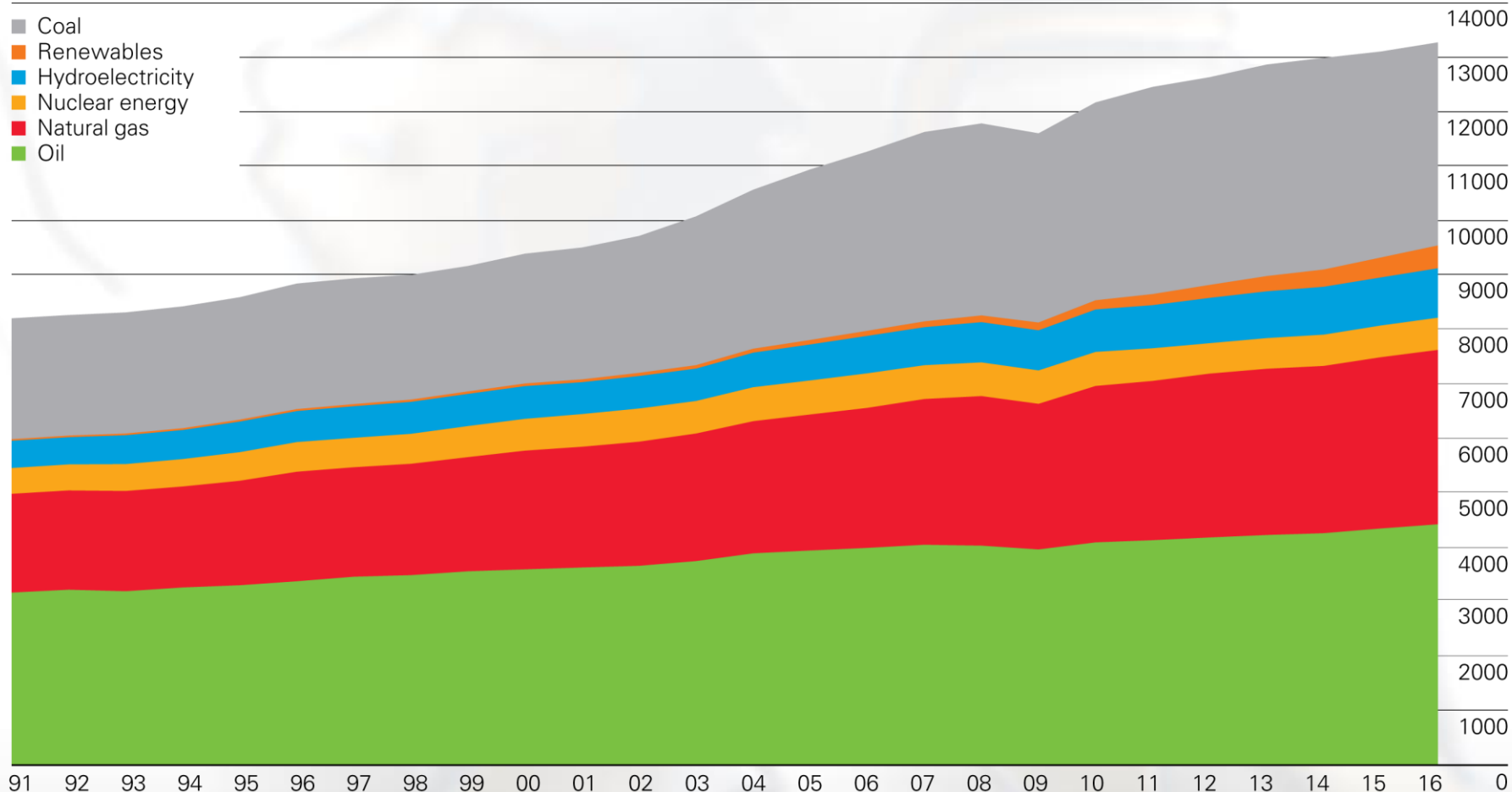


Current Status of the Energy Transition



Associate Prof. Scott V. Valentine, Assistant Dean (Research)
Lee Kuan Yew School of Public Policy

On the surface - gloom



Source: BP Statistical Review of World Energy 2017

But trends tell another story...

