The prospects for fossil fuels from a normative back-casting perspective

Some issues regarding IEA modelling projections

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Agenda

- Study background
- IEA/WEO volume and price projections: can they be taken for granted?
- EU oil & gas imports and international resource rent transfers
- The prospects for CCS applied to fossil power plants
- Main conclusions

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Background of the study on which this presentation is based

- Regards one of the studies on external factors affecting EU performance on renewables in the energy mix in year 2030
- Focus on IEA/WEO (WEO2014) projections on the global prospects for fossil fuels
- Specific attention to:
  - IEA volume and price scenario projections: can they be taken for granted?
  - Resource rents: geopolitical externalities of EU oil & gas imports
  - CCS applied to coal and gas fired power plants: will this application take off?

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A normative back-casting approach: two postulated key premises

- *The world is in an advanced stage of completing a trend towards cataclysmic climate change phenomena, degrading habitats for humanity, flora and fauna*

- *The policy area of non-GHG environmental impacts - notably air pollution – is on the verge of moving to the centre stage of leading issues driving energy policy making world-wide*

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Meta-trends projected by IEA/WEO2014 central scenario up to year 2040 -1-

1. *Strong if decelerating global population growth.*

2. *Rising global-average living standards and a growing affluent middle class, especially in non-OECD countries.*

3. *A world-wide strong urbanisation trend.*

4. *Robustly rising global energy demand as energy intensity reduction does only partially offset the growth of the world economy.*

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Meta-trends projected by IEA/WEO2014 central scenario up to year 2040 -2-

5. *A sustained prominent, if rather slowly declining, role of fossil fuels.*

6. *Under the WEO2014 NPS scenario unconventional oil production, such as tight/shale oil, and unconventional gas are poised to increase significantly.*

7. *The projected global energy trends are poised to lead to catastrophic energy-driven climate change, consistent with 3.6% °C temperature rise as expected value by 2100.*

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Global total primary energy demand, including fossil fuels: annual growth rates - WEO2014

(Compound average annual growth rates)

Scenario	Actuals	New Policies Scenario			450 Scenario		
Year	1990-2012	2012-20	2020-30	2030-40	2012-20	2020-30	2030-40
Coal	2.5%	1.0%	0.3%	0.2%	0.1%	-2.8%	-1.3%
Oil	1.2%	0.8%	0.4%	0.2%	0.5%	-1.0%	-2.0%
Natural gas	2.5%	1.4%	1.8%	1.5%	1.1%	0.9%	0.2%
Total PED	1.9%	1.4%	1.1%	0.9%	1.0%	0.3%	0.5%

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Global total primary energy demand, including fossil fuels: annual growth rates - WEO2014

Scenario	Actuals	New Policies Scenario			450 Scenario		
Year	2012	2020	2030	2040	2020	2030	2040
Coal	29%	28%	26%	24%	27%	20%	17%
Oil	31%	30%	28%	26%	30%	27%	21%
Natural gas	21%	21%	23%	24%	21%	23%	22%
TPED (in EJ)	559	627	700	766	608	625	654
PM							
Share fossil fuels	82%	79%	77%	74%	78%	69%	59%

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Global gross electricity consumption, with fossil fuel shares (%) - WEO2014

Scenario	Actuals	New Policies Scenario			450 Scenario		
Year	2012	2020	2030	2040	2020	2030	2040
Coal	41%	37%	33%	31%	35%	20%	13%
Oil	5%	3%	2%	1%	3%	1%	1%
Natural gas	22%	22%	23%	24%	22%	22%	16%
Total (TWh)	22,721	27,771	33,881	40,104	26,760	30,296	35,043
PM							
Share fossil fuels	68%	62%	58%	55%	60%	43%	30%

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Analysis on possible biases in IEA/WEOs 2005-2015 central scenario projections

- We have compared deviations of WEO2005-WEO2014 projections from WEO2015 projections
- In most WEOs preceding 2015 a significant positive deviation has been identified of the year 2030 projection on global primary energy demand, compared to the one in WEO2015
- This is also the case regarding projections of the share of fossil fuels in global primary energy demand
- Positive deviations of the demand for oil rather than deviations regarding the demand for coal and for gas explain the apparent positive bias regarding the prospective share of fossil fuels
- Projections of the oil price in year in pre-2015 WEOs show quite high deviations — both positive and negative ones — compared to WEO2015's oil price projection.

