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Excitement in the Air:
The Energy Revolution

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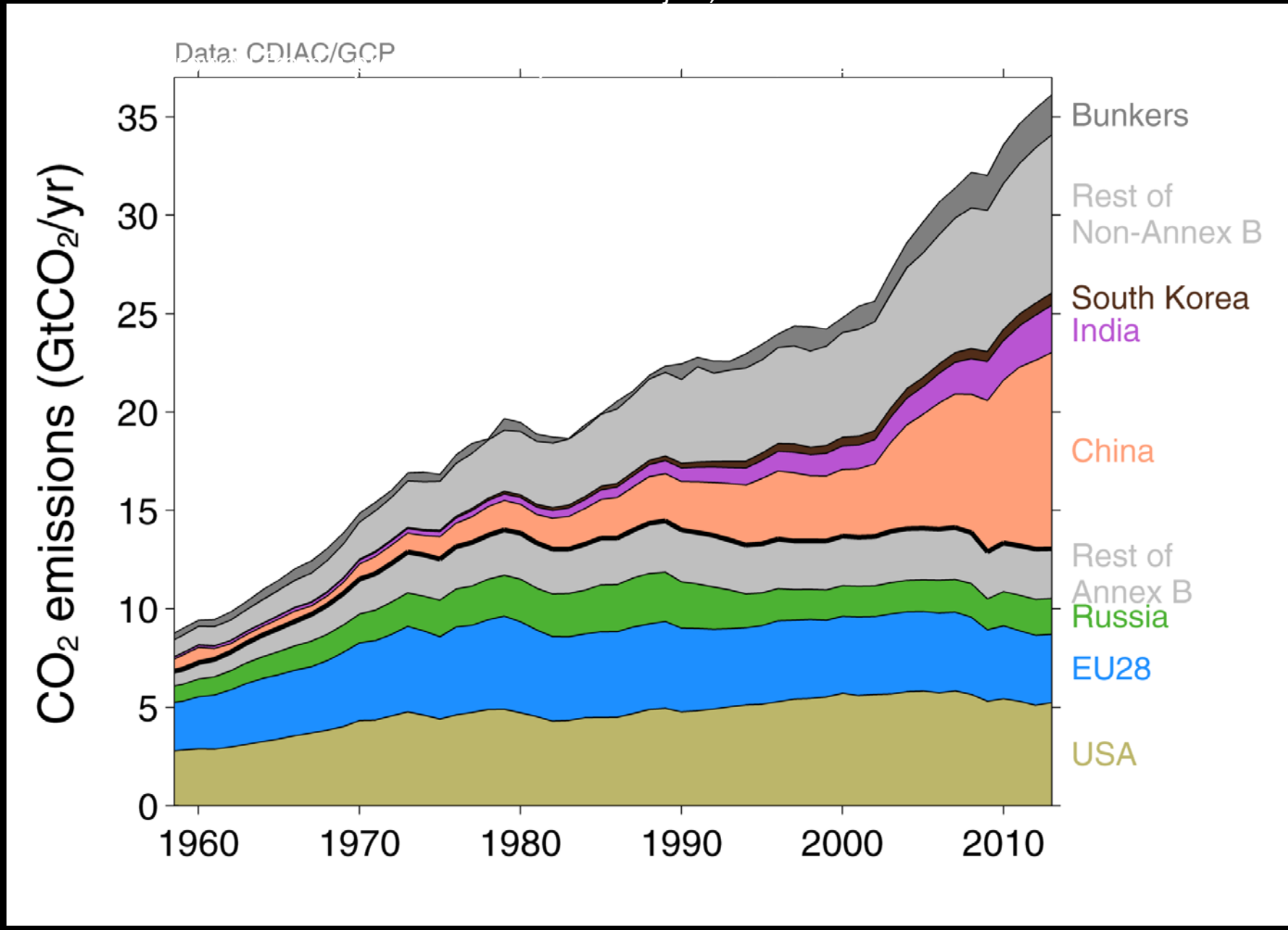
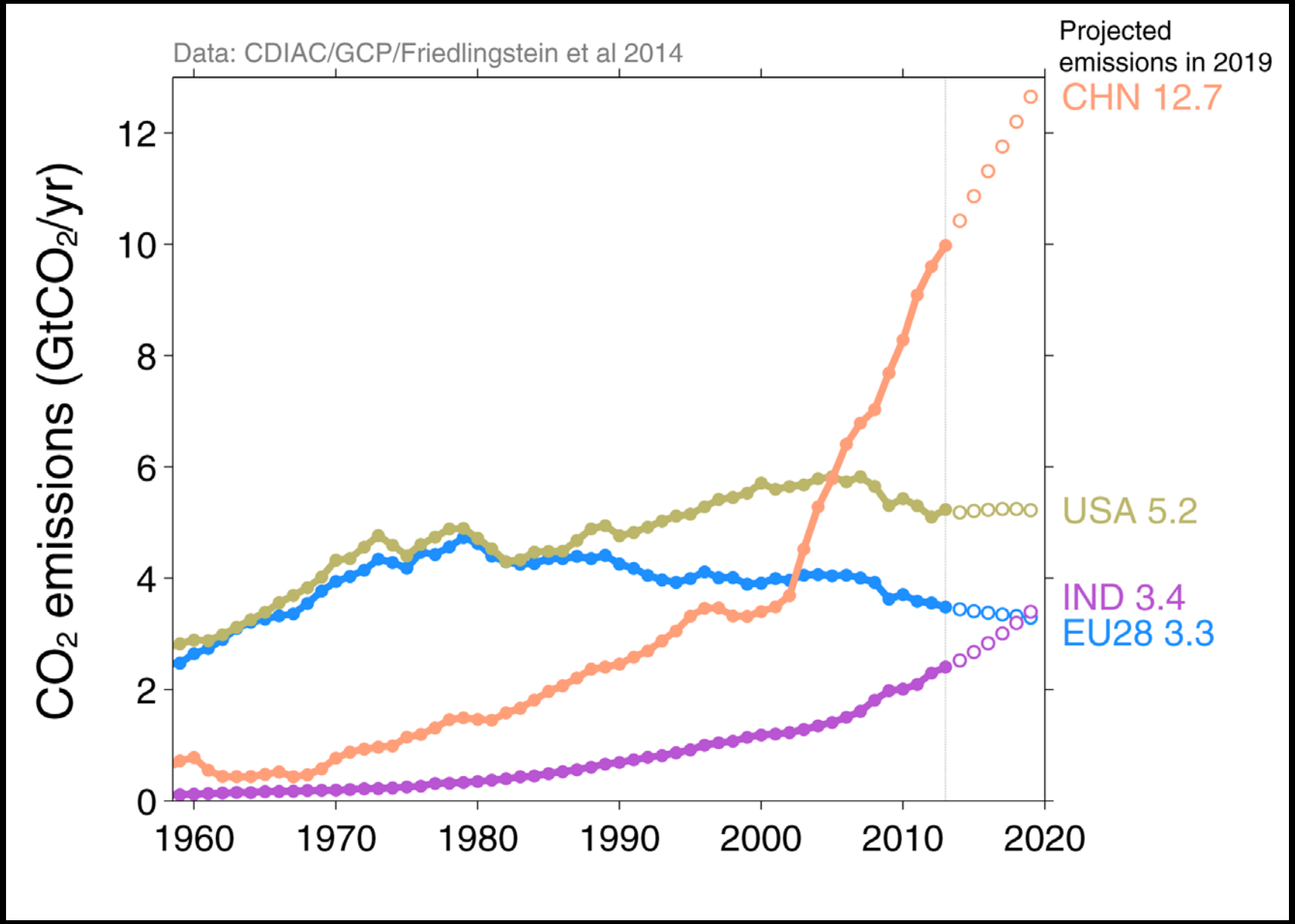
The Global Challenge

