UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Energy Transitions and Magical Thinking

David Reiner, EPRG

Presentation to EPRG-CEEPR Conference

La Sorbonne, Paris

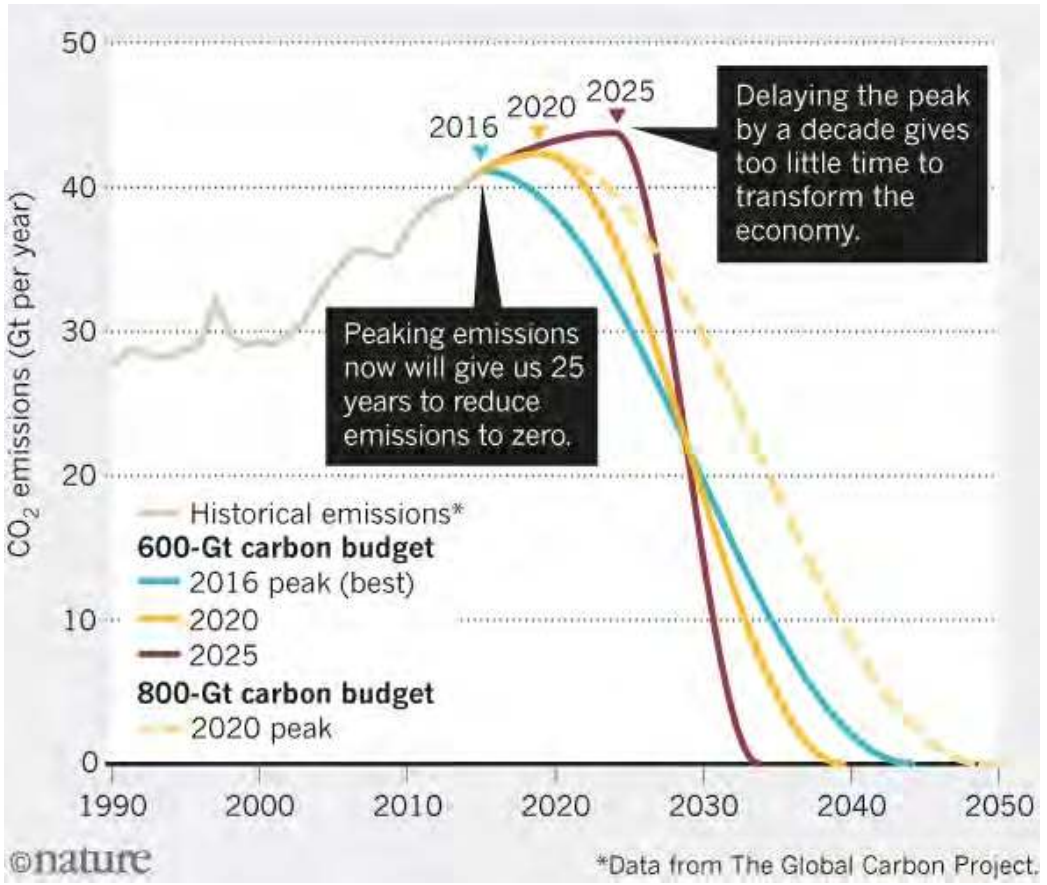
6 July, 2017

Dec 2015: Paris Accord:

Keep temperature rise well below 2°C and pursue efforts to limit to 1.5°C

Figueres et al (2017) and our 3 years left…

- Claim 1: CO_2 emissions levelling off in past three years is 'evidence that policies and investments in climate mitigation are starting to pay off'
- Claim 2: "Should emissions continue to rise beyond 2020, or even remain level, the temperature goals set in Paris become almost unattainable"
- Claim 3: Carbon budget of 150-1050Gt to meet the 1.5°C ambition.
- "These goals may be idealistic at best, unrealistic at worst. However, we are in the age of exponential transformation and think that such a focus will unleash ingenuity. By 2020, here's where the world needs to be:

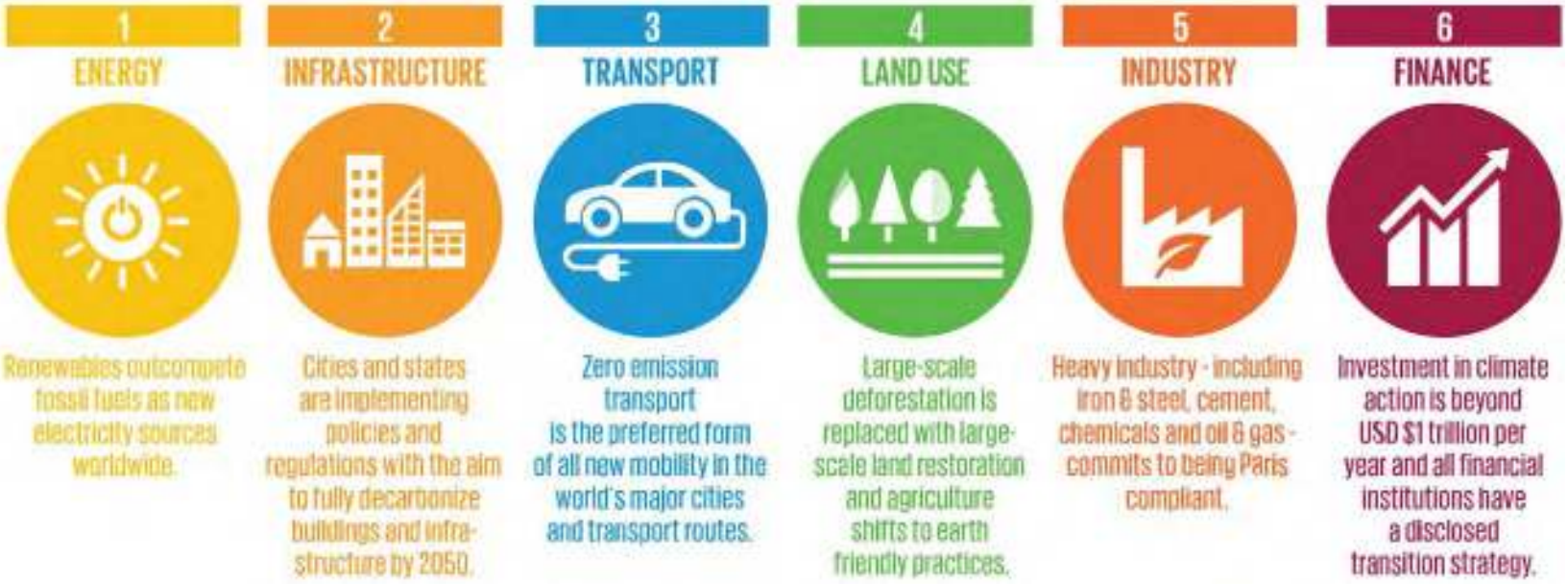


Source: C. Figueres, et al (2017), Three years to safeguard our climate, *Nature* 546: 593-595. 29 June.