Trends 1 & 2

Price Inflation and Market Volatility

Fuel stock	2015 Proven reserves	2015 Production	Reserves to Production
Oil (billion barrels)	1698	33.5	50.7
Natural Gas (trillion cbm)	187	3.5	52.8
Coal (million tonnes)	891531	7820	114

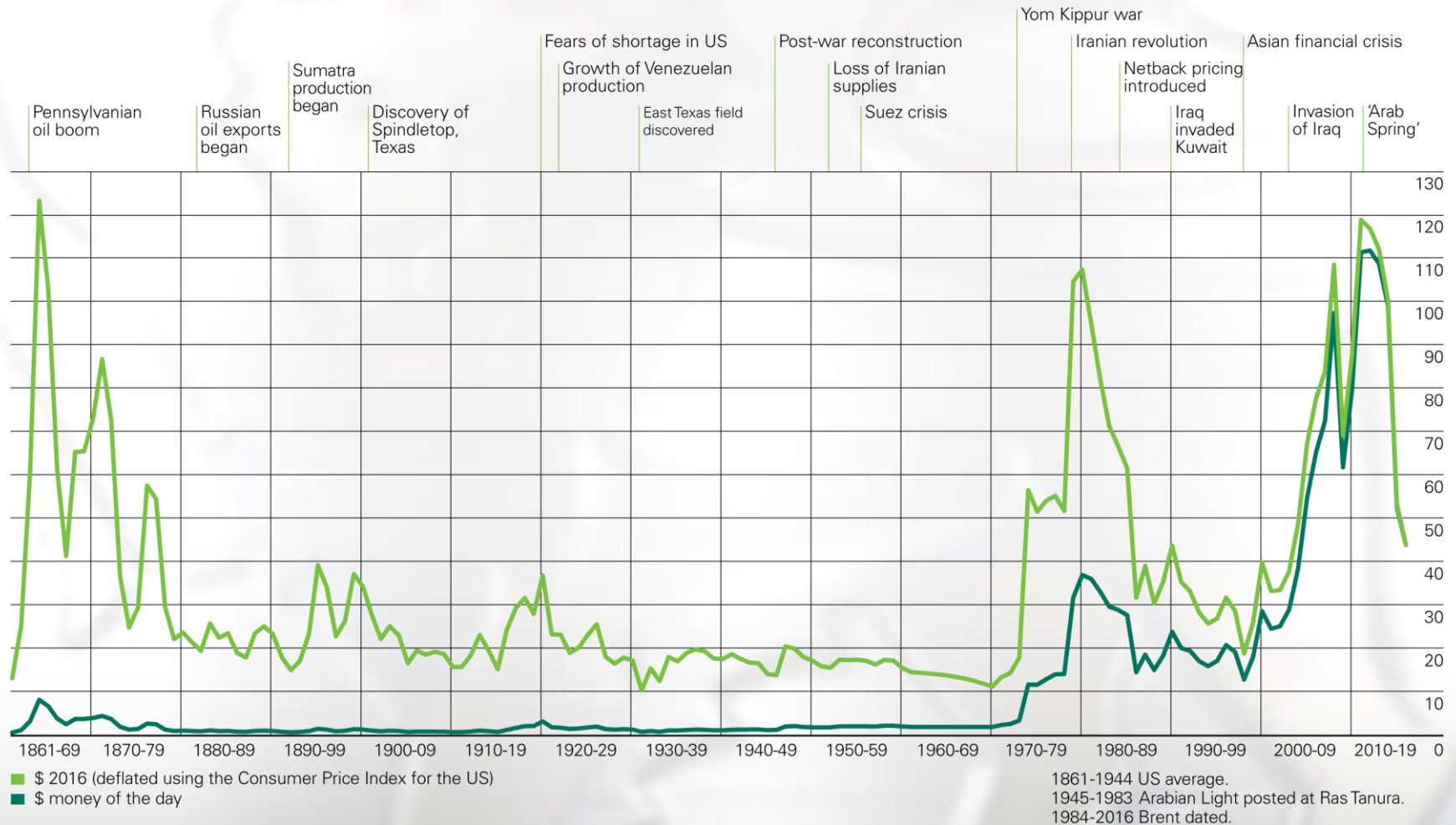
BP Statistical Review of World Energy 2017