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The projected share of oil in world primary energy demand, WEOs 2005-2015

(in %)

Year	2010	2020	2030	2040	Difference w.r.t. WEO2015	
					2020	2030
WEO2005	35.8	35.0	34.1		18%	22%
WEO2006	34.4	33.4	32.6		12%	16%
WEO2007	33.9	32.4	31.5		9%	12%
WEO2008	33.3	31.4	30.0		6%	7%
WEO2009	33.1	30.7	29.8		4%	6%
WEO2010	32.4	29.9	28.4		1%	1%
WEO2011	32.6	29.7	28.1		0%	0%
WEO2012	**32.3**	29.9	27.9		1%	-1%
WEO2013	**32.3**	29.8	27.7		0%	-1%
WEO2014	**32.3**	30.0	28.0	26.0	1%	0%
WEO2015	**32.3**	30.3	28.2	26.4		

Estimated realisations in bold

Source: (IEA, 2005-2015)

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Projected IEA import prices of crude oil, World Energy Outlooks 2005-2015

(in US$2014/bll)

Year	2010	2020	2030	2040	CAAGR 2010-20	CAAGR 2020-30	CAAGR 2030-40	Difference w.r.t. WEO2015 (%) 2020	Difference w.r.t. WEO2015 (%) 2030
WEO2005	43	45	47		0.6%	0.5%		-44%	-58%
WEO2006	61	*59*	65		-0.3%	0.9%		-26%	-43%
WEO2007	67	*67*	71		0.0%	0.5%		-16%	-37%
WEO2008	111	122	136		1.0%	1.0%		53%	20%
WEO2009	*103*	109	125		0.6%	1.4%		36%	11%
WEO2010	*70*	107	119		4.4%	1.1%		34%	5%
WEO2011	**84**	116	125		3.4%	0.8%		45%	11%
WEO2012	**84**	125	130		4.1%	0.3%		57%	15%
WEO2013	**84**	116	125		3.4%	0.7%		45%	10%
WEO2014	**84**	114	125	134	3.1%	0.9%	0.7%	42%	10%
WEO2015	**84**	80	113	128	-0.4%	3.5%	1.3%		

Figures in bold are realisations; the figure in italics is a geometric intrapolation

CAAGR = compound annual average growth rate

Source: (IEA, 2005-2015)