6 MILESTONES BY 2020

TO MEET SDGS BY 2030

2050 : NET ZERO



2020 Milestones

IT'S NECESSARY
IT'S DESIRABLE
IT's ACHIEVABLE

- **Energy.** Renewables make up at least 30% of the world's electricity supply — up from 23.7% in 2015. No coal-fired power plants are approved beyond 2020, and all existing ones are being retired.
- **Infrastructure.** Cities and states have initiated action plans to fully decarbonize buildings and infrastructures by 2050, with funding of $300 billion annually. Cities are upgrading at least 3% of their building stock to zero- or near-zero emissions structures each year.
- **Transport.** Electric vehicles make up at least 15% of new car sales globally, a major increase from the almost 1% market share that battery-powered and plug-in hybrid vehicles now claim. Also required are commitments for a doubling of mass-transit utilization in cities, a 20% increase in fuel efficiencies for heavy-duty vehicles and a 20% decrease in greenhouse-gas emissions from aviation per kilometre travelled.

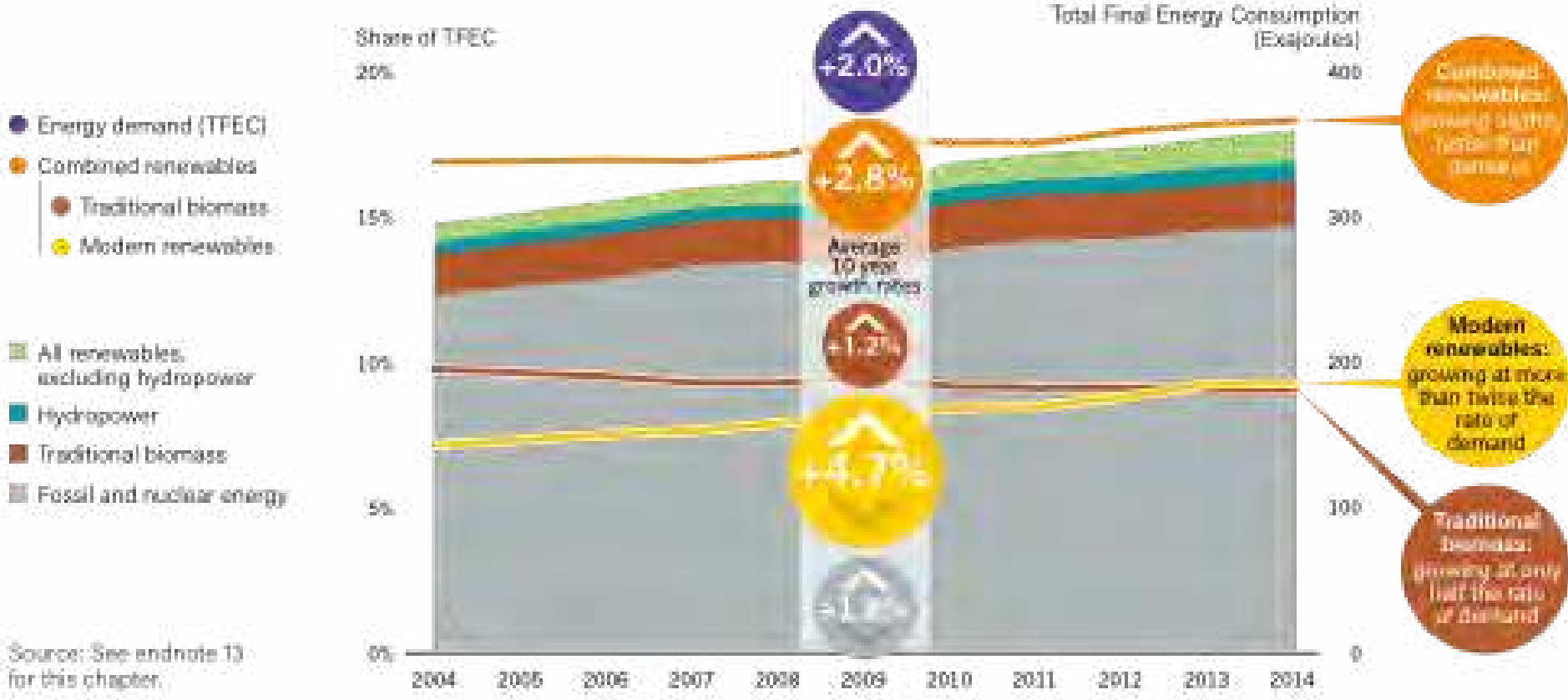
2020 Milestones

IT'S NECESSARY
IT'S DESIRABLE
IT's ACHIEVABLE

- **Land.** Land-use policies are enacted that reduce forest destruction and shift to reforestation and afforestation efforts. Current net emissions from deforestation and land-use changes form about 12% of the global total. If these can be cut to zero next decade, and afforestation and reforestation can instead be used to create a carbon sink by 2030,
- **Industry.** Heavy industry is developing and publishing plans for increasing efficiencies and cutting emissions, with a goal of halving emissions well before 2050.
- **Finance.** The financial sector has rethought how it deploys capital and is mobilizing at least $1 trillion a year for climate action. Most will come from the private sector. Governments, private banks and lenders such as the World Bank need to issue many more 'green bonds' to finance climate-mitigation efforts. This would create an annual market that, by 2020, processes more than 10 times the $81 billion of bonds issued in 2016.