Fuel stock	1995 Proven reserves	Change
Oil (billion barrels)	1126	572 (51%)
Natural Gas (trillion cbm)	120	67 (56%)
Coal (million tonnes)	1031610	-140079 (-14%)

Next 20 years

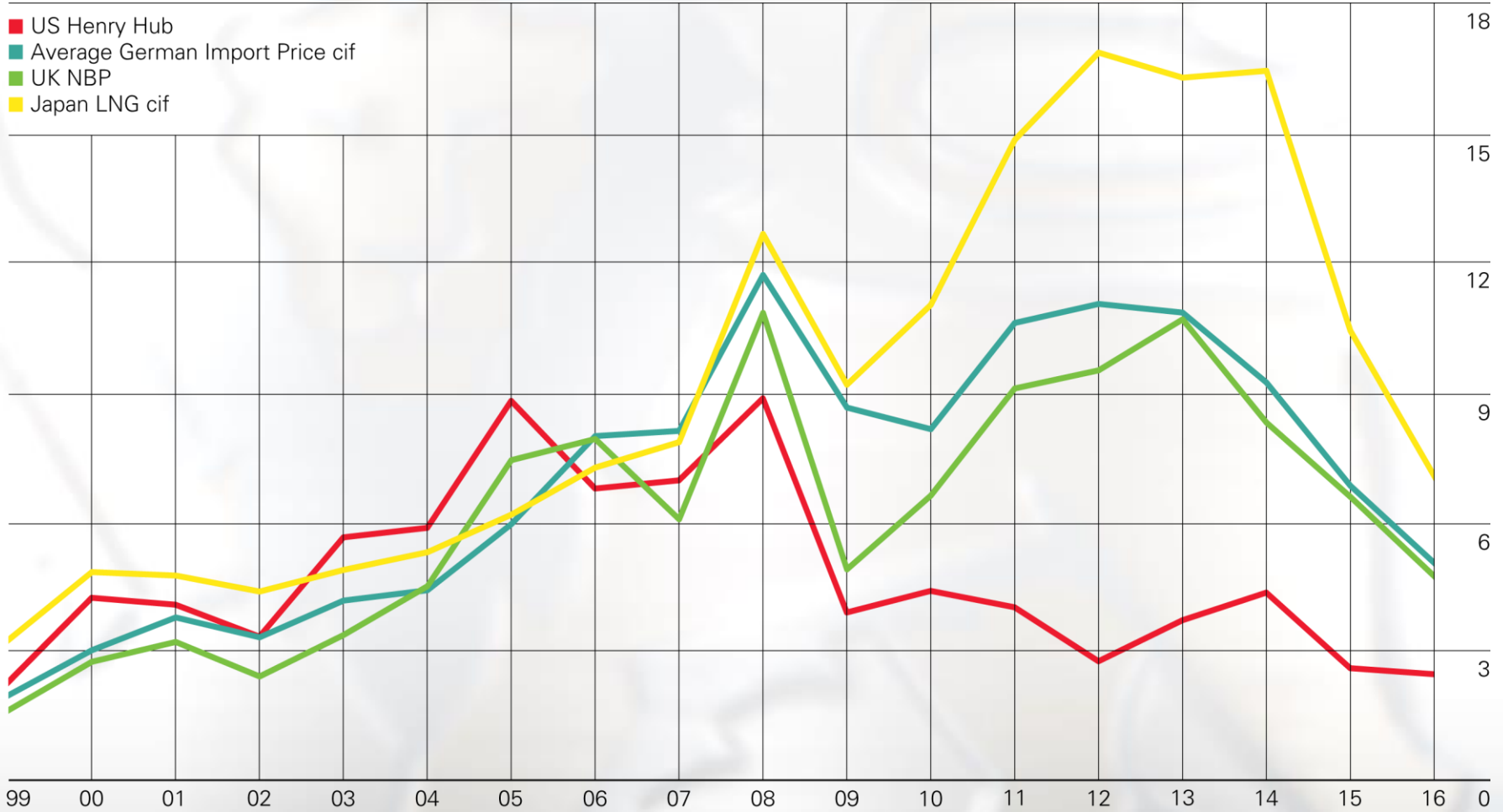
Energy
 demand
 +30%

Oil Prices (\$/barrel)



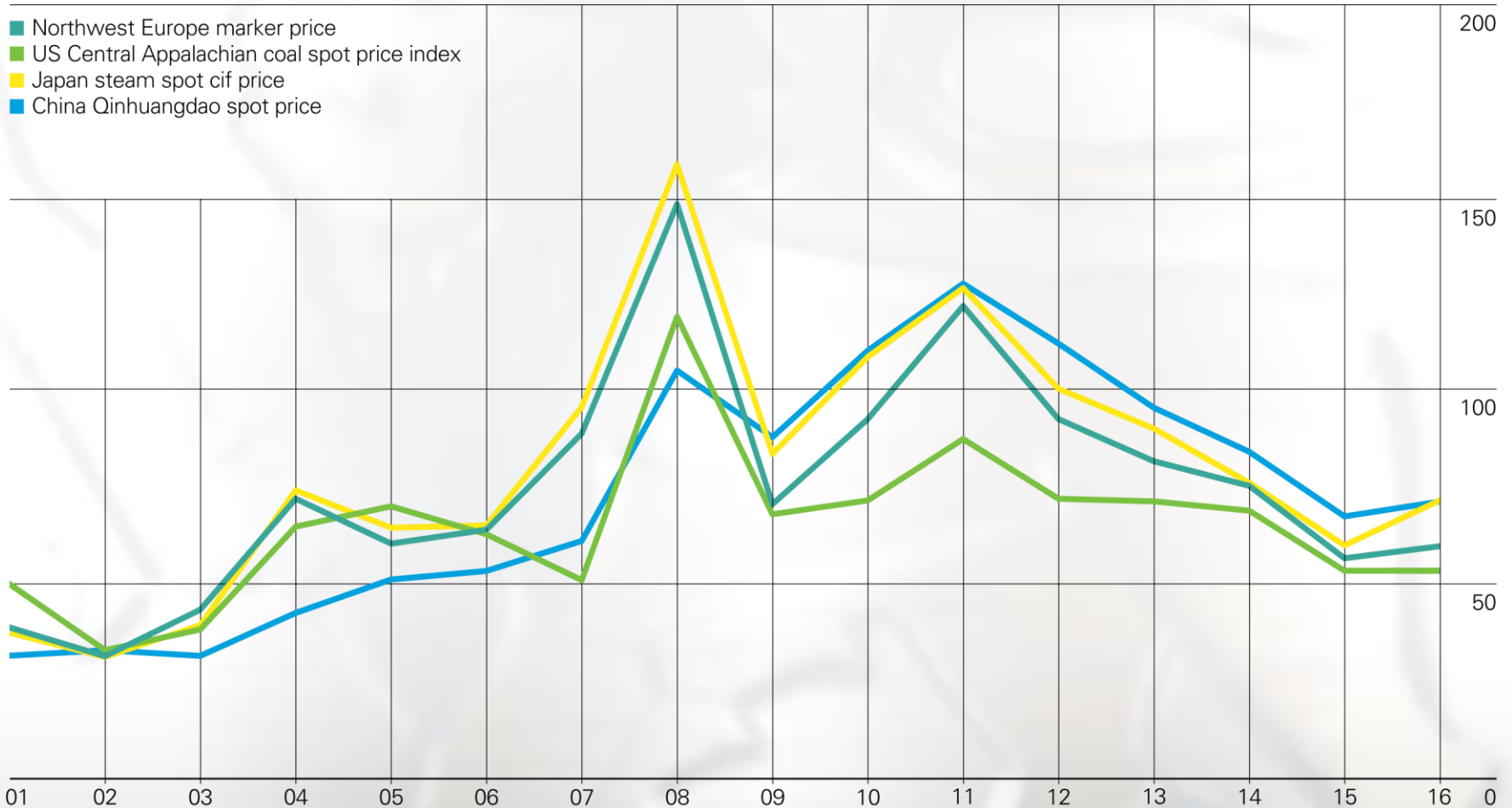
Source: BP Statistical Review of World Energy 2017