- We know that something is not working here
- The puzzle is striking: global warming is already affecting the lives of millions and will dramatically change the lives of virtually all of us within our life expectancy.
- Millions die every year as a result of fossil fuel related pollution
- Renewable energy is by now competitive, price wise, with most modes of fossil fuel generated energy.
- Renewable energy is not polluting and it is the only way to stop global warming. Energy Saving and Recycling are problematic policy solutions in more ways than one.
- Renewable energy technology is readily available
- And yet, the market is not investing more … or, to be more accurate, it is not investing everything it's got in renewable to get this whole issue done and over with.
- Hence a Global Challenge

Source: Global Carbon Project, 2013 data




Data: CDIAC/GCP/Friedlingstein et al 2014
Projected emissions in 2019
CHN 12.7
USA 5.2
IND 3.4
EU28 3.3
CO_2 emissions ($GtCO_2$/yr)
0
2
4
6
8
10
12
1960
1970
1980
1990
2000
2010
2020

Recycling is not a good policy solution: GHG Emissions Of Virgin And Recycled Material Production (Kg CO_2eq / kg)

Material	Virgin	Recycled	Factor
Aluminum cans	12.94	1.03	12.6
Steel cans	2.82	0.99	2.8
Copper wire	7.41	6.09	1.2
Glass	0.48	0.33	1.5
HDPE	1.76	0.18	9.8
LDPE	2.16	0.18	12.0
PET	2.05	0.18	11.4
Cardboard	0.84	0.92	0.9
Newspaper	2.13	1.27	1.7

Source: EPA (2006) Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks, EPA 530-R-06-004