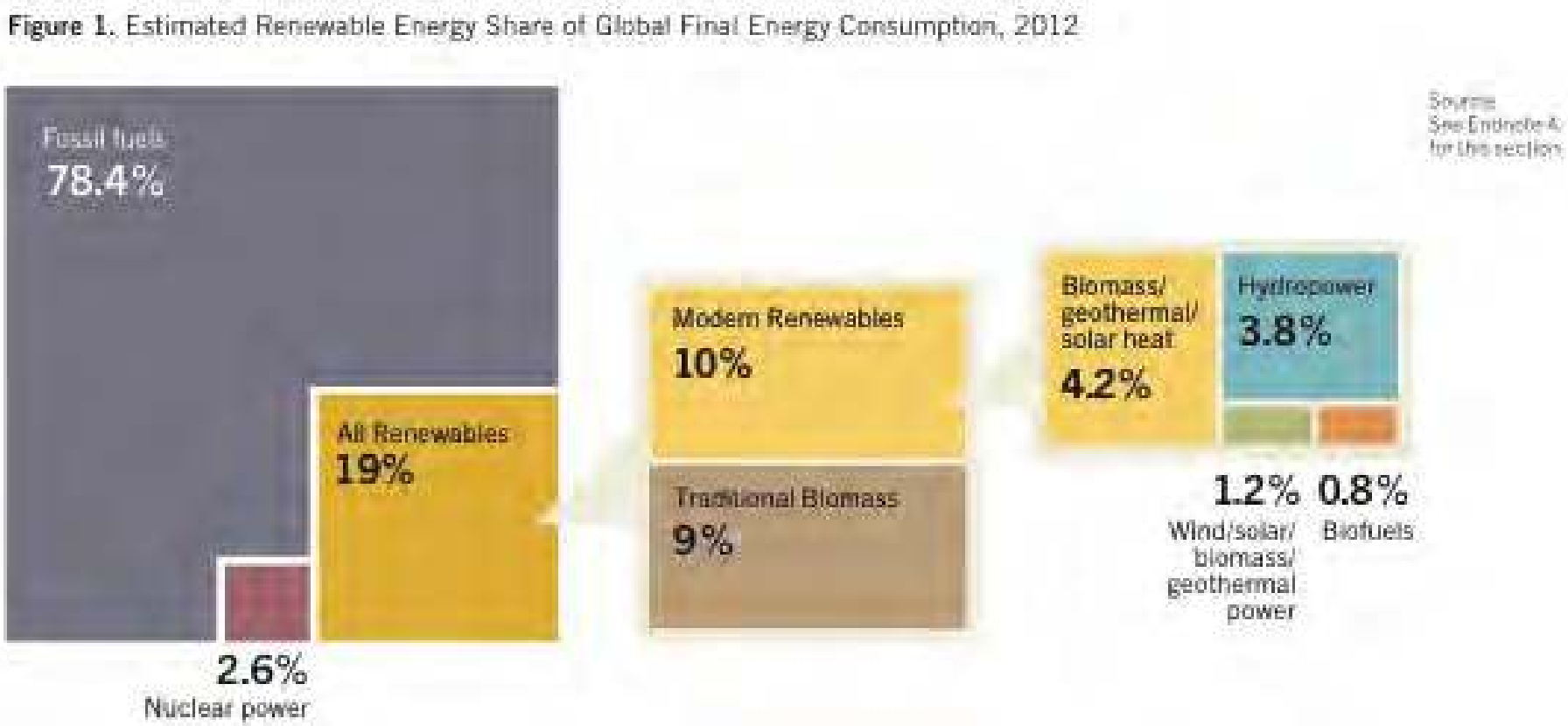
Reality of slow but steady progress

Figure 2. Growth in Global Renewable Energy Compared to Total Final Energy Consumption, 2004-2014



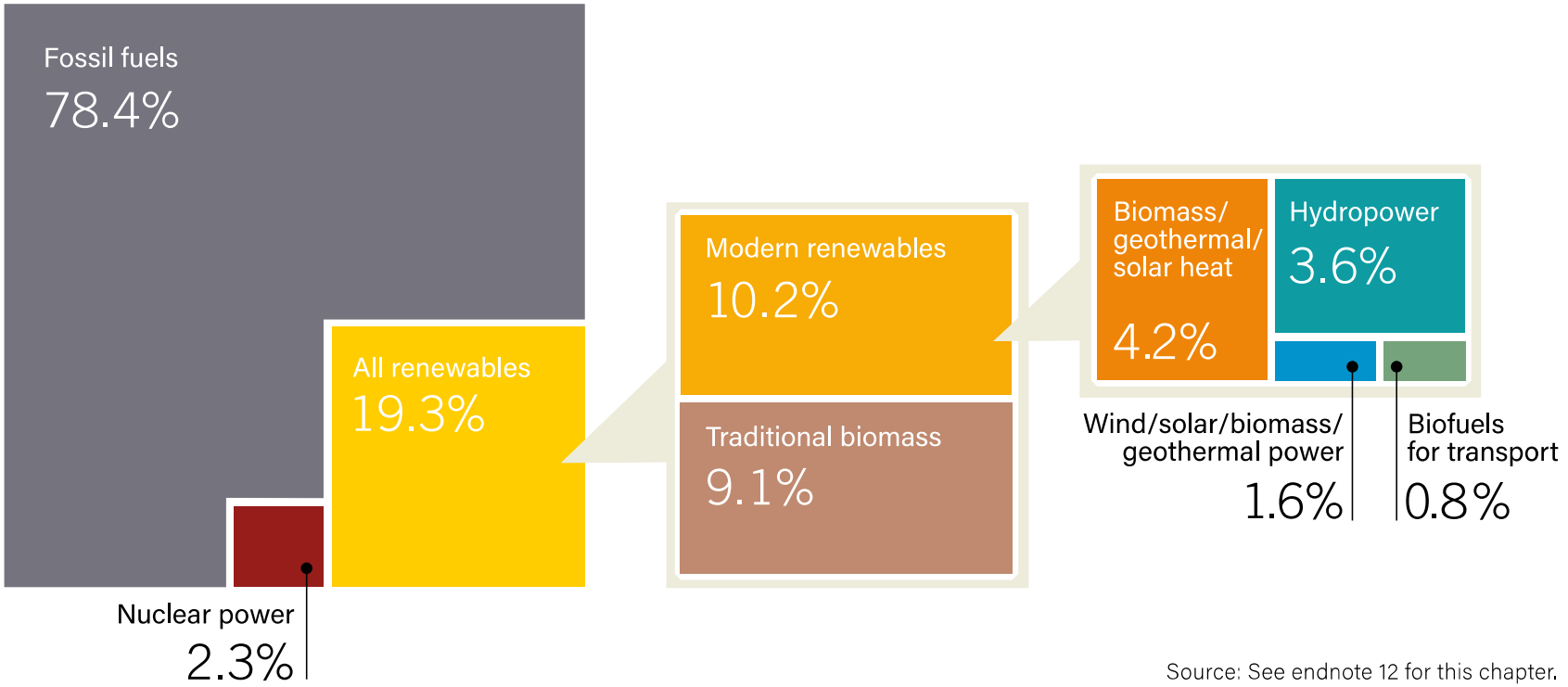
Source: REN21, *2017 Global Status Report*