Gas Prices (\$/mmBTU)



Source: BP Statistical Review of World Energy 2017

Coal Prices (US\$tonne)



Source: BP Statistical Review of World Energy 2017

Fossil fuels do the superman

Table 1.6 ▶ Fossil-fuel import prices by scenario

	2014	New Policies Scenario			Current Policies Scenario			450 Scenario			Low Oil Price Scenario		
		2020	2030	2040	2020	2030	2040	2020	2030	2040	2020	2030	2040
Real terms (2014 prices)													
IEA crude oil imports (\$/barrel)	97	80	113	128	83	130	150	77	97	95	55	70	85
Natural gas (\$/MBtu)													
United States	4.4	4.7	6.2	7.5	4.7	6.3	7.8	4.5	5.7	5.9	4.7	6.2	7.5
Europe imports	9.3	7.8	11.2	12.4	8.1	12.5	13.8	7.5	9.4	8.9	5.9	8.9	11.4
Japan imports	16.2	11.0	13.0	14.1	11.4	14.9	16.0	10.7	11.8	11.1	8.8	10.7	12.4
OECD steam coal imports (\$/tonne)	78	94	102	108	99	115	123	80	79	77	88	97	102
Nominal terms													
IEA crude oil imports (\$/barrel)	97	89	153	210	92	176	246	85	131	156	61	95	140
Natural gas (\$/MBtu)													
United States	4.4	5.2	8.3	12.3	5.2	8.6	12.8	5.0	7.6	9.7	5.2	8.3	12.3
Europe imports	9.3	8.6	15.1	20.3	9.0	16.9	22.6	8.4	12.7	14.6	6.6	12.1	18.7
Japan imports	16.2	12.2	17.6	23.1	12.6	20.1	26.3	11.9	15.9	18.2	9.8	14.4	20.3
OECD steam coal imports (\$/tonne)	78	104	138	178	110	155	202	89	106	126	98	130	168

Notes: MBtu = million British thermal units. Gas prices are weighted averages expressed on a gross calorific-value basis. All prices are for bulk supplies exclusive of tax. The US price reflects the wholesale price prevailing on the domestic market. Nominal prices assume inflation of 1.9% per year from 2014.

Trend 3

The Strategic Need to Diversity



Trend 4

The Needs to Sever Links to Instability

Rank	Exporter	2016 Crude Oil Exports	% World Total
1.	Saudi Arabia	US\$136.2 billion	20.1%
2.	Russia	\$73.7 billion	10.9%
3.	Iraq	\$46.3 billion	6.8%
4.	Canada	\$39.5 billion	5.8%
5.	United Arab Emirates	\$38.9 billion	5.7%
6.	Kuwait	\$30.7 billion	4.5%
7.	Iran	\$29.1 billion	4.3%
8.	Nigeria	\$27 billion	4.0%
9.	Angola	\$25.2 billion	3.7%
10.	Norway	\$22.6 billion	3.3%