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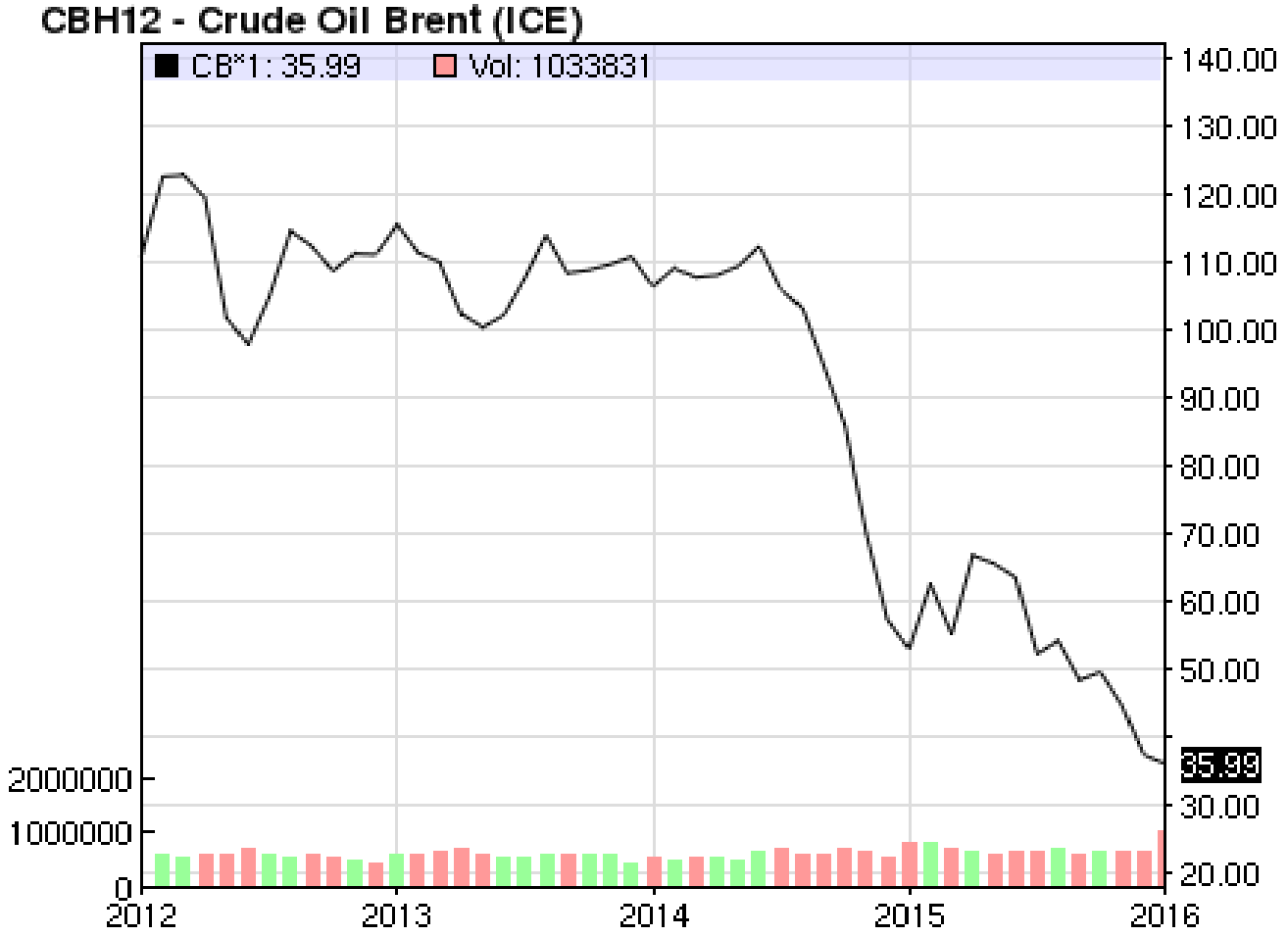
The Brent crude oil price, February 2012 - January 2016



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Our conclusions regarding IEA/WEO world-level projections -1-

- WEO central scenario, NPS, nor 450S projections can be taken at face value
- By and large we concur with the projected megatrends, as depicted by IEA/WEO2014's NPS and 450S scenarios
- We have some doubts on the projected (high) prospective time trajectories of global energy demand under IEA's central scenario
- From the adopted normative back-casting perspective, our doubts are stronger about the projected sustained dominance of fossil fuels, especially of coal and oil, in the overall energy demand mix
- We reckon with much faster phasing out of coal-fired power plants
- Oil may well retreat faster on medium term, mainly because of higher penetration of electric vehicles than assumed by the IEA

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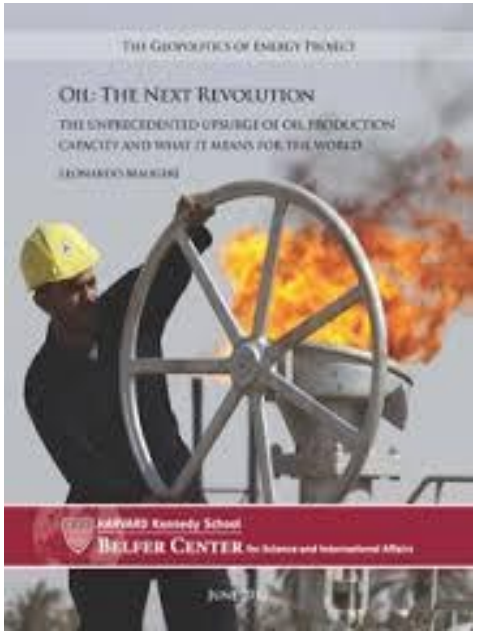
Our conclusions regarding IEA/WEO world-level projections -2-

- Most striking is how WEO2014 projections on the future price of oil missed the price impact of the underlying mechanics at work in the global oil market.
- This in spite of, e.g., the excellent report of Leonardo Maugeri published in June 2012, predicting the current oil glut.