Reality of slow but steady progress II



Source: REN21, *2014 Global Status Report*

Reality of slow but steady progress III

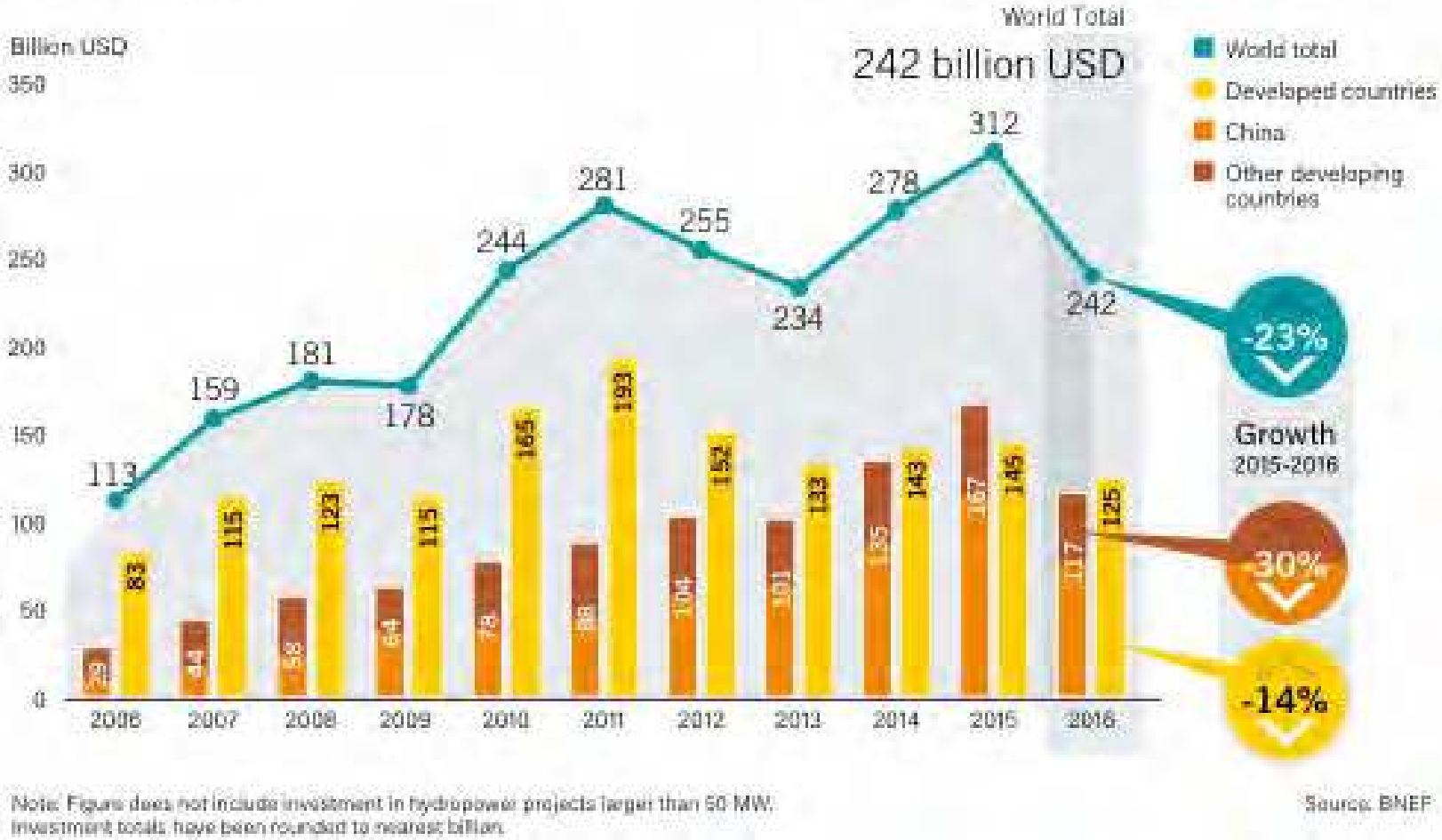


Source: See endnote 12 for this chapter.

Source: REN21, *2017 Global Status Report*

Reality of slow but steady progress IV

Figure 41. Global New Investment in Renewable Power and Fuels, Developed, Emerging and Developing Countries, 2006-2016



Note: Figure does not include investment in hydropower projects larger than 50 MW. Investment totals have been rounded to nearest billion.

Source: BNEF

nature climate change

NATURE CLIMATE CHANGE | COMMENTARY

Why the right climate target

Hans Joachim Schellnhuber, Stefan Rahmstorf &

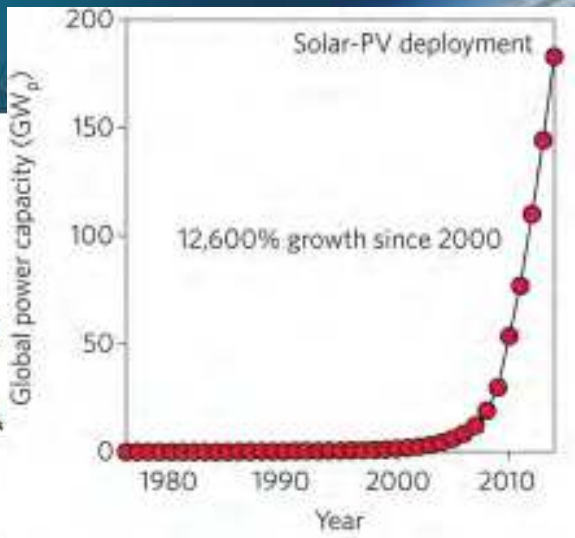
Affiliations | **Corresponding authors**

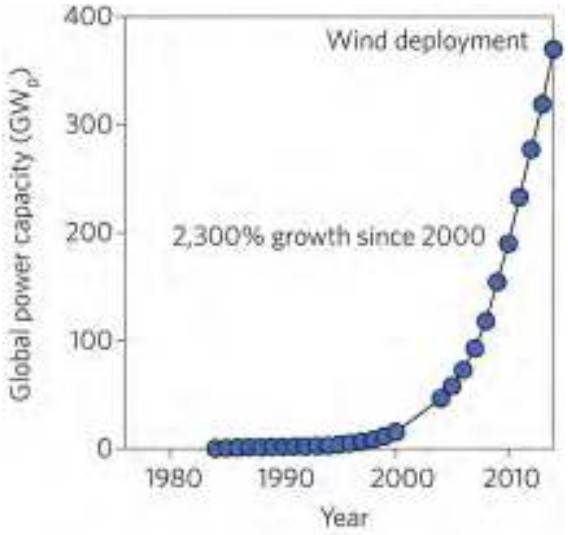
Nature Climate Change **6**, 649–653 (2016) | doi:1(

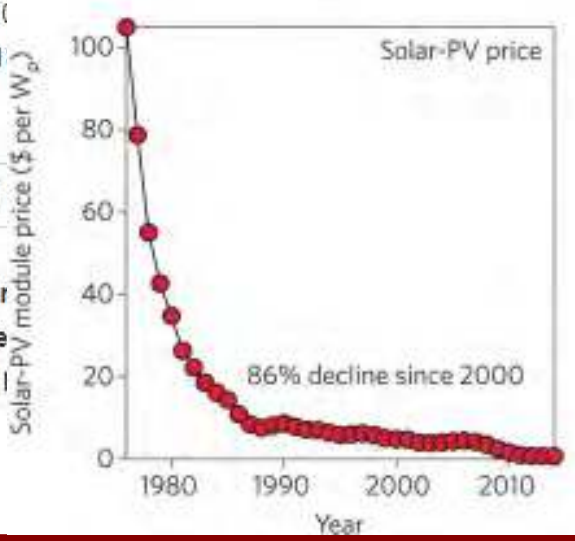
Published online 23 June 2016 | Corrected online 1

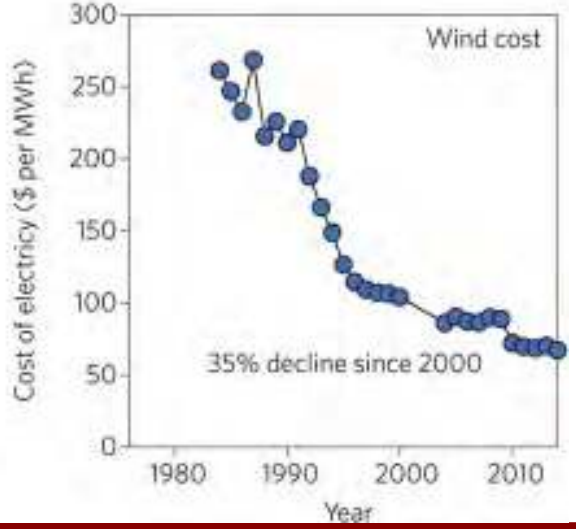
Correction (September, 2016)

