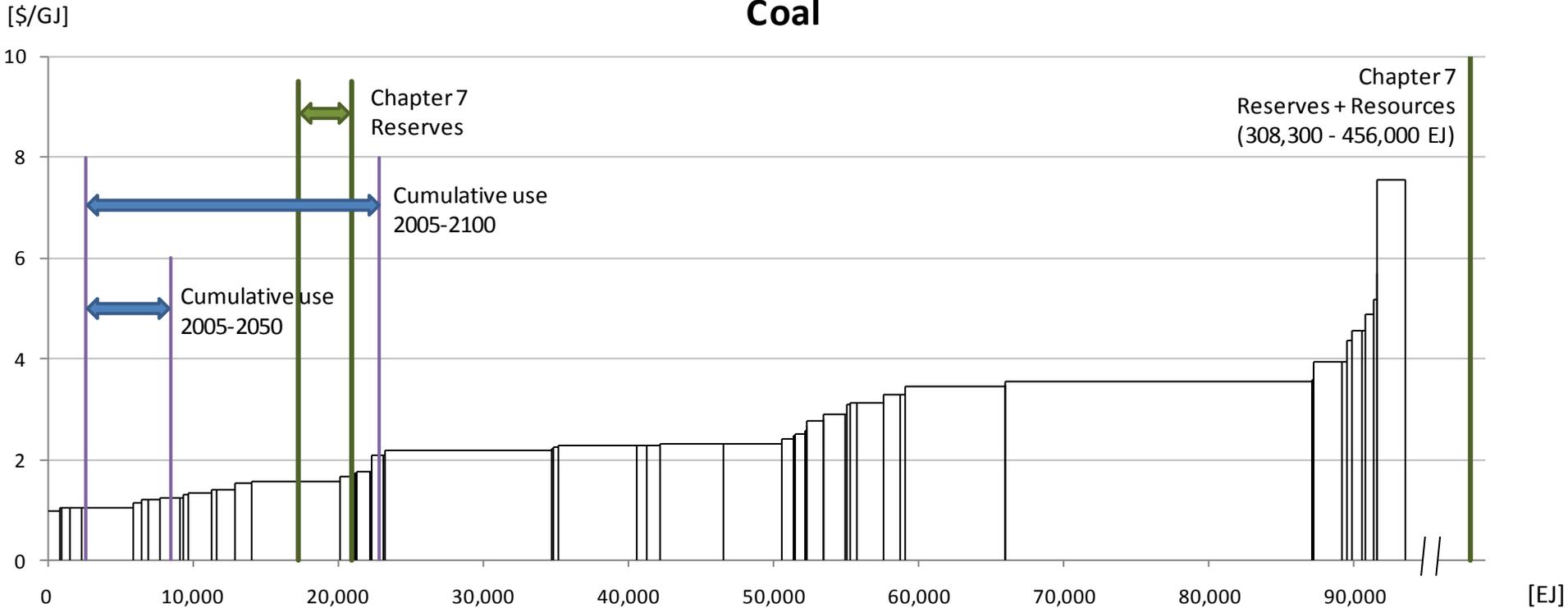
- ▲ Nuclear US: Average and Minimum/Maximum 1971-1996
- Nuclear US: Single Reactor (No Range) 1971-1996
- Nuclear France: Average and Min/Max 1977-1999
- Offshore Wind: All EU project prices 1999-2008
- ◇ Onshore Wind Denmark: Average costs 1981-2009
- Onshore Wind US: Capacity weighted average price 1984-2010
- Solar PV Modules: World average prices 1975-2007
- ◇ PV Si Modules: World average prices (IPCC SRREN) 2003-2010
- PV Systems US: Average installation price +/- SD 1998-2009
- Heatpumps Switzerland: Average cost of 7.6 kW unit 1982-2008
- ◇ Heatpumps Sweden: Average cost of 6.6-8.6 kW unit 1994-2008
- Ethanol prices Brazil 1975-2011

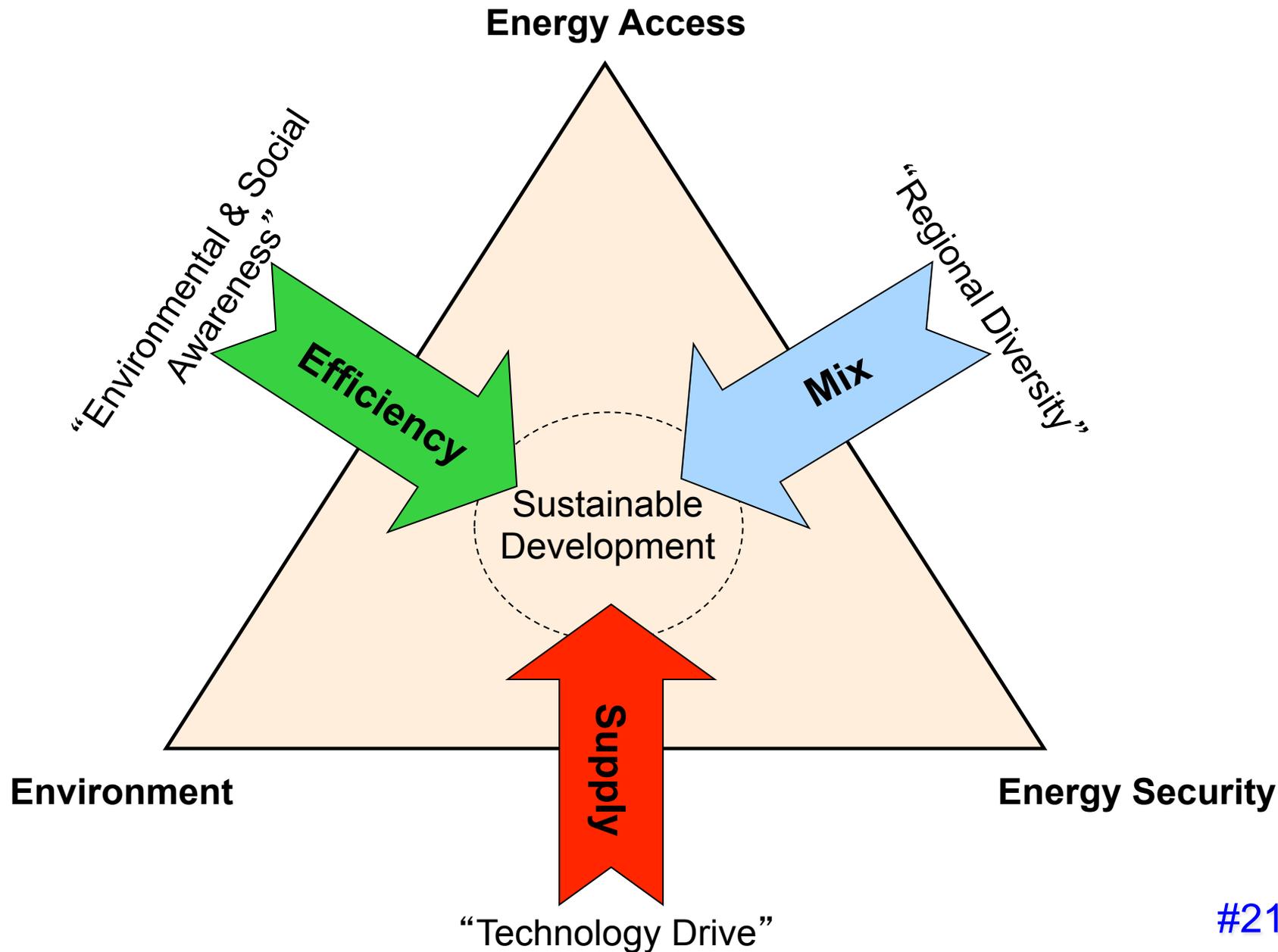






Coal

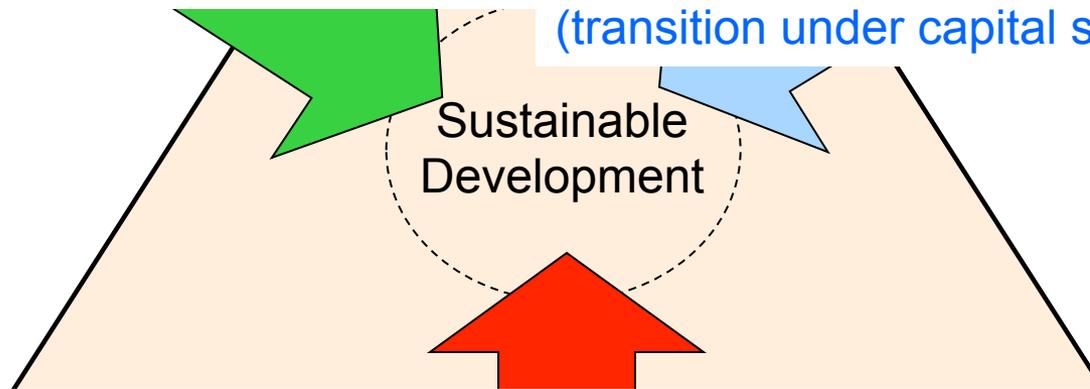




Energy Access

- Very high efficiency & rapid energy intensity improvements
- behavioral/life-style changes, including mobility, diets toward less meat, interconnected homes, etc..
- Sensitivity: 0-nuclear & 0-CCS cases
- Very stringent climate targets (400 ppm equ. with overshoot or 450 ppm without)