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In 2013 value of EU gross oil and natural gas imports ≈ 3% of EU GDP

(Billion €)

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Gross imports									
Oil	177.4	214.0	212.0	279.4	170.2	231.1	297.6	340.0	302.3
Crude oil	*172.8*	*207.5*	*206.5*	*273.1*	*165.7*	*226.2*	*291.1*	*333.2*	*295.0*
Oil products	*4.6*	*6.5*	*5.5*	*6.3*	*4.5*	*4.9*	*6.5*	*6.8*	*7.3*
Natural gas	47.2	68.4	61.3	89.4	67.3	74.2	88.1	97.2	87.0
Pipeline gas	*40.7*	*57.9*	*52.3*	*76.4*	*55.4*	*58.3*	*66.9*	*79.6*	*73.4*
LNG	*6.5*	*10.5*	*9.0*	*13.0*	*11.9*	*15.9*	*21.2*	*17.6*	*13.6*
Coal	13.8	14.5	15.0	23.8	15.2	16.6	22.2	21.0	16.6
Coal	*12.9*	*13.9*	*14.3*	*22.4*	*14.8*	*16.1*	*21.7*	*20.7*	*16.1*
Lignite				*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
Coke	*0.9*	*0.6*	*0.7*	*1.3*	*0.3*	*0.4*	*0.4*	*0.2*	*0.4*
TOTAL	**238.4**	**296.9**	**288.3**	**392.6**	**252.7**	**321.9**	**407.9**	**458.2**	**405.8**

Source: Eurostat

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Recent fossil fuel price trends at current prices, 2005-2014

Fuel	Unit	Year									
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Oil											
Brent	$US/bll	54.52	65.14	72.39	97.26	61.67	79.50	111.26	111.67	108.66	98.95
Avg OECD import price	$/MBtu	8.74	10.66	11.95	16.76	10.41	13.47	18.56	18.82	18.25	16.80
Natural gas											
Pipeline, cif Germany	$/MBtu	5.88	7.85	8.03	11.56	8.52	8.01	10.49	10.93	10.73	9.11
LNG cif Japan	$/MBtu	6.05	7.14	7.73	12.55	9.06	10.91	14.73	16.75	16.17	16.33
Pipeline, Henry Hub	$/MBtu	8.79	6.76	6.95	8.85	3.89	4.39	4.01	2.76	3.71	4.35
Coal											
Steam coal, cif NW Europe	$/t	60.54	64.11	88.79	147.67	70.66	92.50	121.52	92.50	81.69	75.38
Oil											
Brent	$US/GJ	9.30	11.11	12.35	16.59	10.52	13.56	18.98	19.05	18.54	16.88
Avg OECD import price	$US/GJ	8.27	10.09	11.32	15.87	9.86	12.76	17.57	17.82	17.28	15.91
Natural gas											
Pipeline (PL) cif Germany	$US/GJ	5.57	7.44	7.60	10.95	8.07	7.59	9.94	10.35	10.16	8.63
LNG cif Japan	$US/GJ	5.73	6.76	7.32	11.88	8.58	10.33	13.95	15.86	15.31	15.47
Pipeline, Henry Hub	$US/GJ	8.32	6.41	6.58	8.38	3.69	4.16	3.80	2.61	3.51	4.12
Coal											
Steam coal API2 , cif ARA	$US/GJ	2.17	2.30	3.18	5.29	2.53	3.31	4.35	3.31	2.93	2.70
Price premium											
Brent vs PL gas cif Germany	%	49	36	49	45	22	68	77	72	70	84
PL gas cif Germany vs Henri Hub	%	-33	16	15	31	119	83	162	297	189	110
LNG cif Japan vs Henry Hub	%	-31	6	11	42	133	149	267	508	336	276
PL gas Germany vs coal AP2 cif ARA	%	281	339	256	200	290	285	304	438	490	489