The Paris Agreement duly reflects the latest scier warming risks. Limiting the anthropogenic tempe yet requires transformational change across the









Energy Transitions Commission (April 2017)

- Cut annual carbon emissions from 36 Gt today to 20 Gt by 2040 (compared to 47 Gt expected by 2040 in a business as usual scenario), which can be accomplished through four pathways:
  - 1. Clean electrification
  - 2. Decarbonization of "hard-to-electrify" sectors –
  - 3. A revolution in the pace of energy productivity improvement
  - 4. Optimization of remaining fossil fuels use
- By 2040, half of emissions reductions compared to a business as usual scenario could come from the combination of the decarbonization of power generation and the electrification of a wider set of activities in the transport and buildings sectors. Provided appropriate policies are put in place, it will be possible within 15 years to build power systems that rely on variable renewables for 80/90% of power supply and that can deliver electricity at an all-in cost (including back-up and flexibility needs) of less than $70 per MWh

ENERGY TRANSITIONS COMMISSION

IEA/IRENA Energy Transition Study: IEA Findings

- Limiting the global mean temperature rise to below 2°C with a probability of 66% would require an energy transition of exceptional scope, depth and speed.
- The 66% 2°C Scenario would require an unparalleled ramp up of all low-carbon technologies in all countries
- Improvements to energy and material efficiency, and higher deployment of renewable energy are essential components of any global low-carbon transition
- A deep transformation of the way we produce and use energy would need to occur to achieve the 66% 2°C Scenario.
- A fundamental reorientation of energy supply investments and a rapid escalation in low- carbon demand-side investments would be necessary to achieve the 66% 2°C Scenario.

Herculean Labours of IEA

- IEA emphasises the need for extensive energy market reforms and large and immediate

- "Yet even at these unprecedented levels, CO2 prices alone would be insufficient to stimulate the required pace and extent of energy sector transformation and would need to be accompanied by the phase out of fossil fuel subsidies and additional fuel taxation
- In addition, the co-ordinated enforcement of mandates, standards, energy market reforms, research, development and deployment (RD&D) and other emissions reduction policies would also be required"
- Word count: unprecedented (12), exceptional (8), unparalleled (2)

Fabra et al study for CERRE (Oct 2015)

- Lessons from Germany, France and UK
  - The Energy Transition is a long process that requires strong political support
  - The Energy Transition has put extra pressure on electricity bills
  - Efforts in promoting energy efficiency have been weak. There is mixed evidence concerning the potential of some of these policies to reduce energy consumption
  - Plus other conclusions on market arrangements, FITs, use of auctions, ETS reform, R&D, etc

Jacobson et al (2015) on 100% WWS

Low-cost solution to the grid reliability problem with 100% penetration of intermittent wind, water, and solar for all purposes

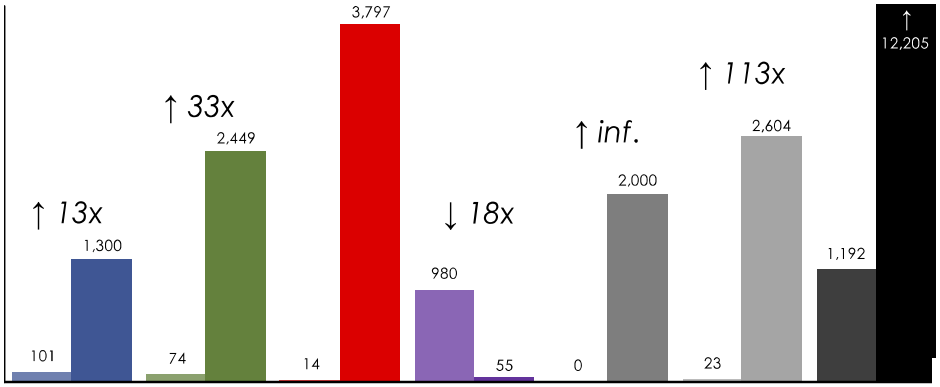
Mark Z. Jacobson[a,1], Mark A. Delucchi[b], Mary A. Cameron[a], and Bethany A. Frew[a]

[a]Department of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305; and [b]Institute of Transportation Studies, University of California, Berkeley, CA 94720

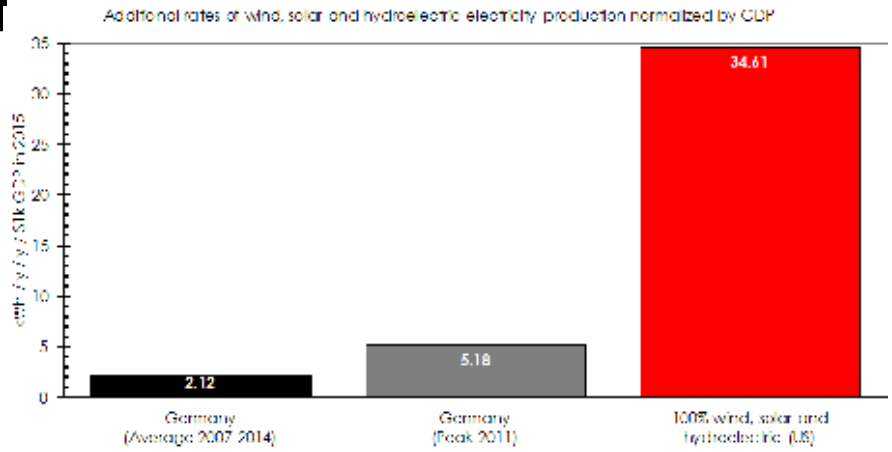
Edited by Stephen Polasky, University of Minnesota, St. Paul, MN, and approved November 2, 2015 (received for review May 26, 2015)

A rebuttal to Jacobson et al (2015)

- "Policy makers should treat with caution any visions of a rapid, reliable, and low-cost transition to entire energy systems that relies almost exclusively on wind, solar, and hydroelectric power"



Source: Clack et al (2017).