Examples: Energy Savings From Reuse and recycling

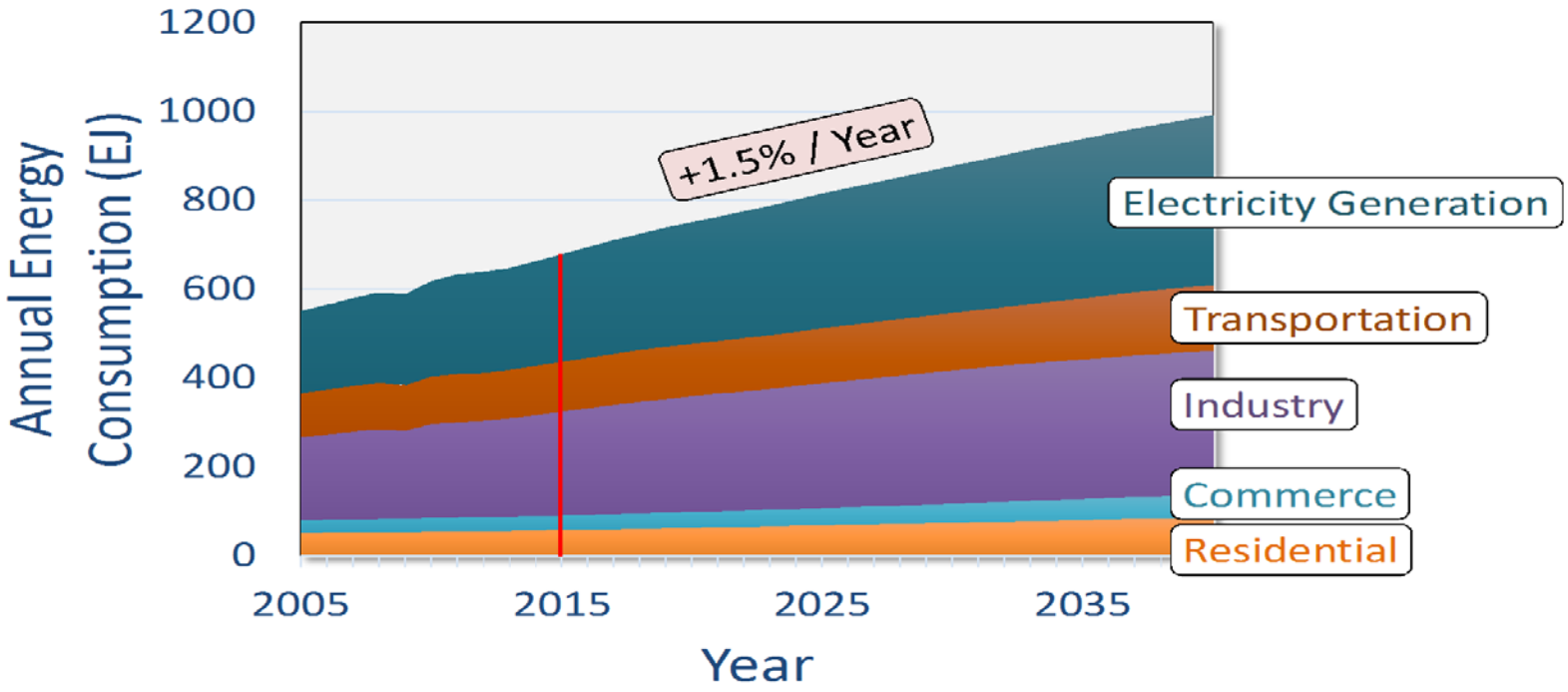
Material	Primary Production (cradle-to-gate in MJ/kg)*	Recycling (scrap-to-gate MJ/kg)	Savings Factor
Aluminum	194.7	10.3	19
Copper	~100	20 – 30	5 – 3.3
Steel	21.7	7.1	3
Steel section	33.3	16.0	2.1
PET	82.7	30.2	2.7
Paper	18	12	1.5
Glass	12	8	1.5

Slide by Roland Geyer, Santa Barbara UCSB

* 1 Kilowatt = 3.6 MJ

Energy Saving Is not an Effective Policy Solution due to the ever Growing Energy Needs

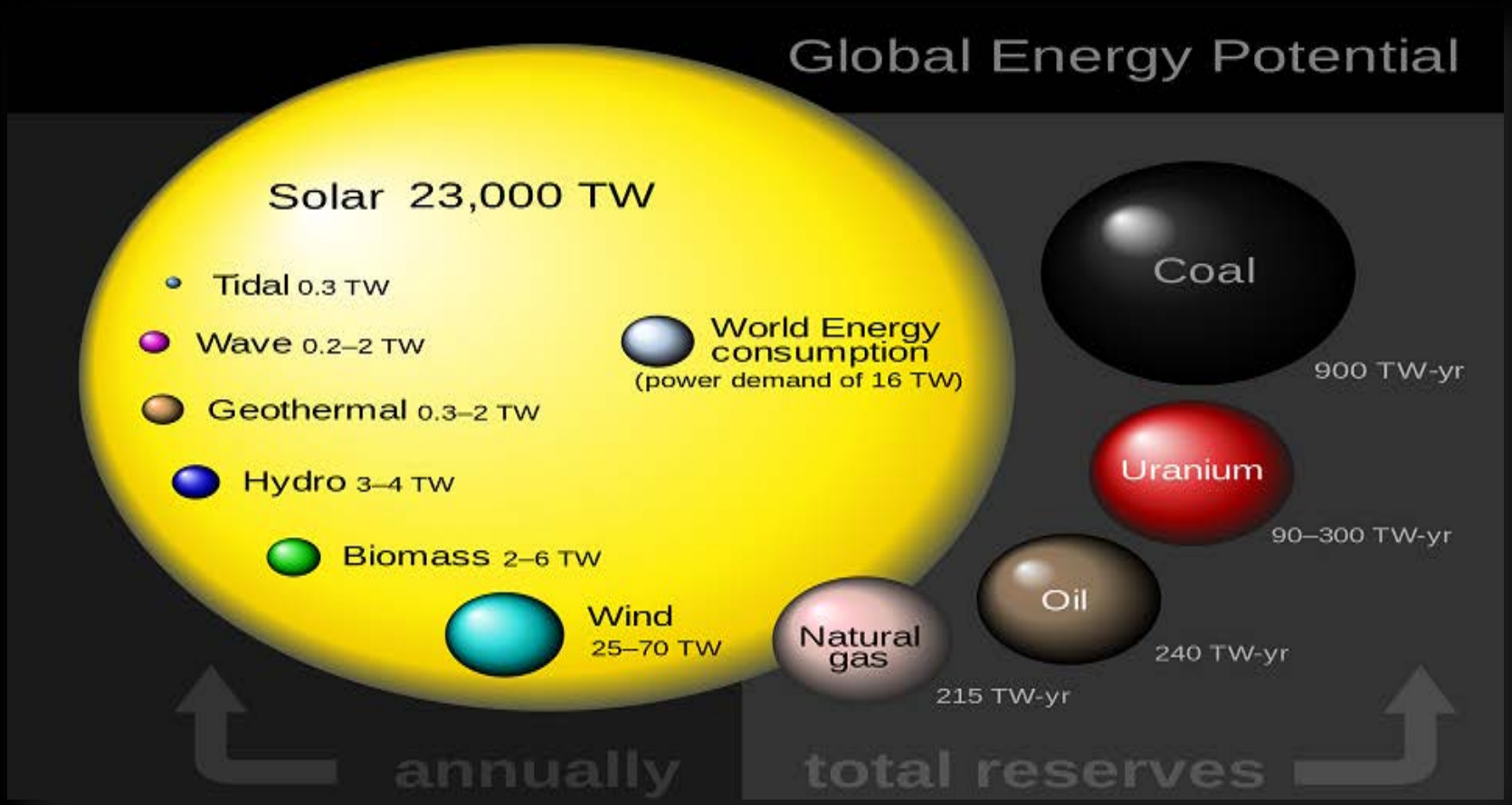
Need for Energy



Annual Energy Outlook 2014, US Energy Information Administration (EIA)