Not Much Better for Natural Gas

RANK	COUNTRY	(CU M)
1	<u>RUSSIA</u>	184,500,000,000
2	<u>QATAR</u>	118,900,000,000
3	<u>NORWAY</u>	114,400,000,000
4	<u>EUROPEAN UNION</u>	93,750,000,000
5	<u>CANADA</u>	77,960,000,000
6	<u>NETHERLANDS</u>	53,650,000,000
7	<u>TURKMENISTAN</u>	45,790,000,000
8	<u>UNITED STATES</u>	42,870,000,000
9	<u>ALGERIA</u>	40,800,000,000
10	<u>MALAYSIA</u>	34,870,000,000
11	<u>INDONESIA</u>	31,780,000,000
12	<u>AUSTRALIA</u>	31,610,000,000
13	<u>NIGERIA</u>	25,000,000,000
14	<u>GERMANY</u>	22,270,000,000
15	<u>BOLIVIA</u>	17,860,000,000

Trend 5

Improved Understanding of Environmental / Health Connections



China and India 2015
- Around 2.2 million deaths annually from air
pollution (State of Global Air 2017)

- US annually:
- Vehicle emissions:
 - 58,000
premature
deaths
 - Power plant
emissions:
 - 54,000
premature
deaths

(Caiazzo et al., 2013)

Trend 6 Enhanced Evidence of CC Severity

- Hurricane Sandy (2012): US\$65 Billion
- 41 Extreme Weather events in 2013
 - Damages over US\$1 billion each
- Before:
 - Benefit now; Pay later
- Now:
 - Pay now; Pay later

Trend 7

Disparate Approaches to Nuclear Power

- Before:
 - Installed nuclear power capacity growth +38% ~ +208% by 2030 (World Nuclear Association, 2008).
 - 60+ nations investigating adoption of nuclear power (Sovacool and Valentine, 2012).
- Post Fukushima:
 - Financial Woes: Westinghouse, Toshiba, Areva