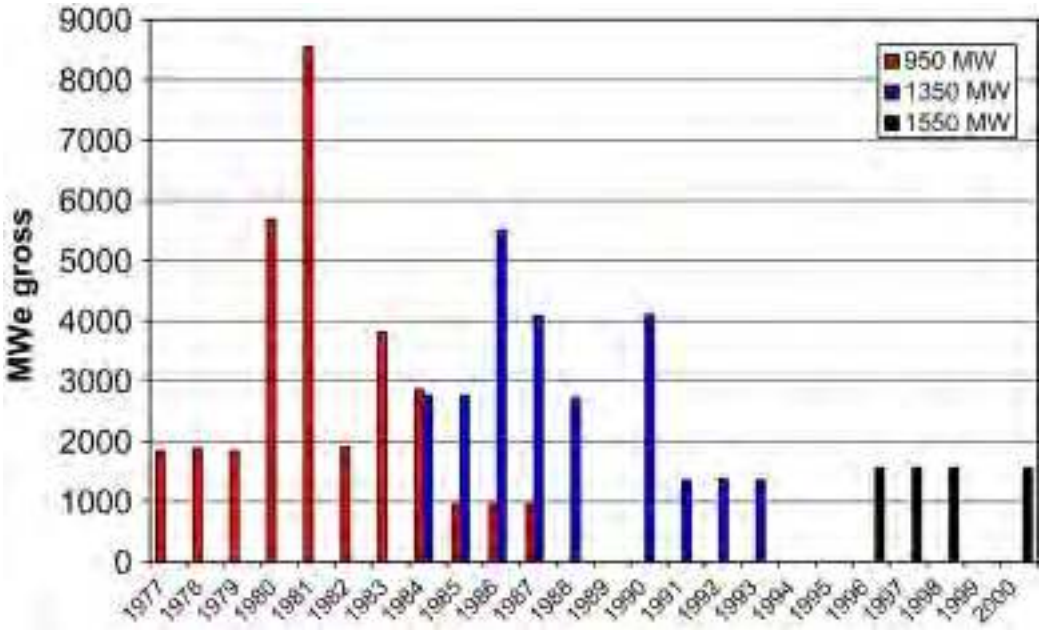
2015-2050
Wind 68 GW/yr for 35 years or ~190 W/cap/yr
Solar 108 GW/yr for 35 years or ~300W/cap/yr

Examples of 'successful' transitions

- French nuclear 1980s
- UK CCGT 1991-2000
- European wind (Denmark, Spain, Germany) 1995-2010
- German solar 2005-2015
- Chinese coal 2000-2010
- and many growth prospects (India, Vietnam, etc)

French nuclear expansion

- In response to the oil crisis of 1973-74, France began a massive rollout of 950 MW and then 1350 MW reactors, which over the subsequent decade shifted France to 80% nuclear as a share of electricity by 1990

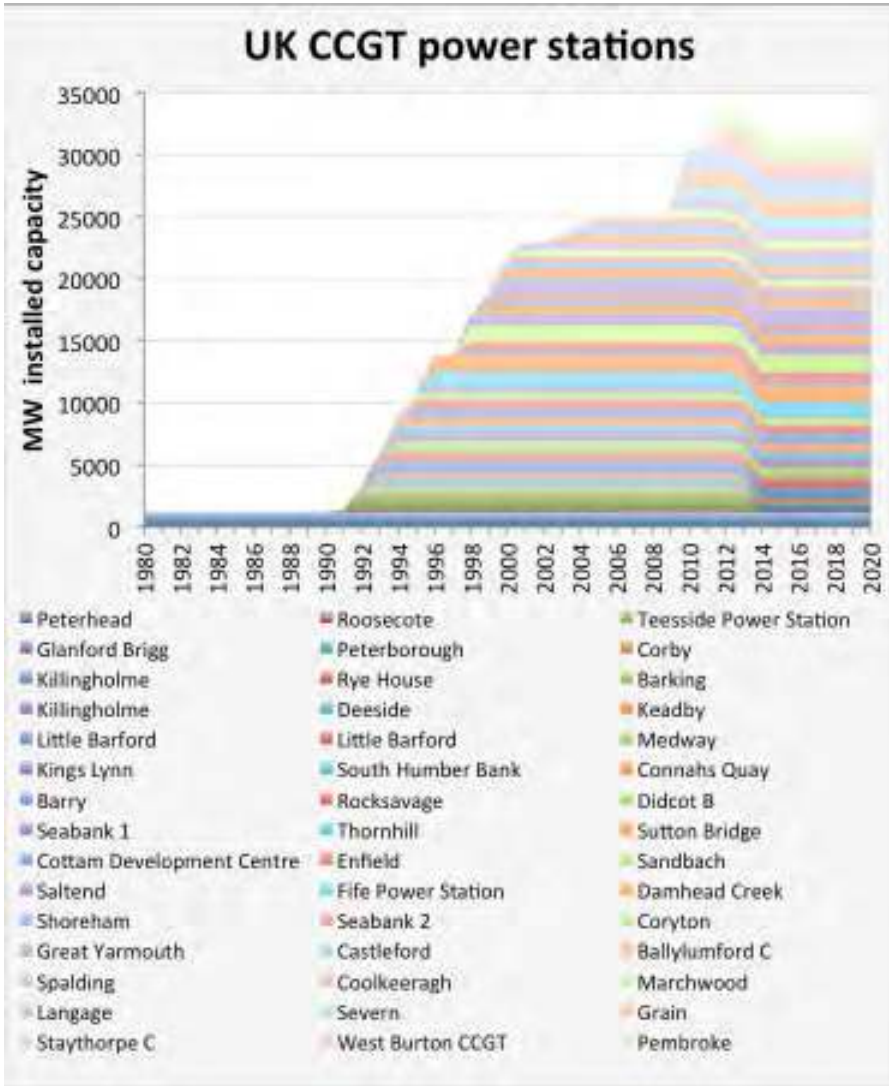


Source: Grubler (2010)

Nuclear
1980-1990: ~4.5 GW/year
~75 W/capita/year

UK gas-fired generation

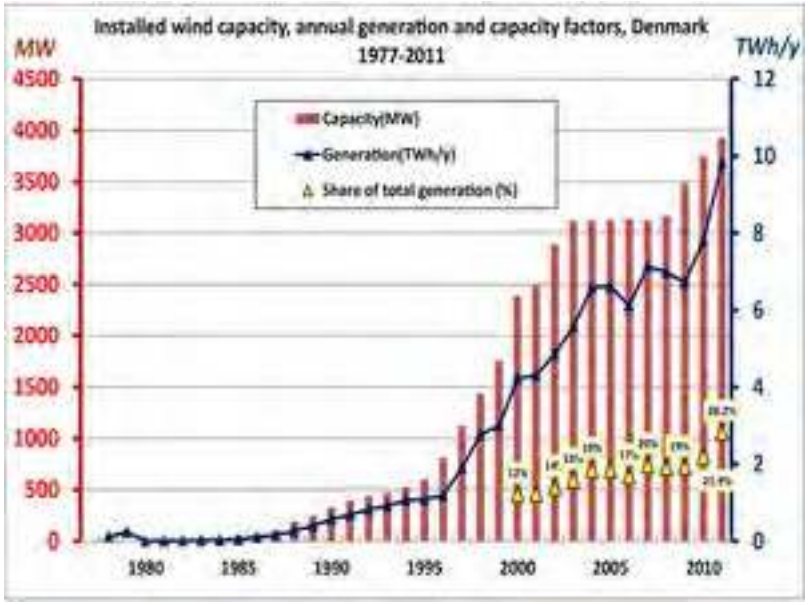
- The timing of industry deregulation combined with advances in natural gas plants, the decline of the British coal industry and the expansion of gas production in the North Sea led to rapid growth from 1991 onward