Nature's Supply and Demand

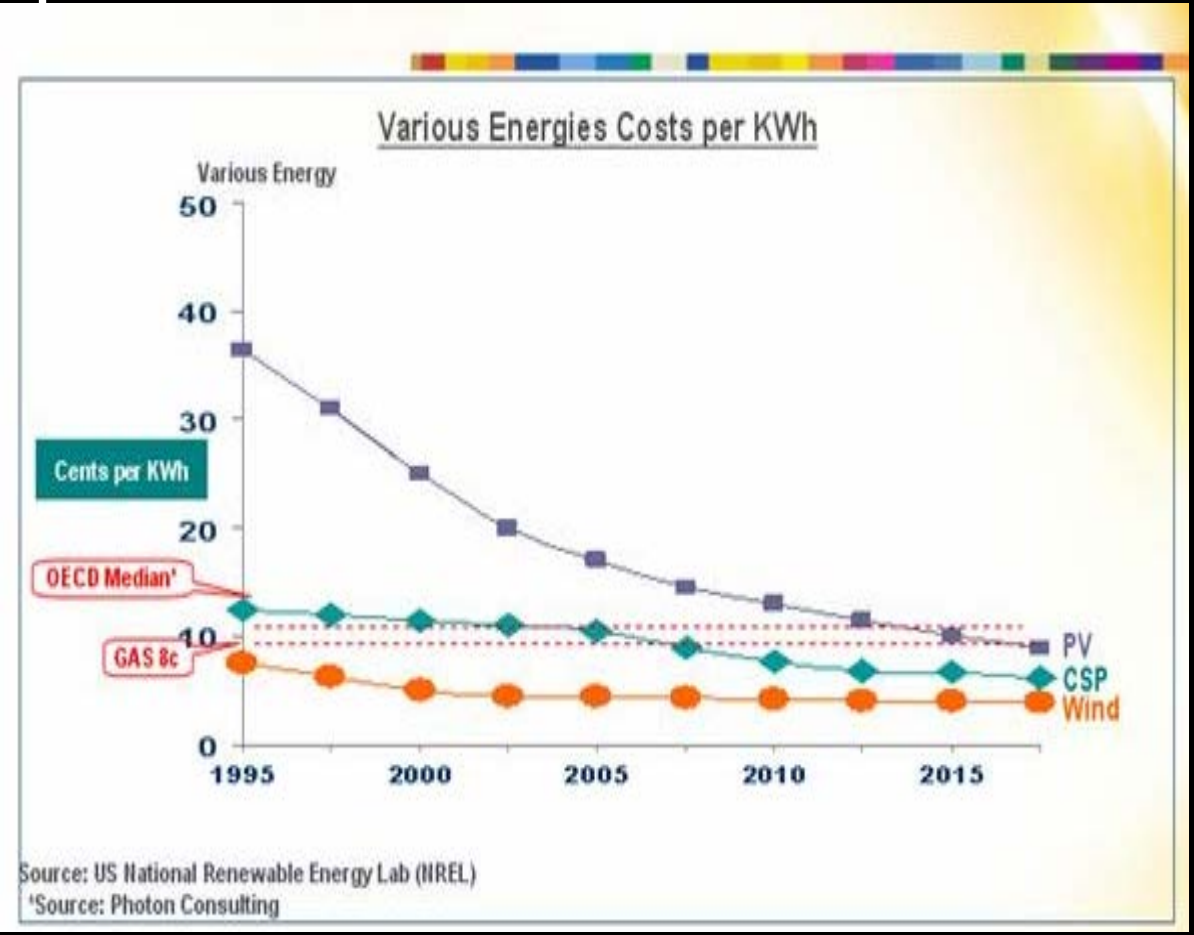
The (non) Scarcity of Resources



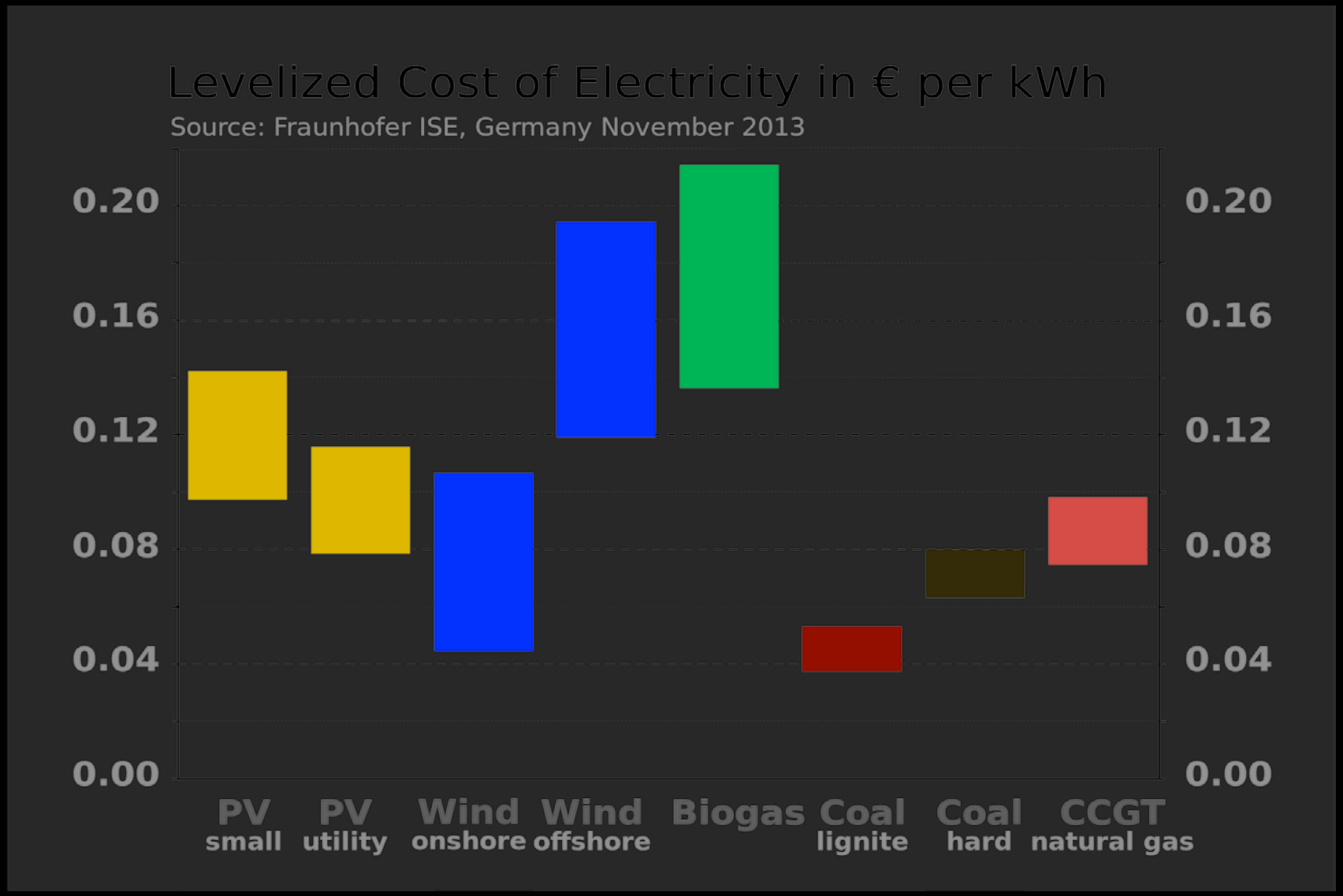
What do prices of Wind and Solar look like? Compared to Fossil Fuels