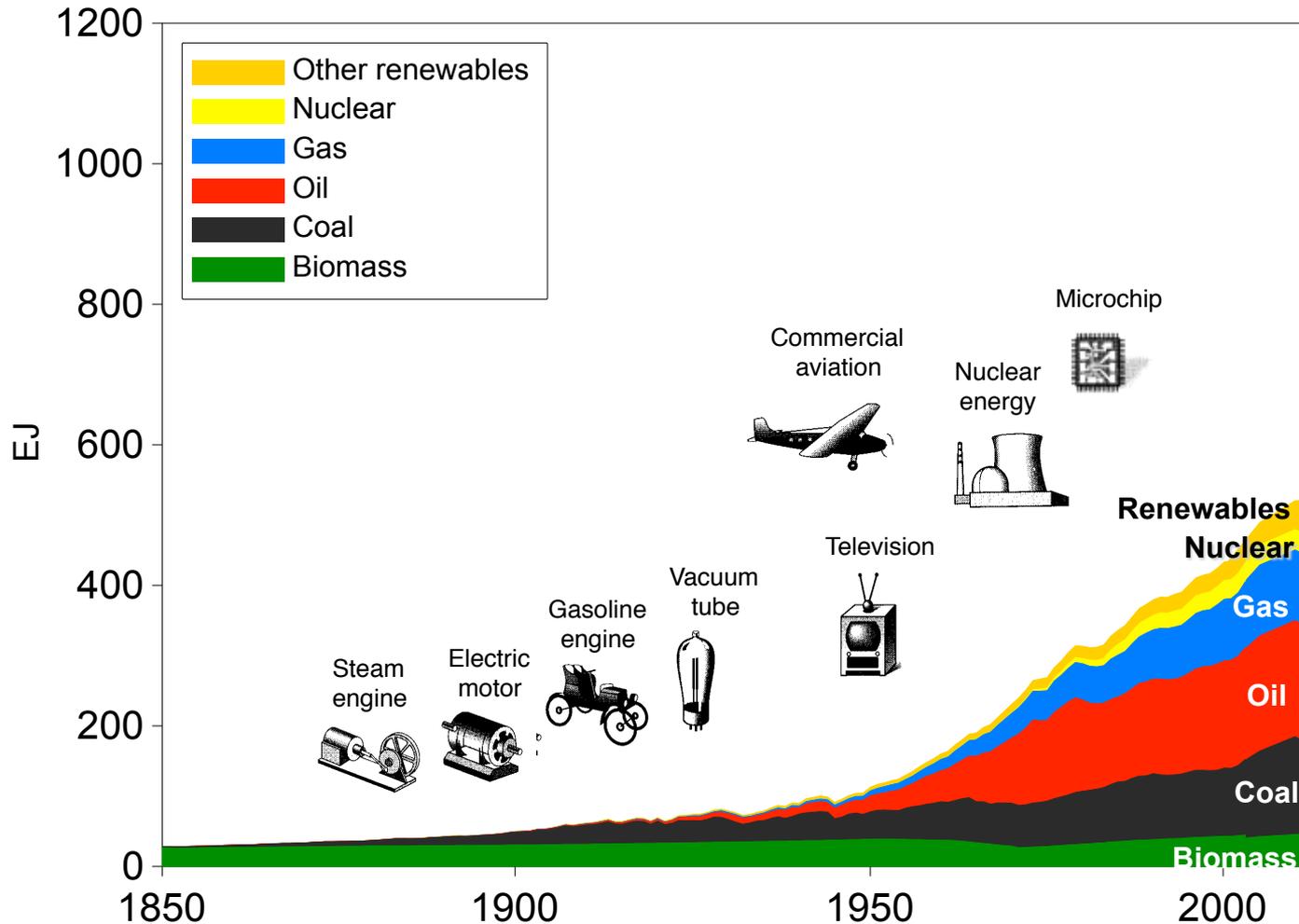
- Heterogeneous combinations, eg C&B
- Different regions with different degree of fulfillment of SD criteria
- Rapid access and security improvements
- Intermediate climate targets (550 ppm equ. or 500 ppm with overshoot) and implications of delayed participation
- Sensitivity: implications of financial crises (transition under capital scarcity);



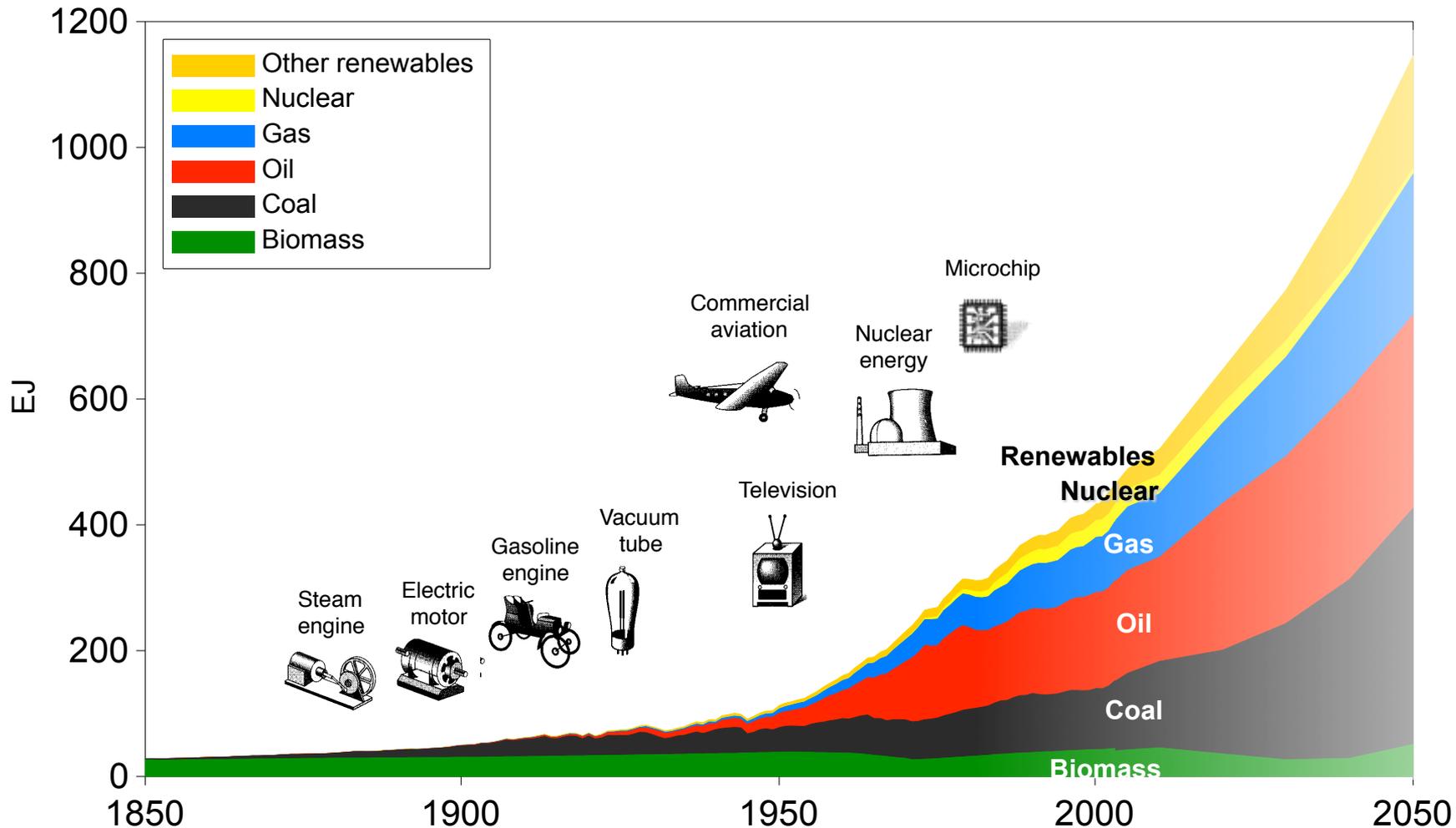
Env

- Massive supply-side changes and new infrastructures
- Eg: H2 + very cheap CCS, nuclear and renewables
- Intermediary energy intensity improvement (higher demand than C)
- stringent climate targets (450 ppm equ. with high overshoot or 500 ppm)