Note: In this report MBtu stands for *mega (million)* Btu (1 Mbtu = 1.05587 GJ (giga=10^9 joules)), and does *not* stand for 1000 Btu

Source: Adapted from (BP, 2015)

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Fossil fuel price ratio developments

In the period 2005-2014:

- The premium of Brent oil versus German import gas firmed
- Price German import gas versus Henri Hub turned from a discount into a large, if in 2014 lessening, premium price
- LNG import price Japan vs Henri Hub turned from a discount into a quite large, if in 2014 somewhat lessening, premium price
- Premium of price German import gas vs coal AP2 ARA firmed

Expected in the medium/longer term (normative back-casting):

- Price discount of gas vs oil will diminish and on longer term turn into a premium
- Regional differences in gas price will diminish
- Price premium of gas vs coal will rise further

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Resource rent rather than the energy import bill matters!

- In the EC's narrative of renewables (RES) benefits the negative effect on the EU fossil energy import bill stands out prominently
- Yet the economic validity of this argument is not necessarily robust
- What matters most is the reverse resource rent transfers from the EU's imports of oil & natural gas
- Resource rent: surplus proceeds from extracting and selling oil and natural gas by oil & gas companies including taxes and royalties, after subtraction of all normal costs
- In emerging/developing economies the dominant oil & gas companies are state owned and typically controlled by the regime and associated elite ruling the exporting country
- Resource rent windfall tends to have severely negative effects on governance of oil&gas exporting country and geopolitical stability

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Resource rent: the cases of Russia and Saudi Arabia

	2009	2010	2011	2012	2013	2014
Oil & gas resource rent accrued in the Russian Federation						
Oil (€ billion)	117	169	220	234	214	197
Oil (% of GDP)	0	0	0	0	0	0
Oil ($US per barrel)	42	64	89	89	77	74
Natural gas (€ billion)	41	43	44	31	31	27
Natural gas (% of GDP)	0	0	0	0	0	0
Natural gas ($US/MBtu)	2,94	2,59	2,72	1,72	1,73	1,58
Oil and gas (€ billion)	**201**	**276**	**353**	**354**	**323**	**298**
Oil and gas (% of GDP)	**18%**	**18%**	**19%**	**17%**	**16%**	**16%**
Oil and gas (% of government expenditure)	**55%**	**63%**	**72%**	**61%**	**54%**	**55%**
Oil & gas resource rent accrued in Saudi Arabia						
Oil (€ billion)	118	160	231	261	244	215
Oil (% of GDP)	0	0	0	0	0	0
Oil ($US per barrel)	49	74	100	102	92	85
Natural gas (€ billion)	10	12	13	14	15	15
Natural gas (% of GDP)	0	0	0	0	0	0
Natural gas ($US/MBtu)	5,51	4,86	5,51	5,19	5,63	5,35
Oil and gas (€ billion)	**128**	**172**	**244**	**276**	**259**	**230**
Oil and gas (% of GDP)	**42%**	**43%**	**51%**	**48%**	**46%**	**41%**
Oil and gas (% of government expenditure)	**112%**	**127%**	**152%**	**145%**	**130%**	**101%**

Note: Resource rent figures for 2014 are own estimations, reconciled with 2009-2013 figures from the World Bank