Hey, Guess what?
Prices of wind and CSP
Solar have just gotten
Below coal and gas
But no one bothered
to tell us ☺

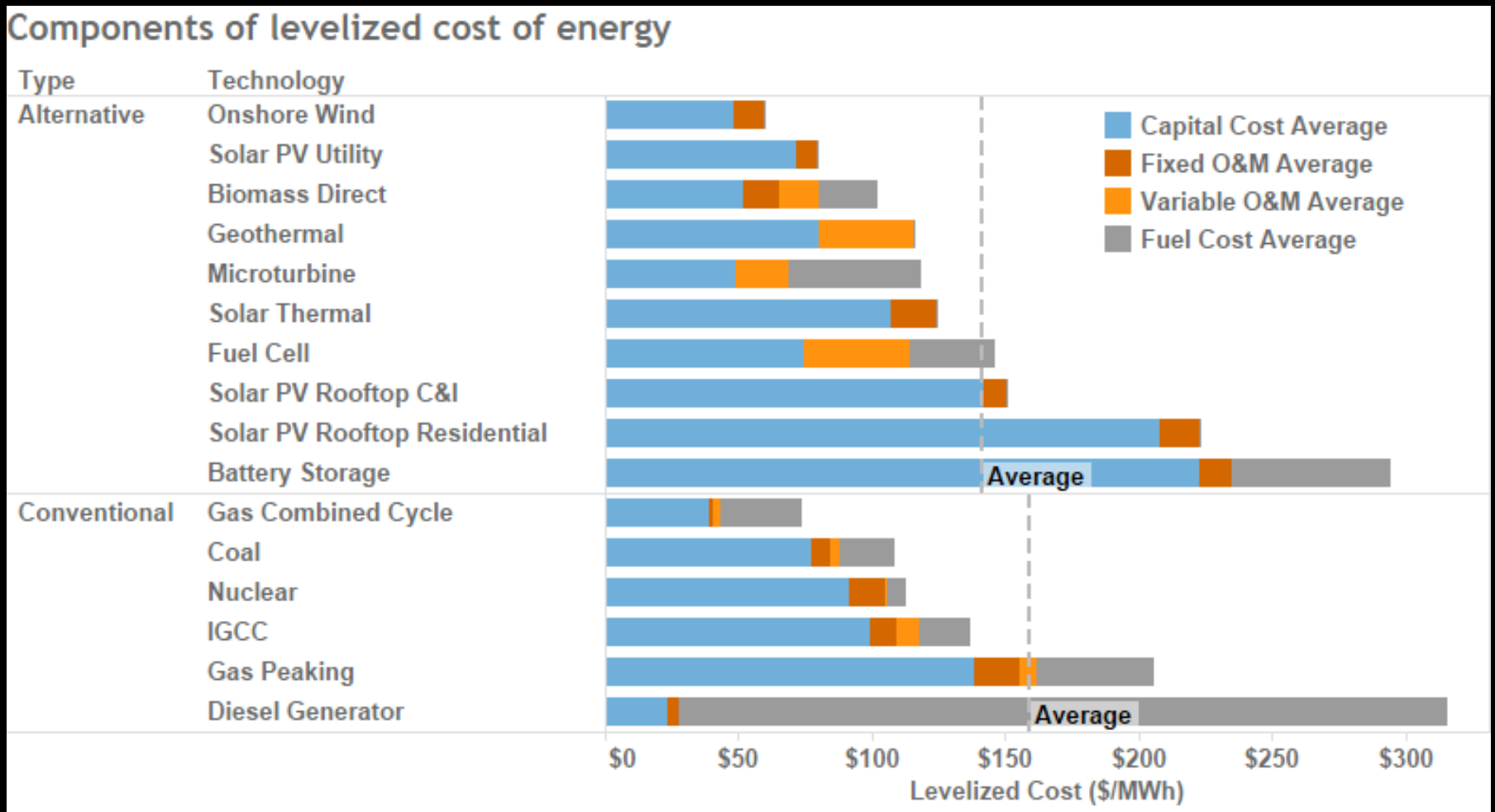
Should we start investing in solar and wind energy?