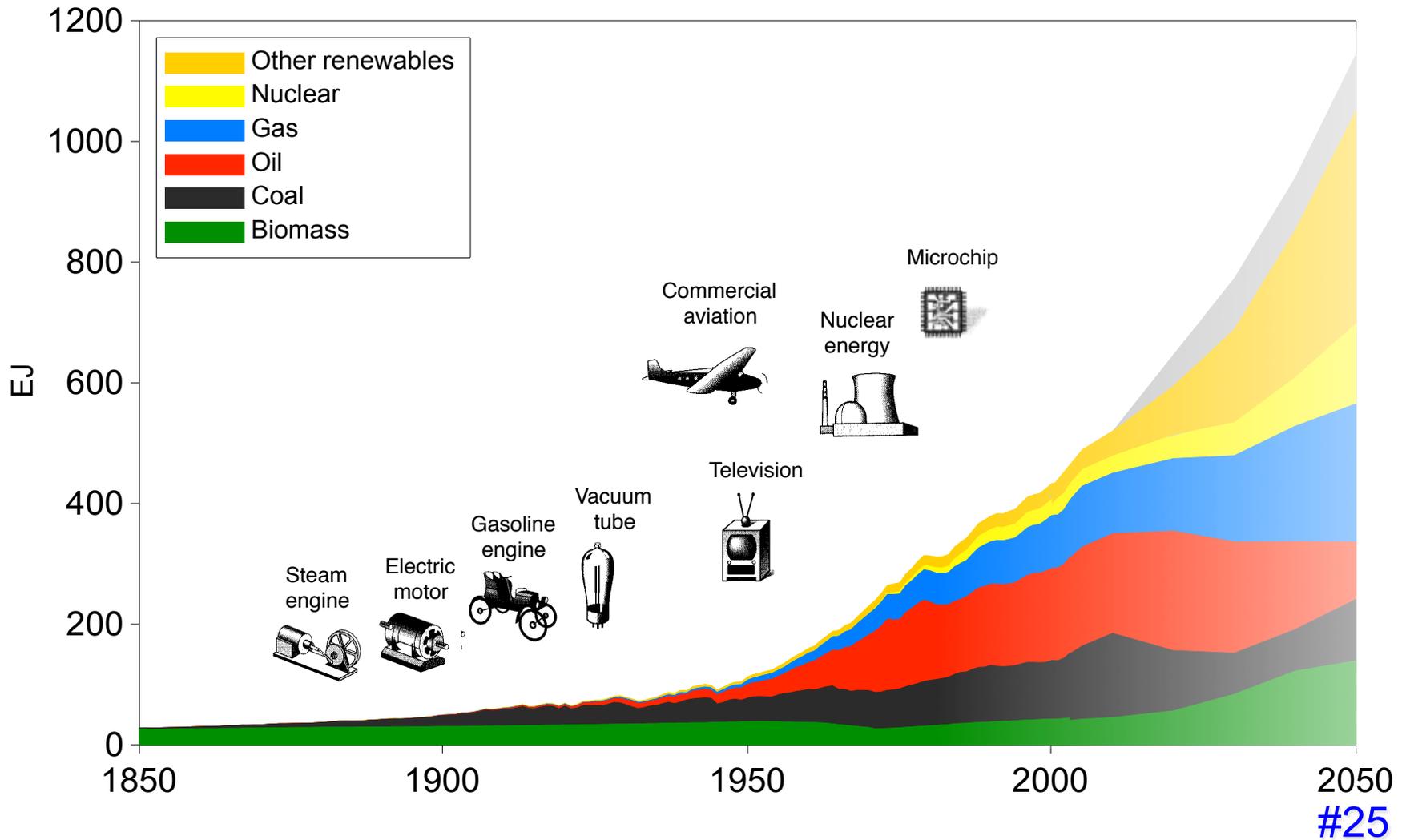
“Technology Push”