Trend 8

Tech Progress and Renewable Energy

Figure 6: Levelized Cost of Electricity for New Power Plants

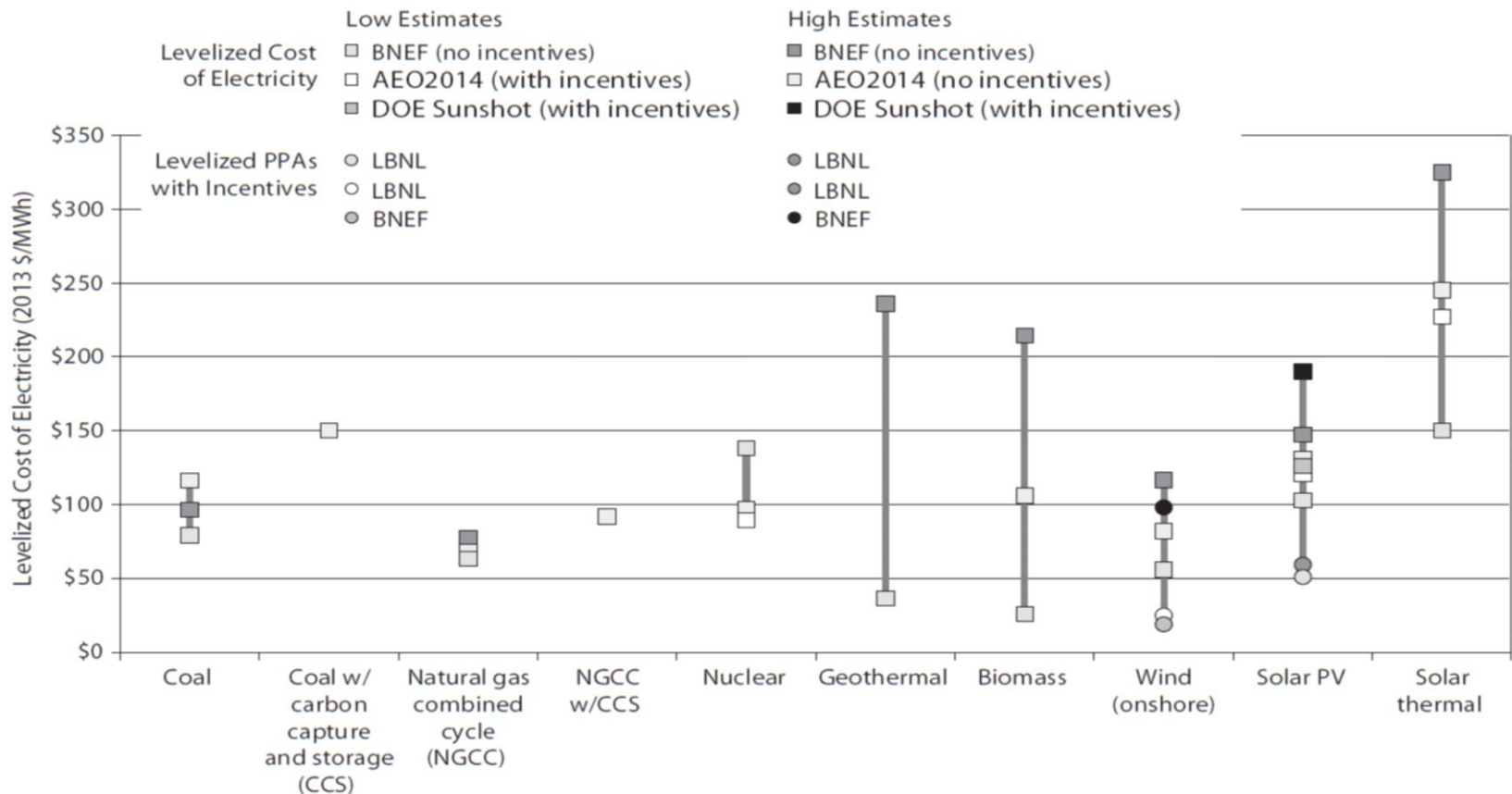


Figure 6.2. Levelized Cost of Electricity for New Power Plants, 2013. Source: World Resources Institute (WRI), *Seeing Is Believing* (Washington, DC: WRI, October 2014). Note: AEO= US Energy Information Administration's Annual Energy Outlook; BNEF= Bloomberg New Energy Finance; DOE= US Department of Energy; LBNL= Lawrence Berkeley National Laboratory; PPA= power purchase agreements; PV= photovoltaic.