Most Current Price Estimates



Another Estimate



Source: Lazard's Levelized Cost of Energy Analysis--Version 8.0, September 2014
http://www.lazard.com/PDF/Levelized%20Cost%20of%20Energy%20-%20Version%208.0.pdf

ENERGY INNOVATION
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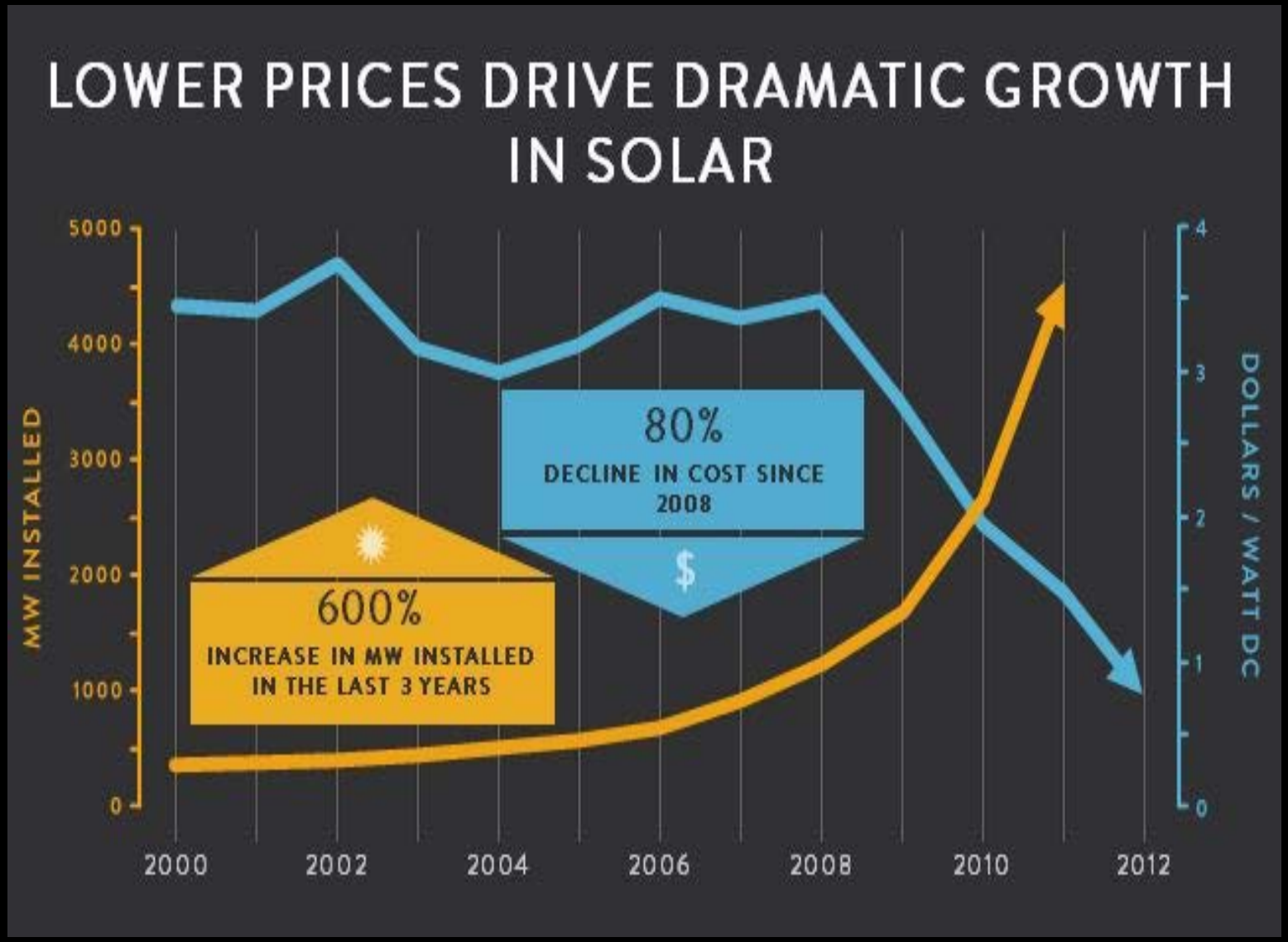
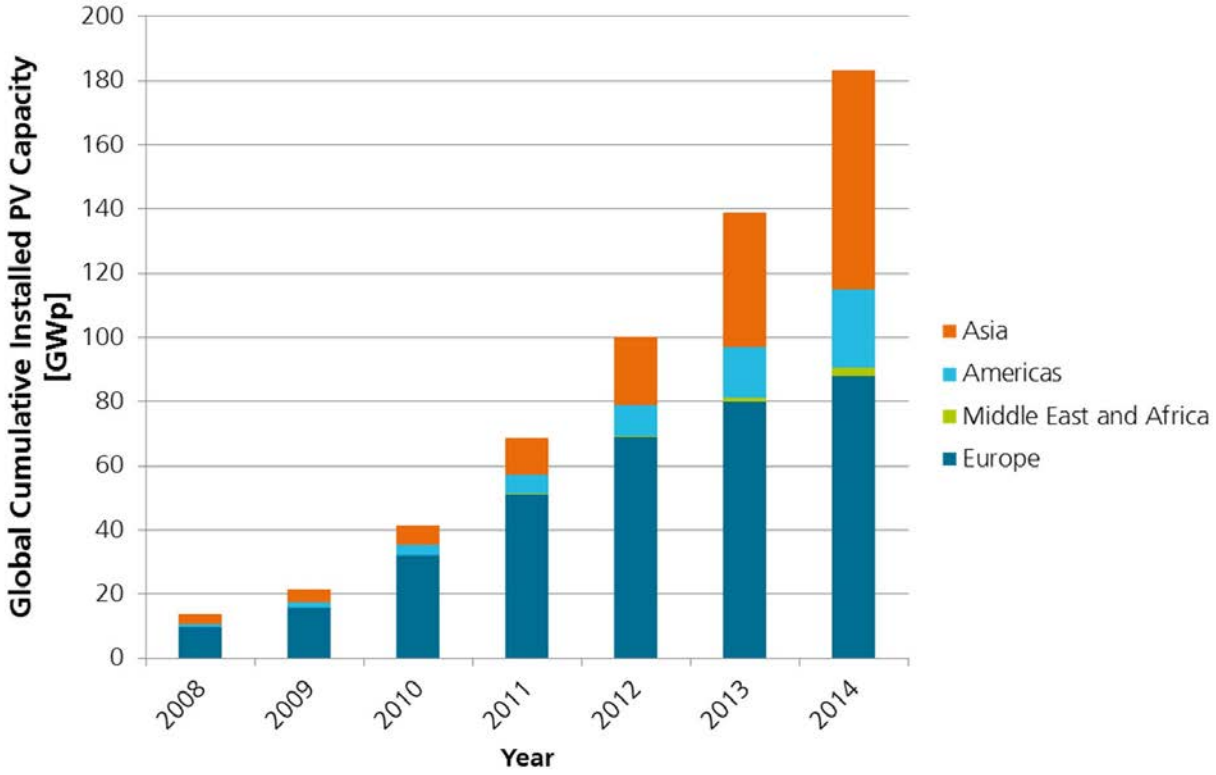