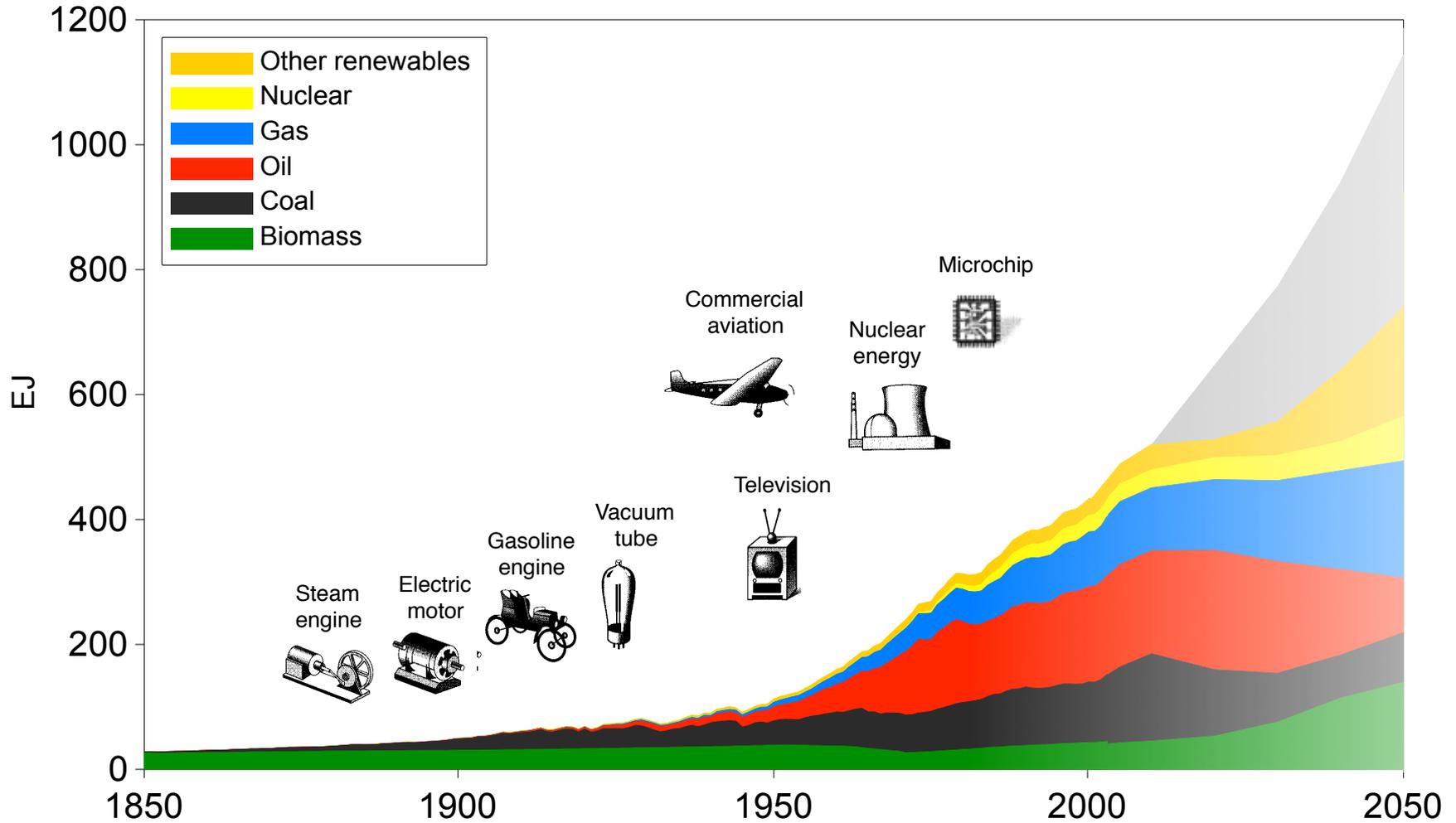
Counterfactual - BAU



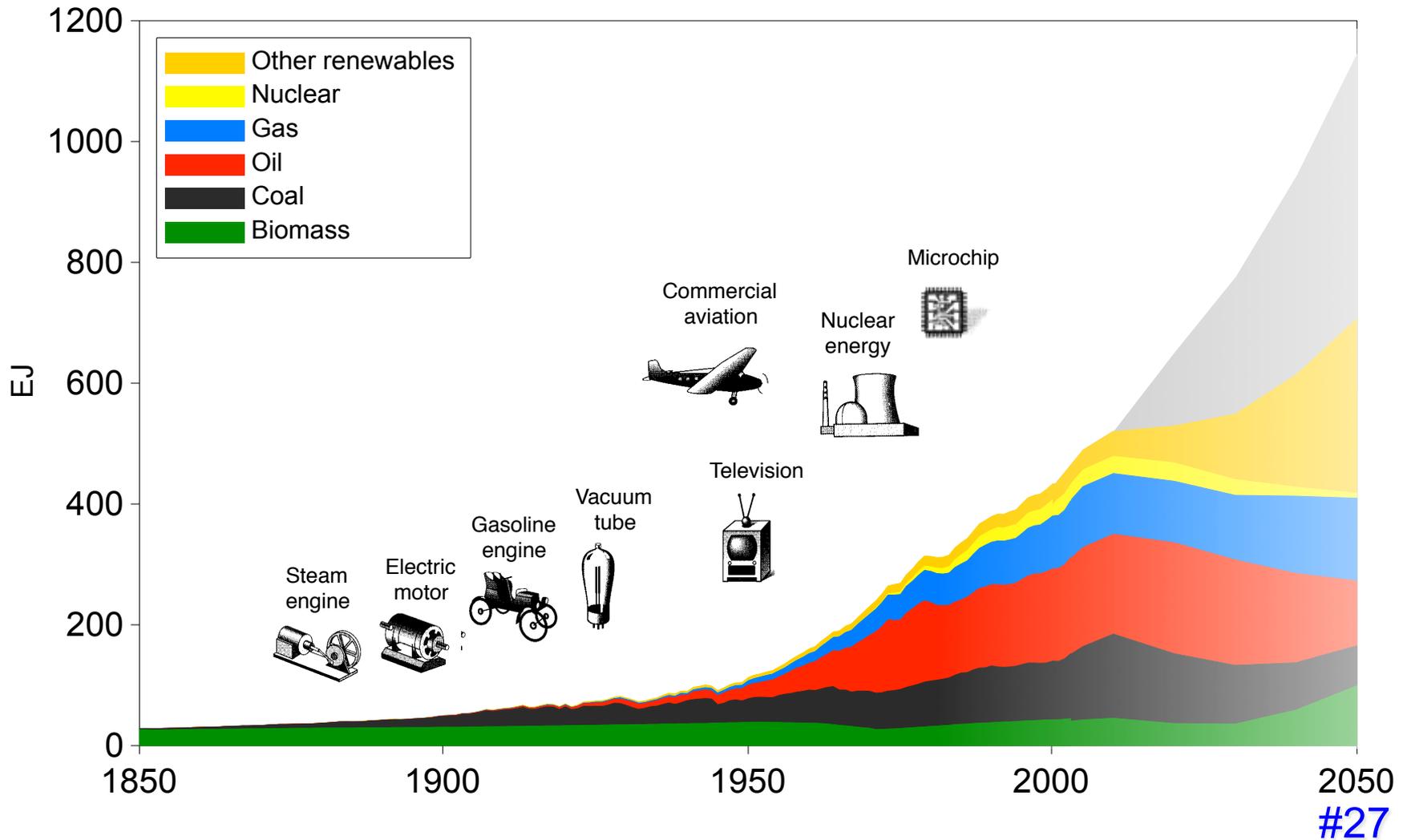
GEA Supply



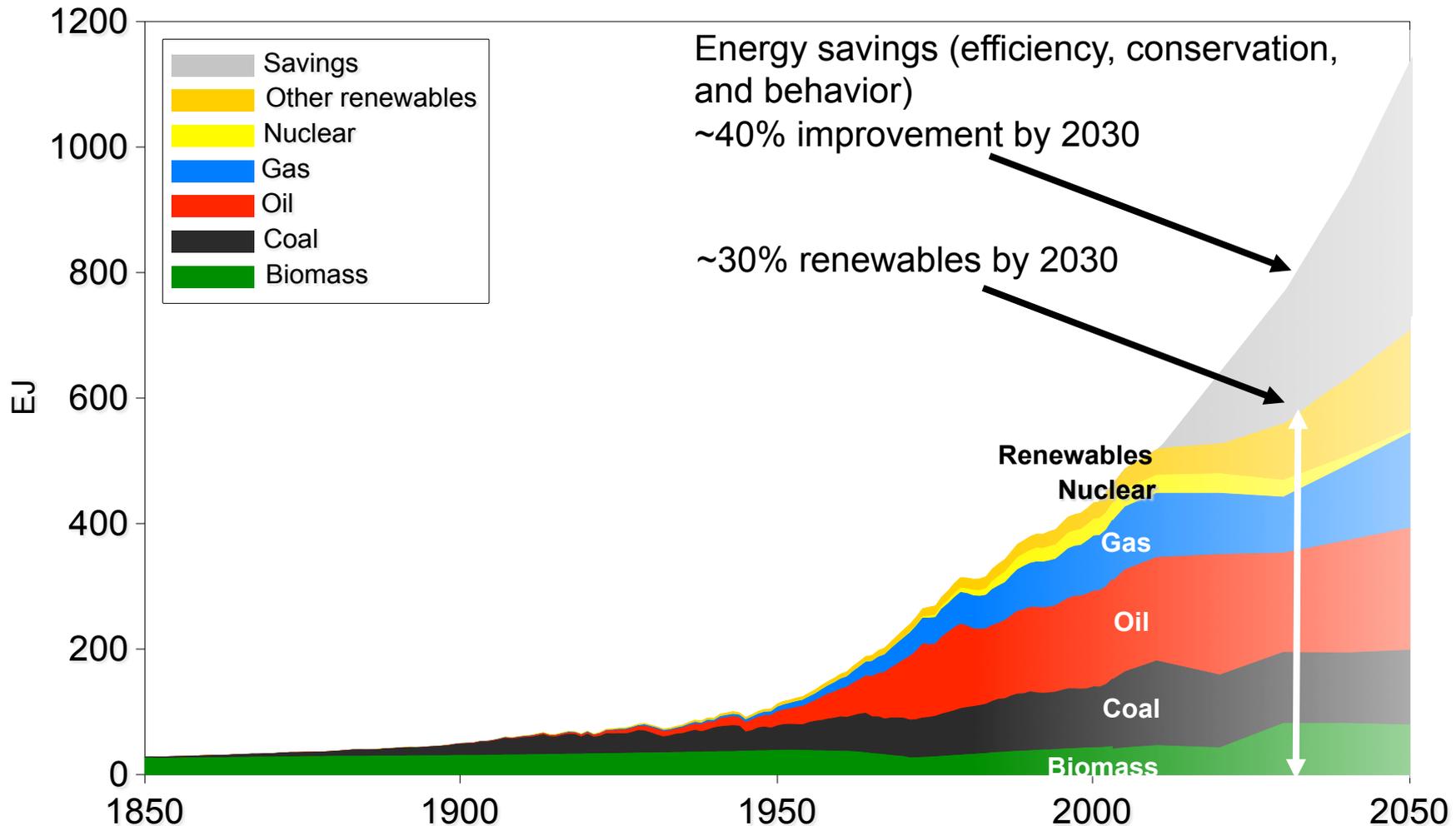
GEA Mix



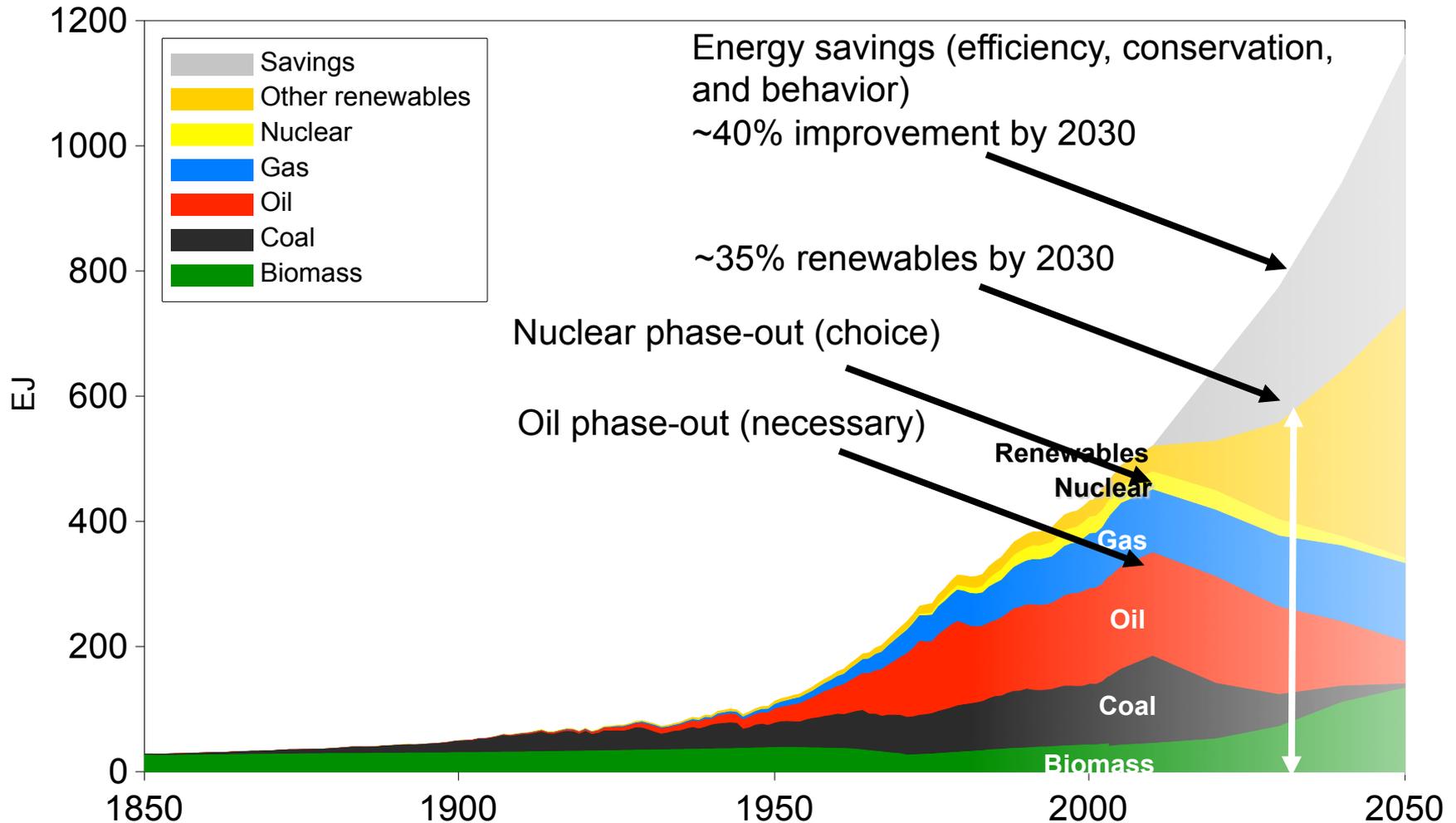
GEA Efficiency



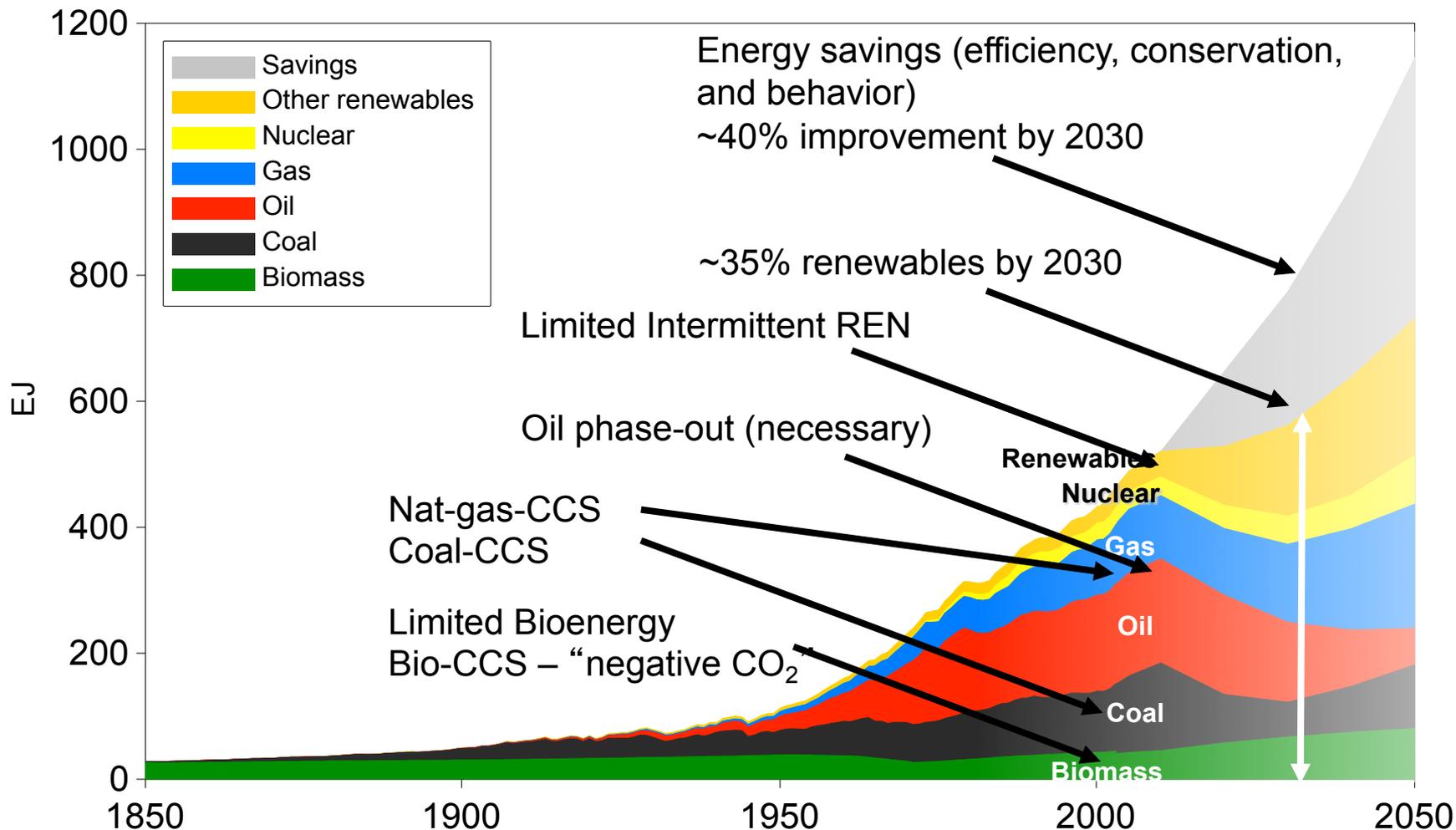
All 3 SE4All Objectives



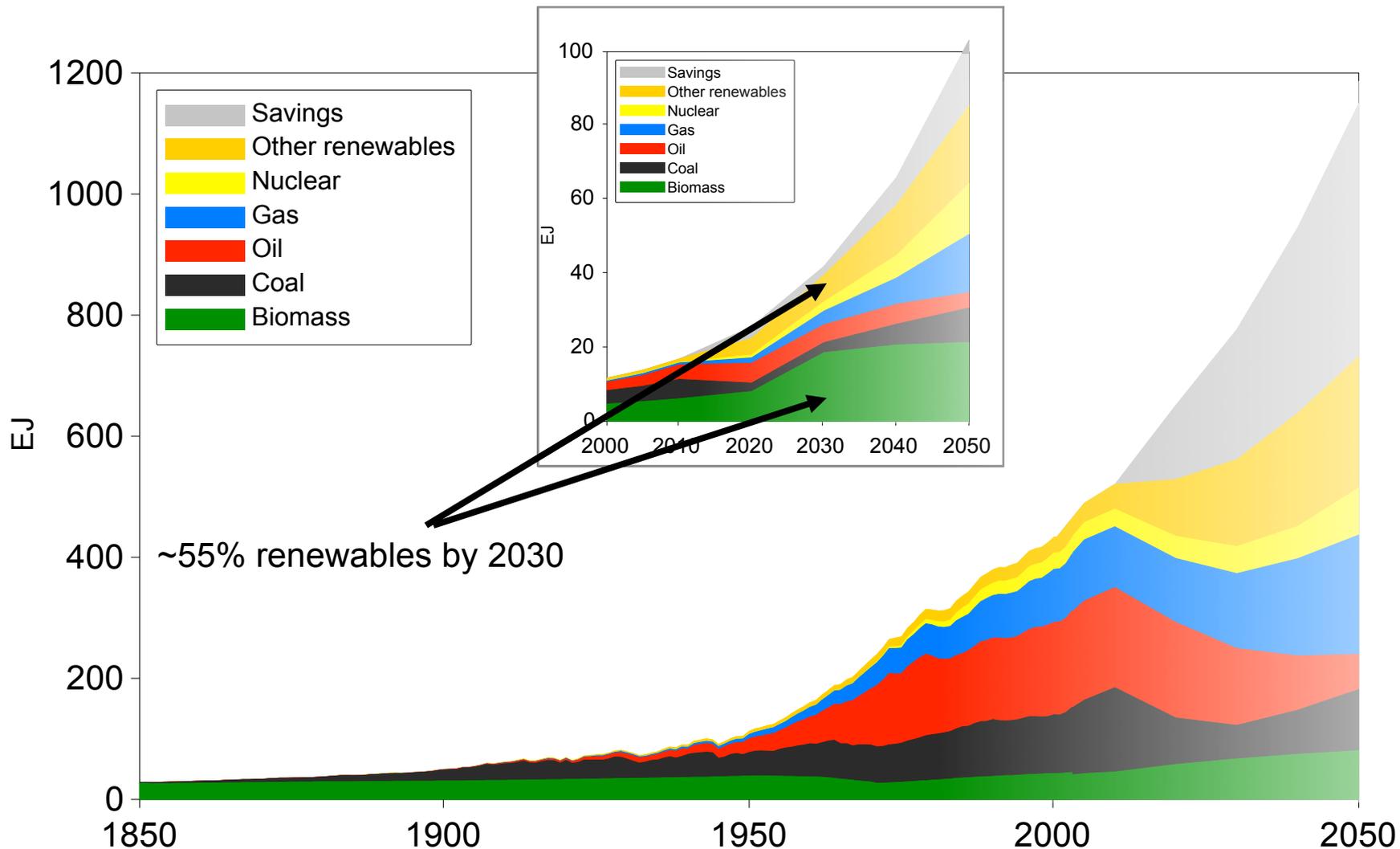
no CCS, no Nuclear



lim. Bioenergy, lim. Intermittent REN

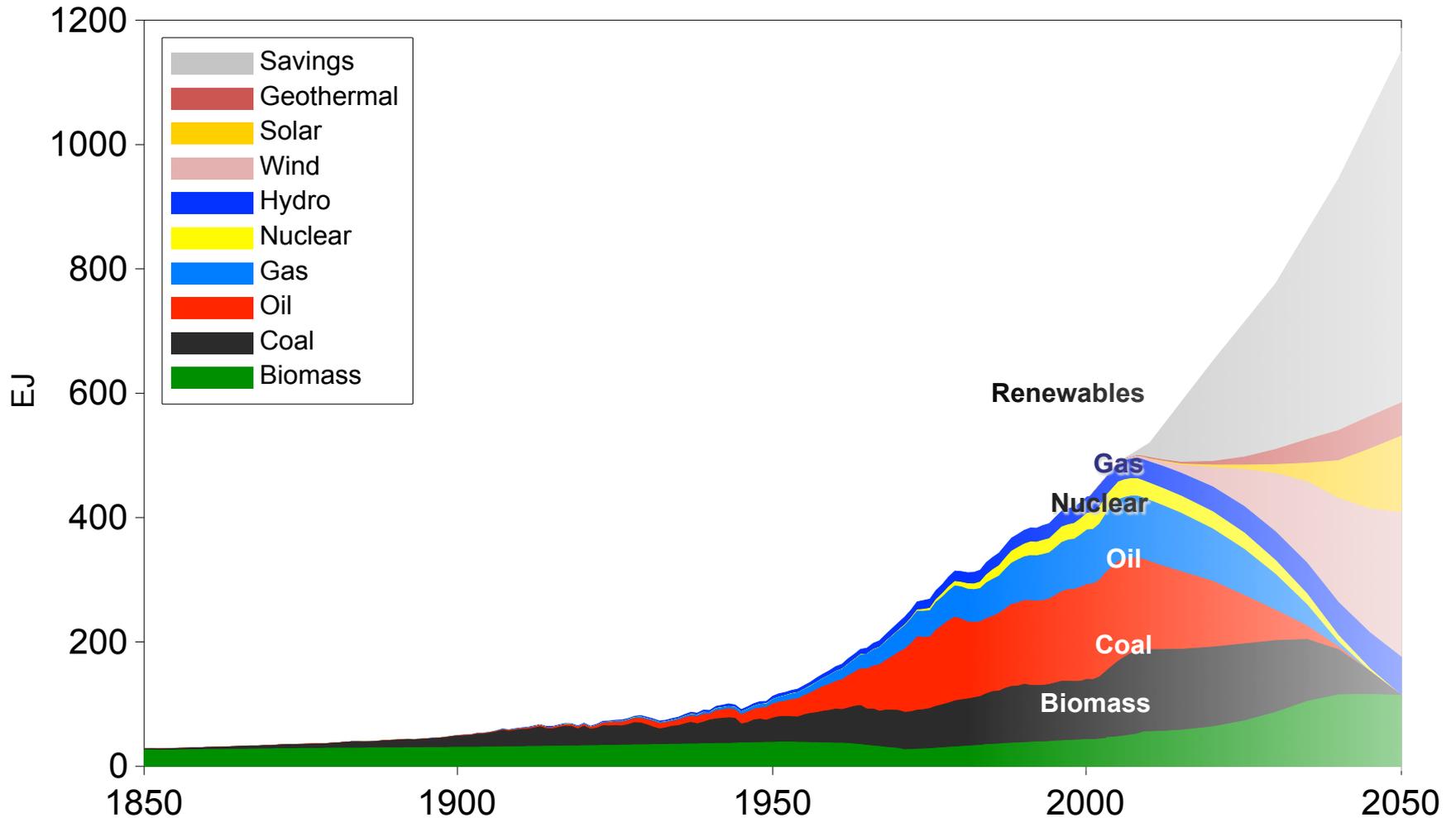


Sub-Saharan Africa

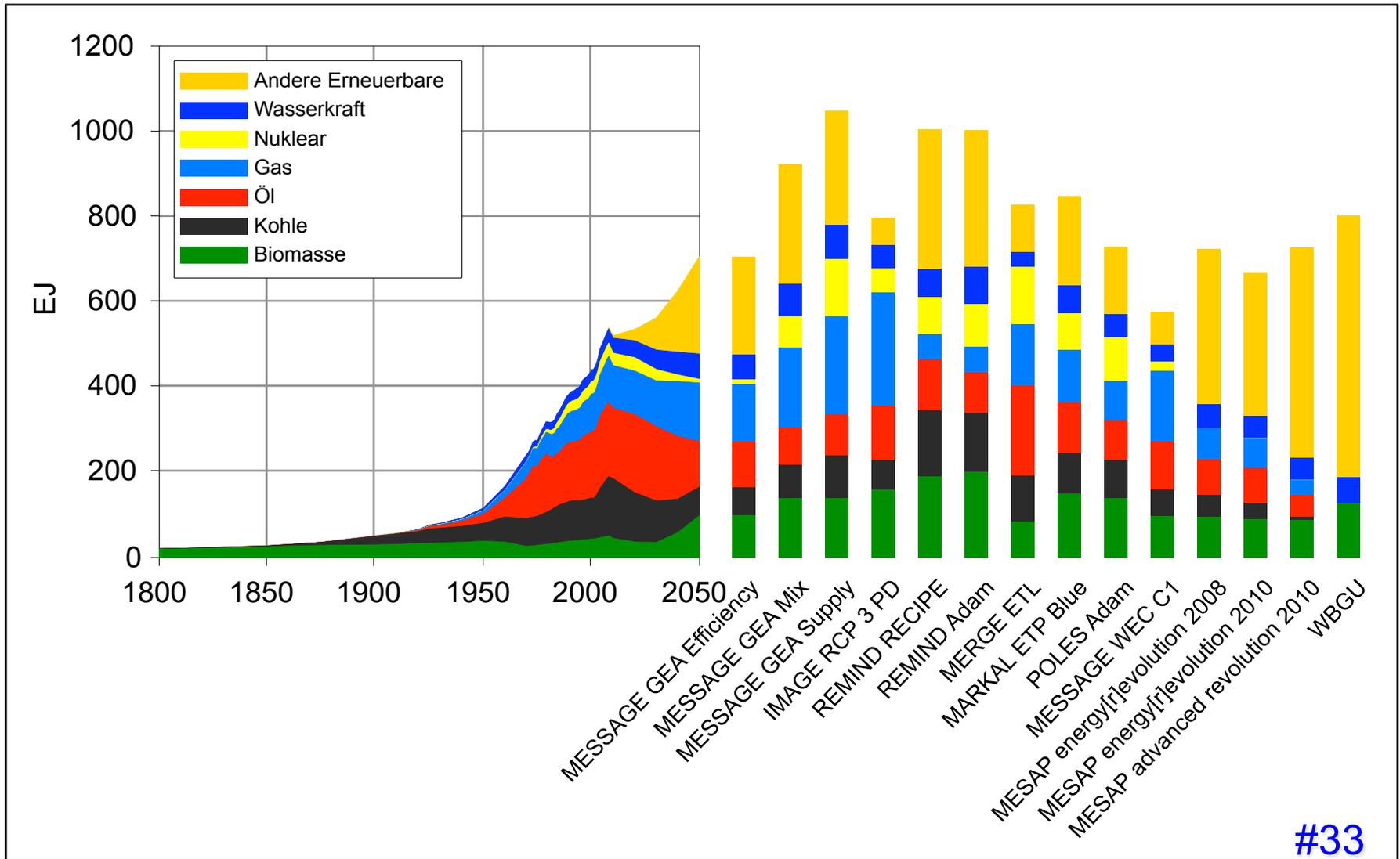


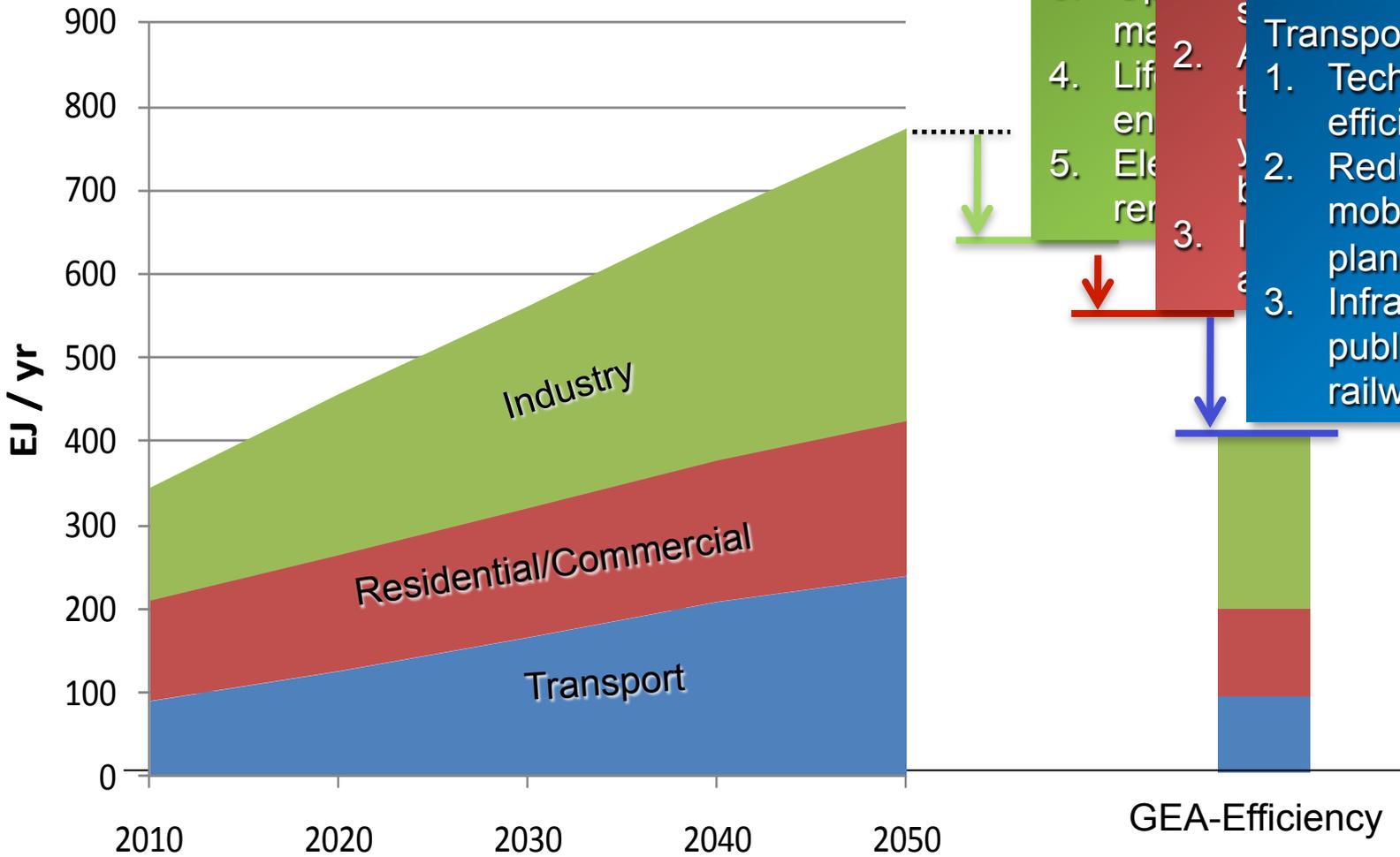
Global Primary Energy

WBGU Exemplary Pathway



Comparison of Stabilization Scenarios





- Industry:**
1. Retrofit of existing plants
 2. Better utilization of industrial capacity
 3. Operation of plants at optimal capacity
 4. Life cycle energy efficiency
 5. Electrical recovery
- Residential:**