Trend 9

The Rise of Government and Market Support for Renewable Energy

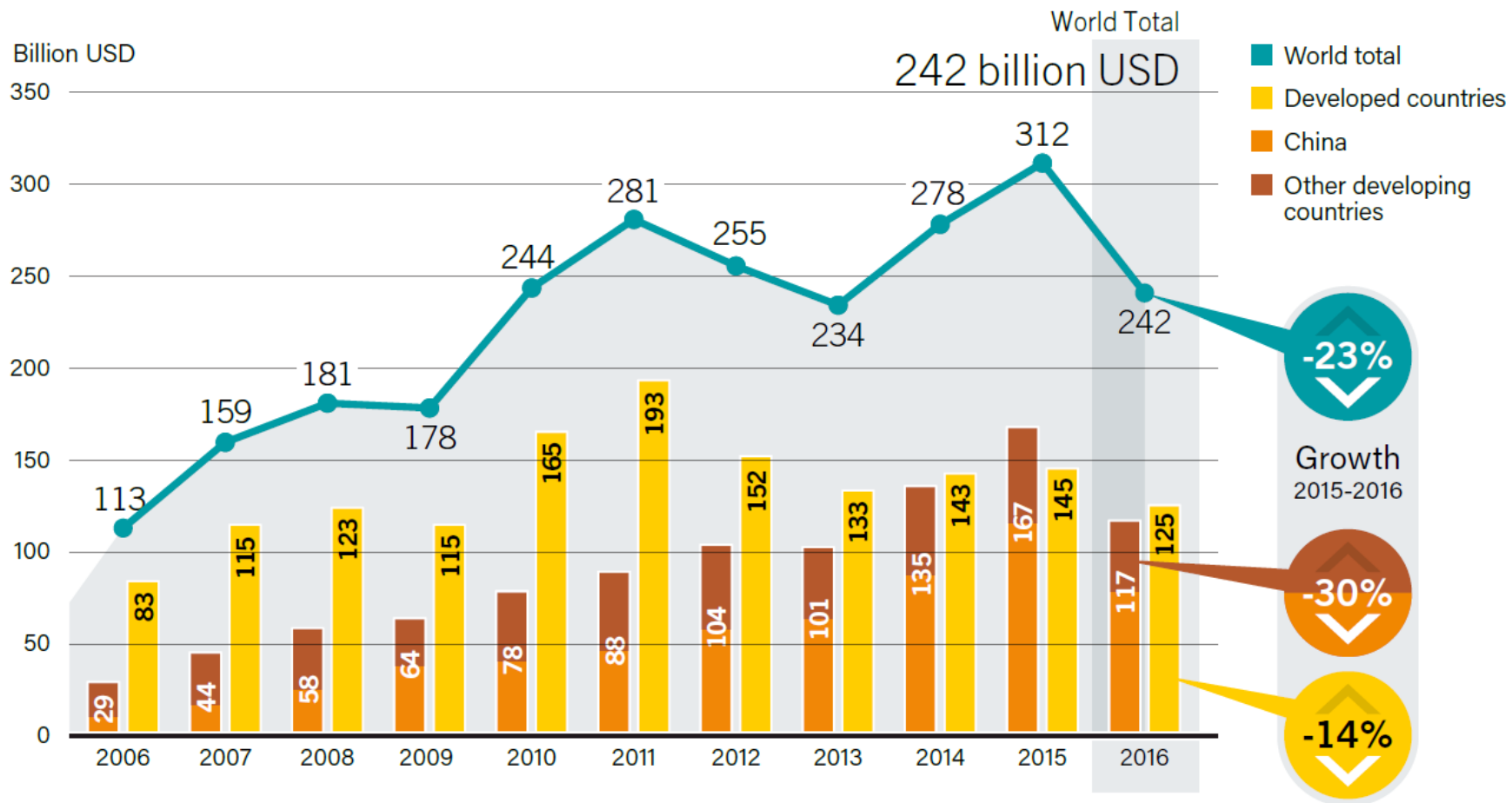
Number of Renewable Energy Regulatory Incentives and Mandates, by Type, 2014-2016



Source: REN21 (REN21, 2017)

Investment in Renewable Energy: 2006-2016

Critical Mass of Investment



Source: REN21 (REN21, 2017)

Investment in Renewable Energy: 2006-2016

Trend 10: First mover advantages

Clean-tech sector - €4 trillion in sales by 2025

(Roland Berger Strategy Consultants, 2011).

Top 10 onshore wind turbine manufacturers

Rank 2016	Manufacturer	Capacity commissioned in 2016 (GW)	New-build market share in 2016 (%)	Rank 2015	Capacity commissioned in 2015 (GW)	New-build market share in 2015 (%)
1↑	Vestas	8.7	16.5%	2	7.3	12.6%
2↑	GE	6.5	12.3%	3	5.9	10.2%
3↓	Goldwind	6.4	12.1%	1	7.8	13.5%
4→	Gamesa	3.7	7.0%	4	3.1	5.3%
5↑	Enercon	3.5	6.6%	6	3.0	5.2%
6↑	Nordex group	2.7	5.0%	unranked	unranked	unranked
7→	Guodian	2.2	4.2%	7	2.8	4.8%
8↓	Siemens	2.1	3.9%	4	3.1	5.3%
9↓	Ming Yang	1.96	3.7%	8	2.7	4.7%
9↓	Envision	1.94	3.7%	8	2.7	4.7%

The Wild Card?



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THANK YOU