LOWER PRICES DRIVE DRAMATIC GROWTH IN SOLAR
MW INSTALLED
5000
4000
3000
2000
1000
0
DOLLARS / WATT DC
4
3
2
1
0
2000
2002
2004
2006
2008
2010
2012
80%
DECLINE IN COST SINCE 2008
$
600%
INCREASE IN MW INSTALLED IN THE LAST 3 YEARS

More Current Data on Actual Capacity Installations



Critical Change of Policy of the Government of China

- ***Guiding Policy Framework –***

- *China's13th five year plan (FYP), was released in March 2016 and covers the period up to 2020. The headline targets are to reduce energy intensity by 15 percent and carbon intensity by 18 percent compared to 2015 levels. In addition, energy consumption will be capped at 5 billion tons of coal equivalent, and the share of primary energy consumption from non-renewable sources will increase to 15 percent. The increased carbon intensity goal means that China would reach, or potentially exceed, its Copenhagen pledge to reduce carbon intensity 40-45 percent below 2005 levels.*

The Virtuous Cycle

Tom Randall of the Bloomberg Report October 5 2015

Bloomberg and MacKensie Conclusion

- Tom Randall of Bloomberg, October 2015: Solar and Wind has just past another (no return) turning point: It never made less sense to build fossil fuel power plants
- Wood MacKensie Februar 2015: *Just as shale extraction reconfigured oil and gas, no other technology is closer to transforming power markets than distributed and utility scale solar.*

The Theoretical Question: Why then do we not see more of it yet?

- The study of misconceptions
- Concentrated versus diffused interests
- The Tipping Point Theory
- Social Movements or lack thereof…
- Market Failures
    - Information
    - Externalities
- The Institutional Approach
    - Path Dependence
    - The Lack in Market Structures
    - **The structure of the existing market**
    - **Economies and diseconomies of scale**

Economies and Diseconomies of Scale

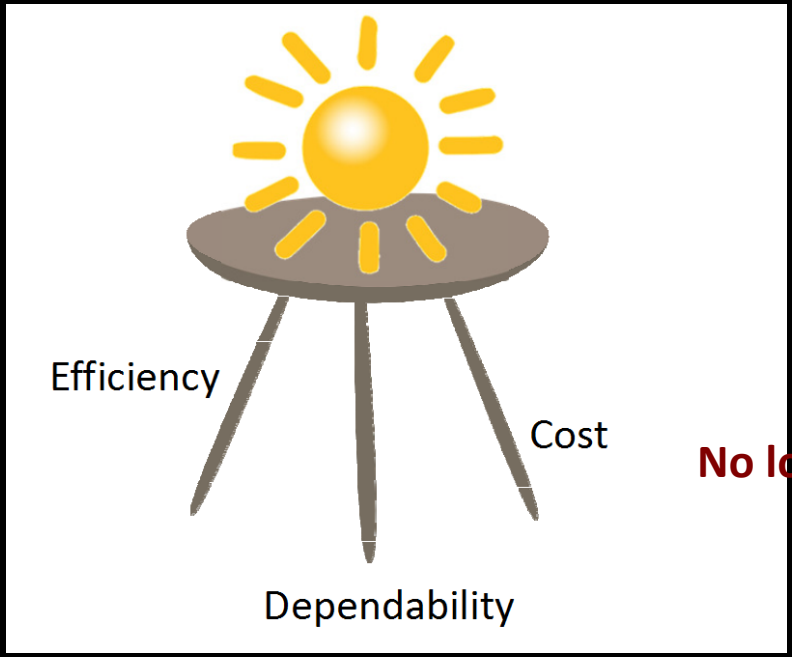
- Scientific Observation:
  - There are no Economies of Scale in the production of renewable energy
  - There are huge economies of scale in the production of energy off fossil fuels

Why?