1. Rapid introduction of energy efficient appliances
 2. Adoption of energy efficient building codes
 3. Improved energy efficiency of buildings
- Transport:**
1. Technology efficiency (50%)
 2. Reduced private mobility (eg urban planning)
 3. Infrastructure for public transport + railway freight

Global gas and oil reserve and resource categories, in ZJ (1000 EJ)

Category	Conventional reserves and resources <i>I,II,III</i>	Unconventional			Unconventional and additional occurrences		Total	Historical Consumption 1860-2005
		Enhanced recovery <i>IV</i>	Recoverable <i>V VI</i>		<i>VII</i>	<i>VIII</i>		
Oil	9.6	6.1	2.7	13.9	24.3	53.5	110.0	6.1
Gas	14.0	2.2	8.0	14.3	15.7	785.4	839.7	3.0

Scenario/ Category	Scenario assumptions						Consumption 2000-2100	
	<i>I,II,III</i>	<i>IV</i>	<i>V</i>	<i>VI</i>	<i>VII</i>	<i>VIII</i>	Oil	Gas
GEA								
Counterfactual	gas/oil	gas/oil	gas/oil	gas			37.5	27.0
Supply	gas/oil	gas/oil	gas/oil	gas	---	---	12.3	17.2
Mix	gas/oil	gas/oil	gas/oil	gas	---	---	12.4	12.7
Efficiency	gas/oil	gas/oil	gas/oil	gas	---	---	11.9	16.3
No Nuclear, No CCS	gas/oil	gas/oil	gas/oil	gas	---	---	10.8	10.6
Lim. Bio, Lim. Ren.	gas/oil	gas/oil	gas/oil	gas	---	---	10.5	18.3
SRES							Consumption 1990 - 2100	
A1O&G	gas/oil	gas/oil	gas/oil	gas/oil	gas/oil	gas	34.4	49.1

Potentials to 2050

Cost Category	I	II	III	IV	Total
	<u>Decreasing Resource Availability</u> →				
Approx. Wind Power Category	7	5 & 6	3 & 4	1 & 2	
Wind (EJ)	19.1	37.8	57.5	55.0	169.5

GEA Pathway/ Scenario	Cumulative Installed Capacity (TWe)		
	2005	2050	2100
Counterfactual	0.060	1.147	153.5
Supply	0.060	4.039	19.401
Mix	0.060	4.201	16.973
Efficiency	0.060	2.977	9.757