Source: Adapted from data published by OPEC, Eurostat, World Bank

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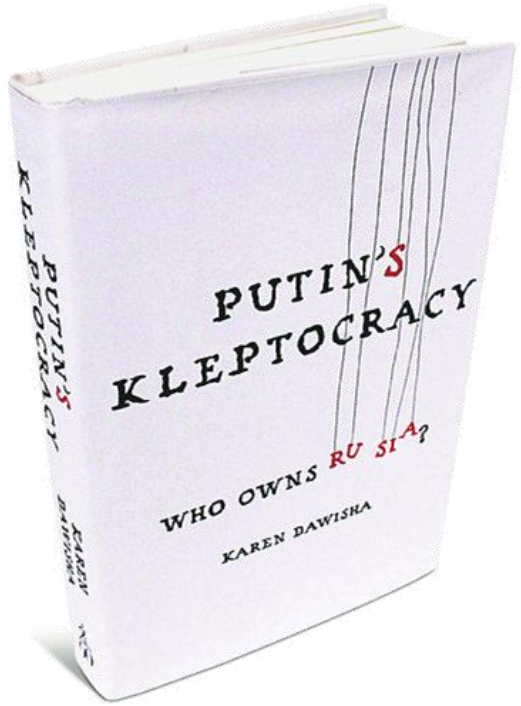
Resource rent: the cases of Russia and Saudi Arabia -2-



- Autocratic regimes
- Power based on a mixture of brutal force, tight grip on media and social compact with relevant constituencies paid from part of the huge but volatile resource rent wealth
- Constituencies influenced by higher (nationalist / religious) ideals
- Aggressive activities abroad by proxy and regular army
- <u>Finance of foreign army excursions and trade gaming for aggressive foreign policy purposes is largely a function of the volume of resource rent inflow from oil & gas exports</u>

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The prospects for CCS applied to fossil power plants

- IEA mantra: "CCS is an important component of achieving the 2D target cost-effectively". Therefore we undertook:
- Detailed analysis of recent review paper of Edward Rubin c.s. (2015) on cost of fossil power generation. Rubin is lead author of 2006 IPCC report on CCS

Conclusions

- Rubin(IPCC)'s analysis of CCS cost per tCO_2 avoided partial in nature: no due allowance for LCA energy penalty and GHG emissions along the fossil fuel supply chain up to delivery to the power plant
- Assumed cost of transport and storage likely too low, allowing for public resistance of onshore geological storage near human settlements
- For lack of demo projects: assumptions on incremental CAPEX and OPEX based on thin air and likely to err substantially on the low side
- Still high uncertainty surrounds the safety and permanency of geological storage among geologists inspite of reassuring statements by IPCC and IEA

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Overall conclusions

- We expect prospective turn-outs of global coal demand to be progressively lower than IEA's 450S projections, already starting in the next few years, while for oil this might be the case somewhat later ahead, i.e. in the 2020s
- The long-term prospects for natural gas look less bleak and IEA's 450S projections might turn out to give more realistic indications, contingent on:
  - The cost of CCS applied to natural gas-fueled power plants nor public resistance will be a show-stopper
  - Measurements of fugitive methane emissions along the natural gas supply chain to become appreciably more reliable and the volume of methane emissions in nat.gas supply to be reduced to acceptable levels
- Reference to resource rent impacts (in a diplomatic way) would strengthen the narrative on the benefits of deployment of renewables in the EU
- Absolute priority to be given to deployment of cost-effective EE and RES but from a precautionary motive (**also other**) geo-engineering options (**than CCS**) need to be developed through serious RD&D efforts as well

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Thank you!

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Global primary energy demand projections - WEO2014 (in EJ)

Scenario	Actuals	New Policies Scenario			450 Scenario		
Year	2012	2020	2030	2040	2020	2030	2040
World							
Coal	**162**	**176**	**182**	**186**	**164**	**124**	**108**
Oil	**176**	**188**	**196**	**199**	**183**	**166**	**136**
Natural gas	**119**	**133**	**159**	**185**	**130**	**142**	**145**
Nuclear	27	35	44	51	36	54	70
Renewables	75	94	119	145	95	140	195
Hydro	*13.2*	*16.4*	*19.6*	*22.4*	*16.4*	*21.4*	*25.0*
Bioenergy	*56.3*	*65.1*	*75.2*	*83.8*	*65.5*	*84.7*	*106.1*
Other renewables	*5.9*	*12.9*	*24.3*	*38.4*	*13.4*	*34.3*	*63.9*
Total	**559**	**627**	**700**	**766**	**608**	**625**	**654**

Source: (IEA, World Energy Outlook 2014)

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