UK 1991-2000:
2.1 GW/yr
~36 W/cap/yr

Renewables in Europe

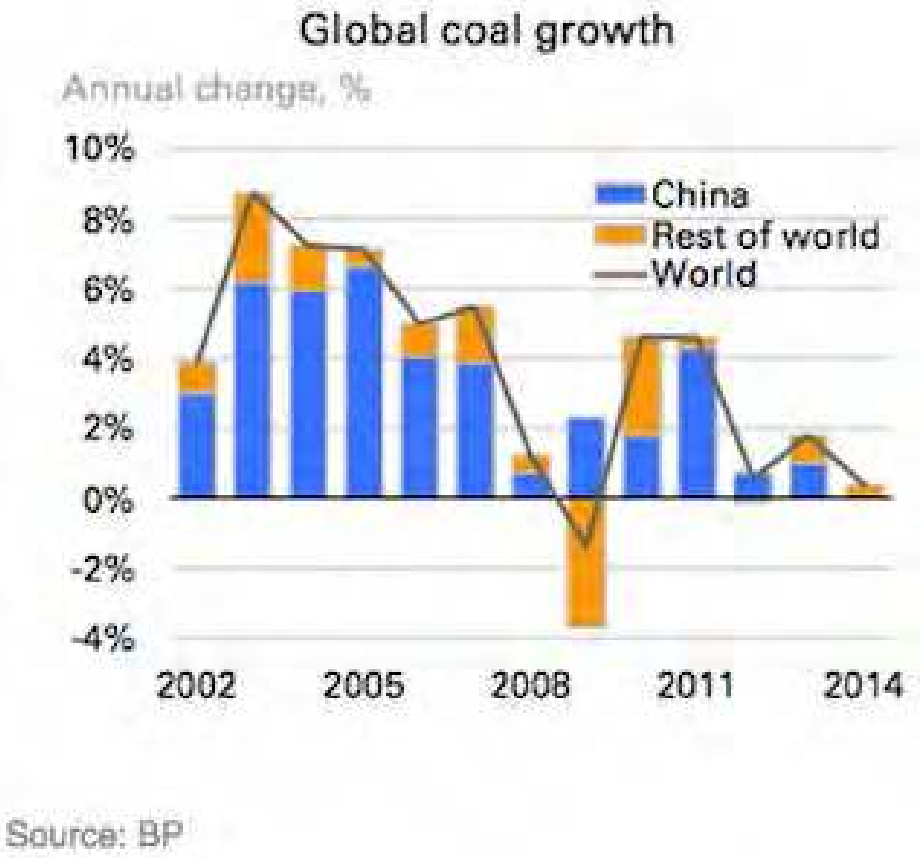
- First Denmark, in the mid-1990s followed by Spain and Germany over 2000-2010 dramatically increased share of wind and Germany added 40GW PV

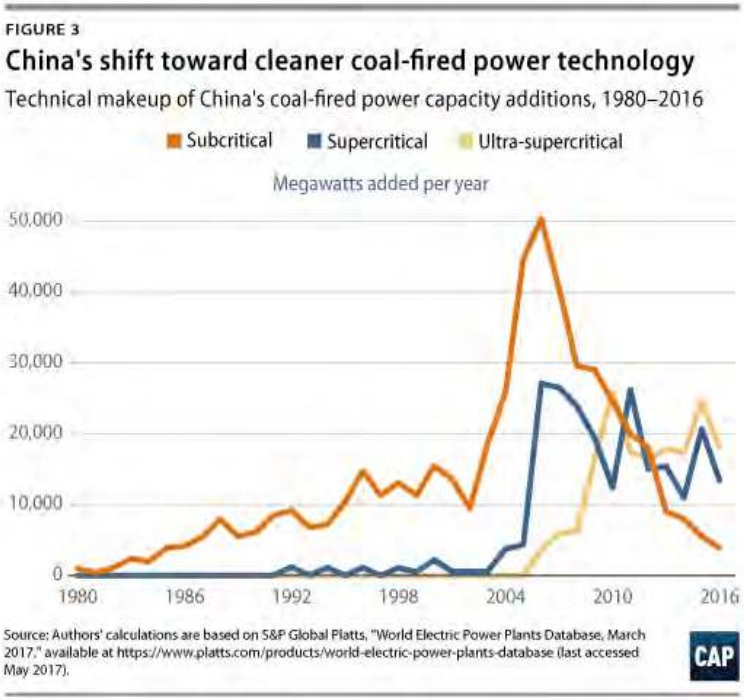


Wind:
Denmark (1994-2003): 270 MW/yr ~52 W/cap/yr
Spain (2000-2010): 1.5 GW/yr ~38 W/cap/yr

Solar:
Germany (2006-2015): 3.8 GW/yr ~47 W/cap/yr
Source: Fraunhofer ISE (2017)

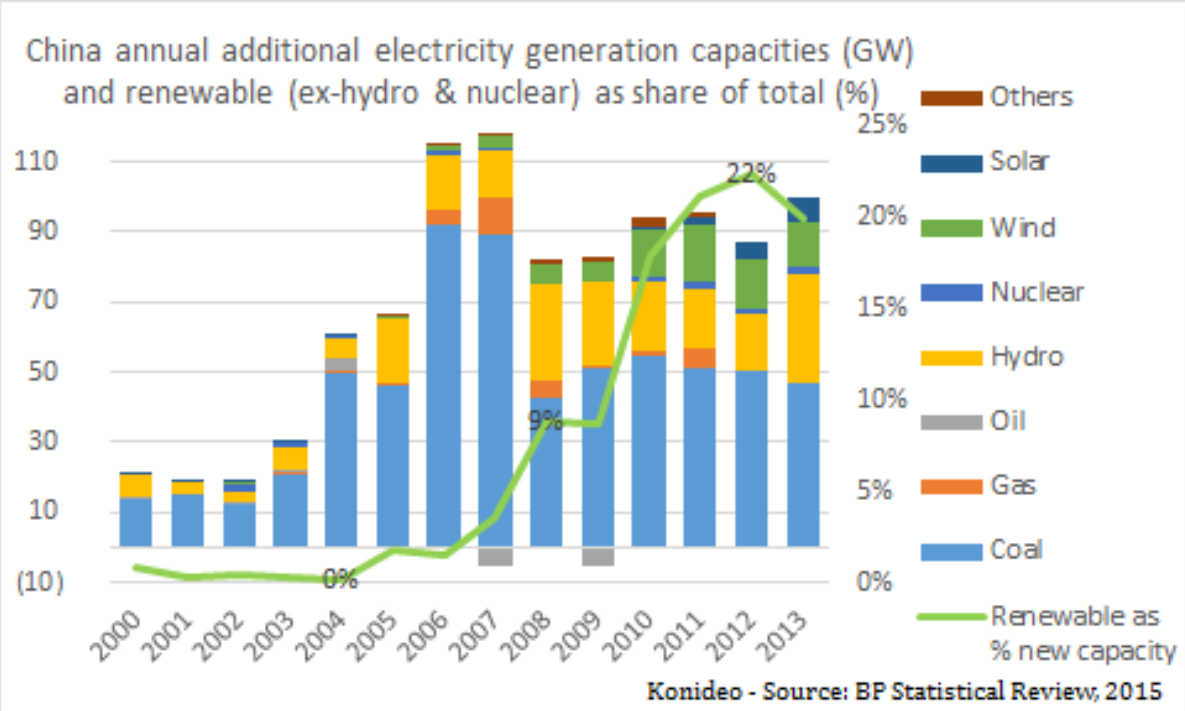
The biggest energy transition of past 50 years