- Transaction costs
- Technicalities
- Technological barriers
  - Cannot transport
  - Cannot store
  - Cannot really trade globally
    - The failure of CO2 global markets
    - ARCH COAL collapses; Barrel of Oil at $ 30
    - And yet – Renewable Energy is doing just fine
    - Market Failure or Market Resilience?
    - Whatever the case may be, it explains the remarkable attractiveness of investing in renewable energy
    - Warning: I am not an investment consultant

Requirements for Success

Remains a Problem



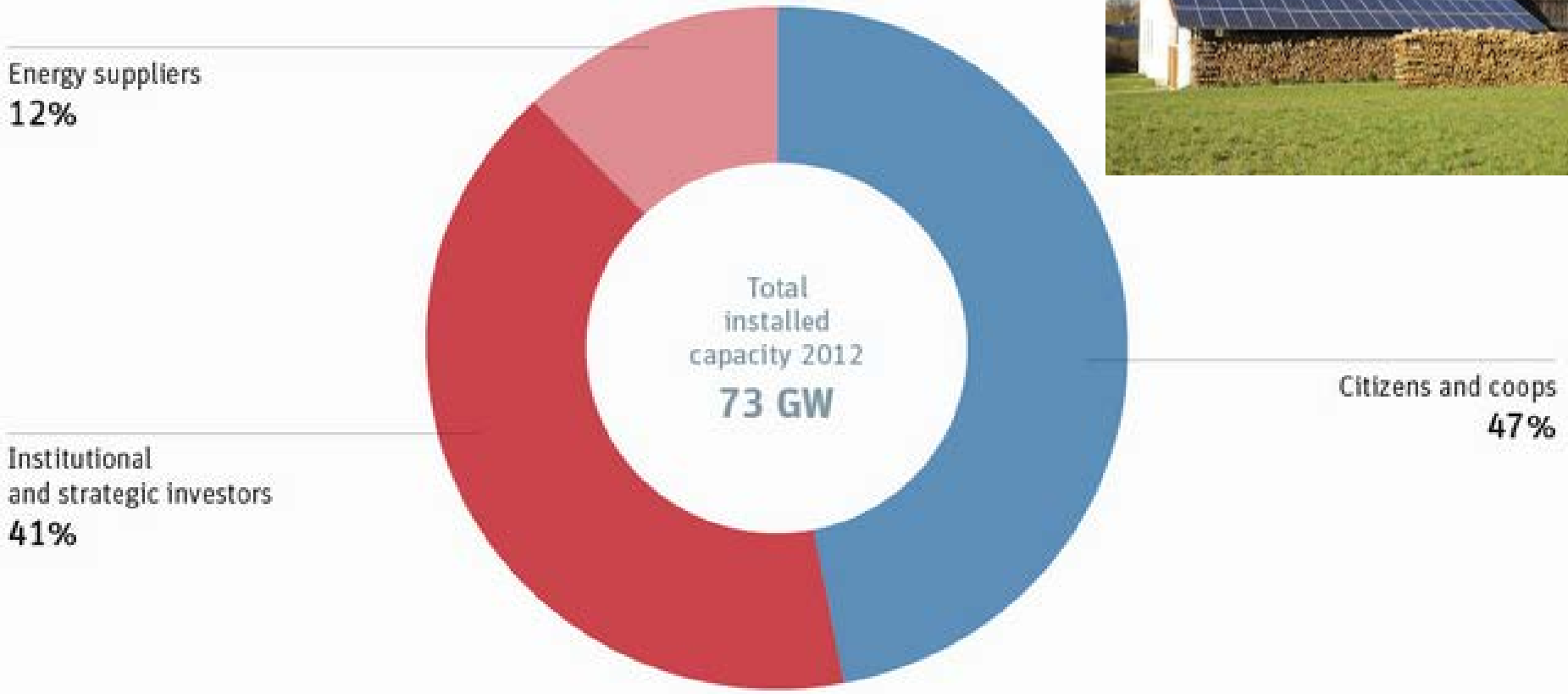
No longer a problem

Not Really a Problem

German energy transition is a democratic movement

Ownership of renewables in 2012

Source: AEE, www.unendlich-viel-energie.de



"The Energiewende"

Off Grid Prosumerism is probably the best option for Renewable Energy

It is Efficient

It Does not require of us to worry about System and grid effects

It allows us to bypass the storage problem

In most developing economies it provides more energy than they are used to get

It would and does work in many developed countries as well

What do we need to worry about: An Ongoing Research Project

Secure property rights

Enabling regulations

Leave the prosummer alone attitude

Most Importantly: Educating a new Generation of Professionals to know how to Install, maintain and Secure these Systems, technically legally and Financially

But in Order to teach and train, we need to figure it all first, hence the urgent need for applied research

How do we cover and what Roof Tops?

Table 5: Electrical data analysis.

Bulding

PV/ Grid

Grid

eet

Thank you,

- Thank you