Limited Biomass & Renewables	0.060	1.895	3.793
No Nuclear & No CCS	0.060	4.699 → 5.777	15.112 → 17.433

Potentials to 2050

Cost Category	I	II	III	IV	Total
Decreasing Resource Availability 					
Approx. Solar Power (kWh/m ² /yr)	> 2500	2100-2500	1800-2100 0	1500-1800	
Solar PV (EJ)	507.1	680.9	397.7	89.2	1674.9
Solar CSP (EJ)	993.3	-	-	-	993.3

GEA Pathway/Scenario	Cumulative Installed Capacity (TWe)			
	2050		2100	
	Solar PV	Solar CSP	Solar PV	Solar CSP
Counterfactual	2.555	0.645	11.17	7.87
Supply	5.117	1.045	32.14	10.56
Mix	4.753	1.025	25.22	10.21
Efficiency	4.249	0.799	31.60	7.57
Limited Biomass & Renewables	2.576	0.214	10.78	0.662
No Nuclear & No CCS	6.94 → 6.87	0.97 → 1.00	48.3 → 49.2	8.98 → 9.33

Potentials to 2050

Category *	Purpose Grown Crops			Traditional		Other	TOTAL
	I	II	III	IV	V	VI	
Biomass (EJ)	25.5	26.4	26.4	26.4	26.4	26.4	157.5

* Not including Residues

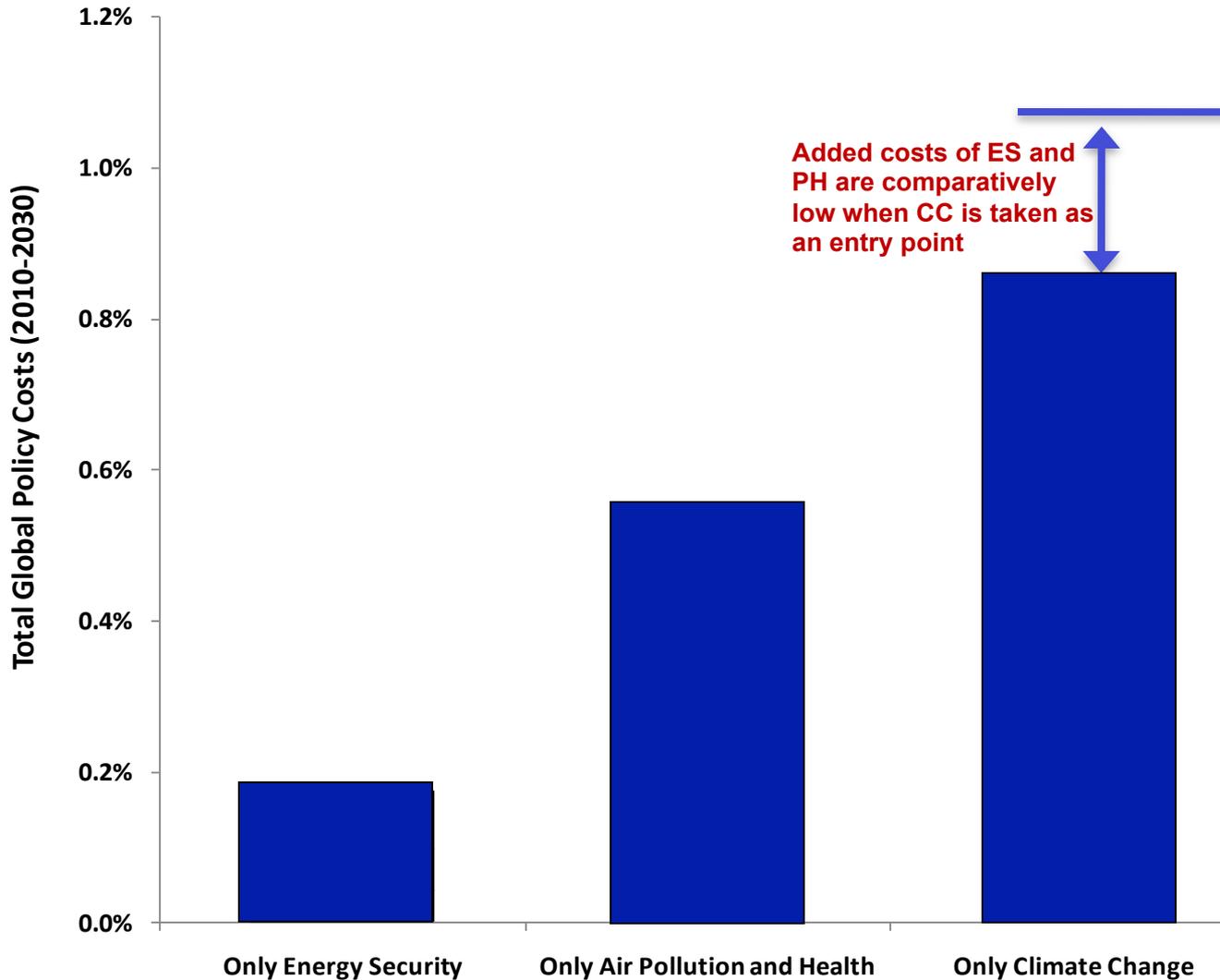
GEA Pathway/Scenario	Cumulative Use (EJ)	
	2050	2100
Counterfactual	51.56	177.3
Supply	139.13	221.0
Mix	139.13	221.0
Efficiency	98.8	221.0
Limited Biomass & Renewables	89.4	123.8
No Nuclear & No CCS	133.5 → 139.3	216.8 → 214.4

by region, 2050 (in EJ and %).

Region	Bioenergy	Hydropower	Wind	Solar ¹	Geothermal	All renewables	All renewables as % of total
Sub-Saharan Africa	8.8-40.5	2.0-5.5	0.0-19.6	0.5-25.5	0.0-0.3	11.4-91.4	31-94
Centrally Planned Asia and China	6.9-24.7	9.7-10.3	3.7-8.8	0.9-40.1	0.0-0.3	21.2-84.2	24-50
Eastern Europe	1.3-2.8	0.8-1.0	0.7-5.0	0.2-6.1	0.0-0.3	2.9-15.3	23-85
Former Soviet Union	2.9-10.1	2.7-15.8	1.4-7.4	0.3-9.7	0.0-1.0	7.4-43.9	25-93
Latin America and the Caribbean	10.5-22.5	10.7-17.6	3.6-12.4	0.5-21.8	0.0-1.8	25.3-76.1	40-100
Middle East and North Africa	1.2-5.1	0.8-1.2	1.3-8.7	0.5-15.8	0.0-0.3	3.8-31.1	17-40
North America	10.0-21.5	7.2-7.9	2.6-36.7	1.2-41.6	0.0-3.4	21-111	38-89
Pacific OECD	3.4-11.3	1.4-1.7	0.6-4.9	0.2-5.4	0.1-0.8	5.7-24	26-89
Pacific Asia	5.0-11.9	1.9-7.2	1.0-2.0	0.4-14.5	0.2-1.3	8.6-36.9	15-63
South Asia	5.2-20.8	3.5-4.3	1.1-6.7	1.0-79.0	0.0-0.2	10.7-111	21-65
Western Europe	3.9-11.0	5.7-7.6	3.0-30.2	0.7-28.9	0.1-2.1	13.4-79.8	34-83
World	78.3-139	49.9-80.1	28.5-134	7-285	0.6-11.9	164-651	28-74

Note: Ranges include restricted supply portfolios and are calculated as primary energy supply using the substitution method.

¹ The representation of solar energy in the IMAGE modeling framework is restricted to solar photovoltaic, which leads to significantly lower solar energy contributions in the IMAGE interpretation of the GEA pathways that typically mark the lower end of solar deployment in this table.



ENE Program (Work) database
Version 0.9.3

About
Regions
Sectors
Series
Countries
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Select region(s), scenario(s), and variable to define your query

(1.) Regions:

- World
- 2 Regions
 - North
 - South
- 5 Regions
 - OECD
 - REF
 - ASIA
 - MAF
 - LAC
- 11 Regions
 - AFR
 - CPA
 - EEU
 - FSU
 - LAC
 - MEA
 - NAM
 - PAO
 - PAS
 - SAS

(2.) Scenarios:

- Illustrative GEA pathways
 - MESSAGE
 - GEA-Supply
 - GEA-Mix
 - GEA-Efficiency
 - IMAGE
 - GEA-Supply
 - GEA-Mix
 - GEA-Efficiency
- Baselines
 - MESSAGE
 - IMAGE
- Restricted supply pathways
 - GEA-Supply
 - Conventional transport
 - Full Portfolio
 - No Nuclear
 - Advanced transport
 - Full portfolio (see illustrati...
 - No BioCCS
 - No Sink

(3.) Variables:

- Population
- Economy
- Resource
- Primary Energy
 - Total
 - Fossil
 - Coal
 - Gas
 - Biomass
 - Nuclear
 - Hydro
 - Wind
 - Solar
 - Geothermal
 - Secondary Energy Trade
- Primary Energy (substitution method)
- Secondary Energy
- Final Energy
- Bunker Fuels
- Trade
- Climate

Query Results - Chart Preview:

Legend:

- Primary Energy|Wind|Total
- Primary Energy|Total
- Primary Energy|Solar|Total
- Primary Energy|Secondary Energy Trade|Total
- Primary Energy|Nuclear|Total
- Primary Energy|Hydro|Total
- Primary Energy|Geothermal|Total

Query Results:

Region	Scenario	Variable	Unit	2005	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
World	GEA - geama_450_btr_full	Primary Energy Geothermal Total	EJ/yr	0.354	0.496	0.679	1.144	2.387	3.499	4.958	6.014	7.081	8.207	7.732
World	GEA - geama_450_btr_full	Primary Energy Hydro Total	EJ/yr	10.413	12.162	14.659	17.950	22.359	26.914	29.043	30.204	32.004	33.173	33.613
World	GEA - geama_450_btr_full	Primary Energy Nuclear Total	EJ/yr	9.967	10.275	12.518	14.336	16.746	25.441	43.742	76.686	101.343	122.339	137.720
World	GEA - geama_450_btr_full	Primary Energy Secondary Energy Trade Total	EJ/yr											
World	GEA - geama_450_btr_full	Primary Energy Solar Total	EJ/yr	0.332	0.973	8.735	26.160	51.177	84.471	116.473	146.978	178.382	221.821	272.185
World	GEA - geama_450_btr_full	Primary Energy Total	EJ/yr	449.980	475.175	505.887	535.493	593.650	664.524	730.073	760.521	788.541	820.772	849.980
World	GEA - geama_450_btr_full	Primary Energy Wind Total	EJ/yr	0.385	1.207	5.933	14.226	23.540	31.025	40.862	48.223	60.498	68.765	69.815

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generated: 2012-04-16 19:23:19

Output Options:

Microsoft Excel

Portable Network Graphics

Scalable Vector Graphics

Notes:

- Direct equivalent is an accounting method for primary energy; direct equivalent primary energy of noncombustible renewables and nuclear is equal to their secondary energy output.
- Regional primary energy use does not include use of or losses incurred in international shipping and transport in pipelines. Shipping fuel consumption and emissions are separately accounted for at the global level.

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Annual Energy Investments	Innovation RD&D [billion US\$2005]	Markets Formation [billion US\$2005]	Present Investments [billion US\$2005]	Future Investments [billion US\$2005]
	2010	2010	2010	2010 - 2030
Efficiency & End Use	>> 8	~ 5	300	~300 - 3500
Renewables	> 12	~ 20	200	~200 - 550
Access	< 1	< 1	~ 9	~40 - 60
Total	> 50	< 150	1250	~1000 - 5000