M. Hart, L. Bassett, B. Johnson, Center for American Progress, 15 May, 2017

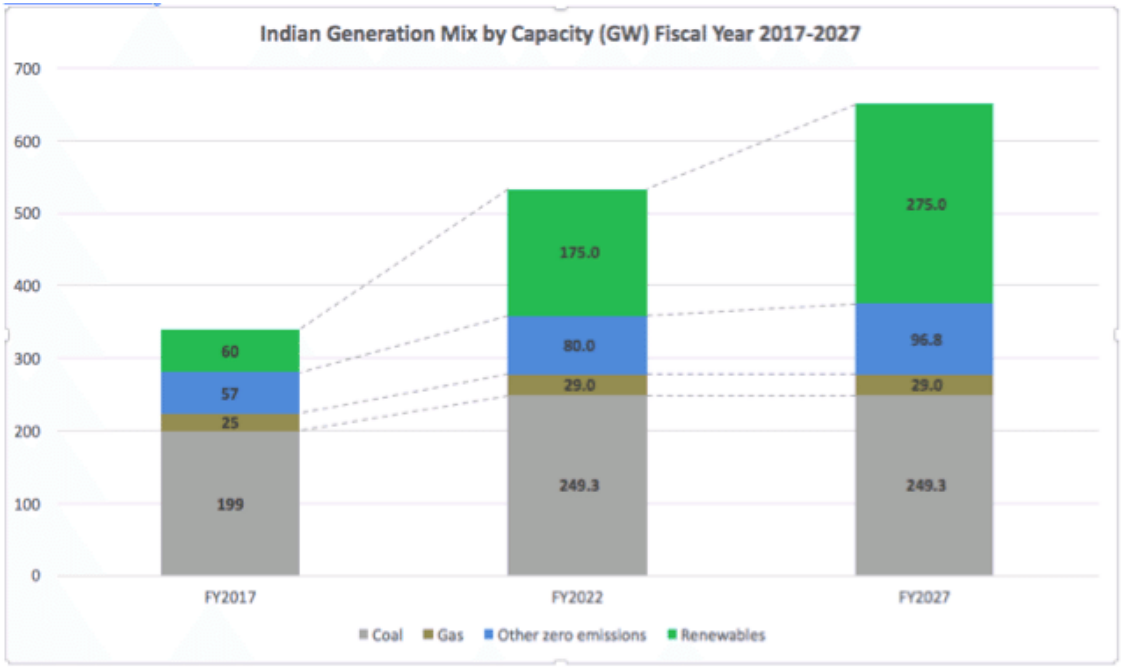
China's Coal expansion



At a time of massive economic transformation, China was able to draw on indigenous coal resource (1->3 Gt coal/yr) and armies of power engineers to build 50-100 GW/yr of new coal

Coal: China (2004-13): 57 GW/yr ~30 W/cap/yr

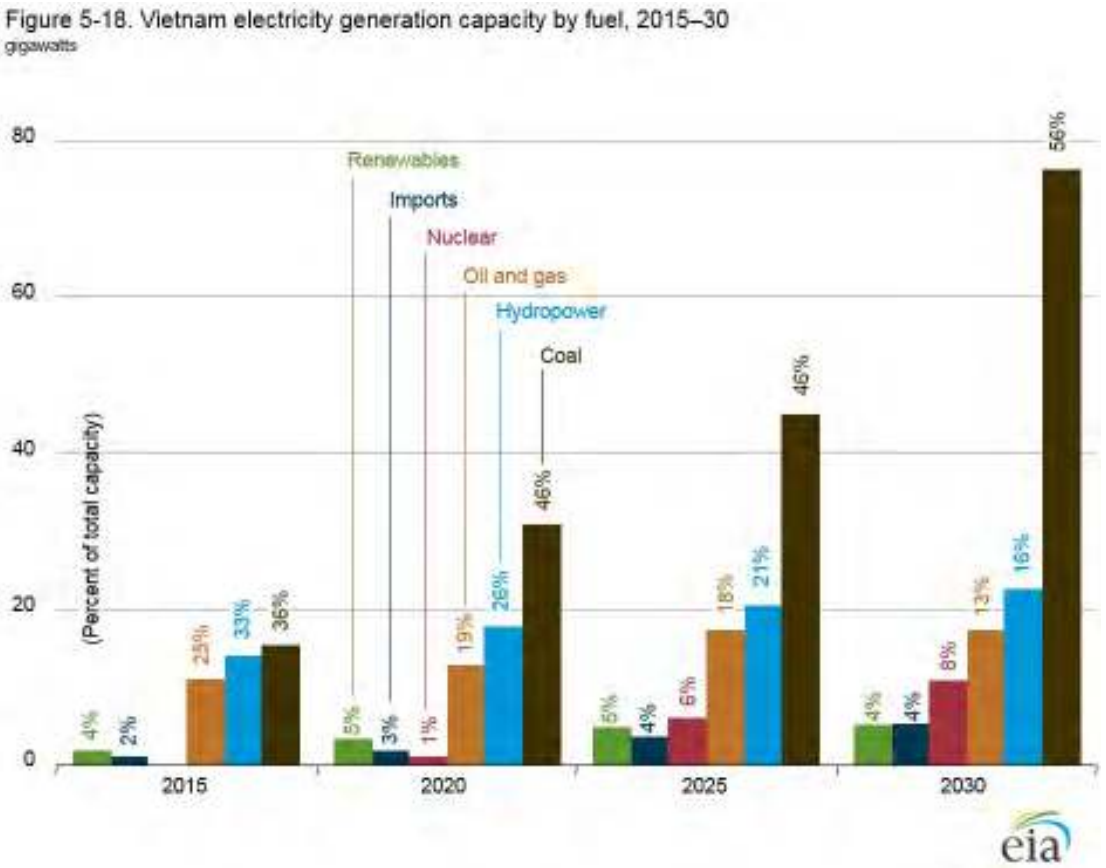
Renewables in India



Source: India's Central Electricity Authority, draft National Electricity Plan, December 2016

- So is India adding 215 GW of renewables over a decade represent a breakthrough transition?
- Average over the period is ~15W/cap/yr of intermittent generation (cf China 3x for baseload generation).

Coal in Vietnam

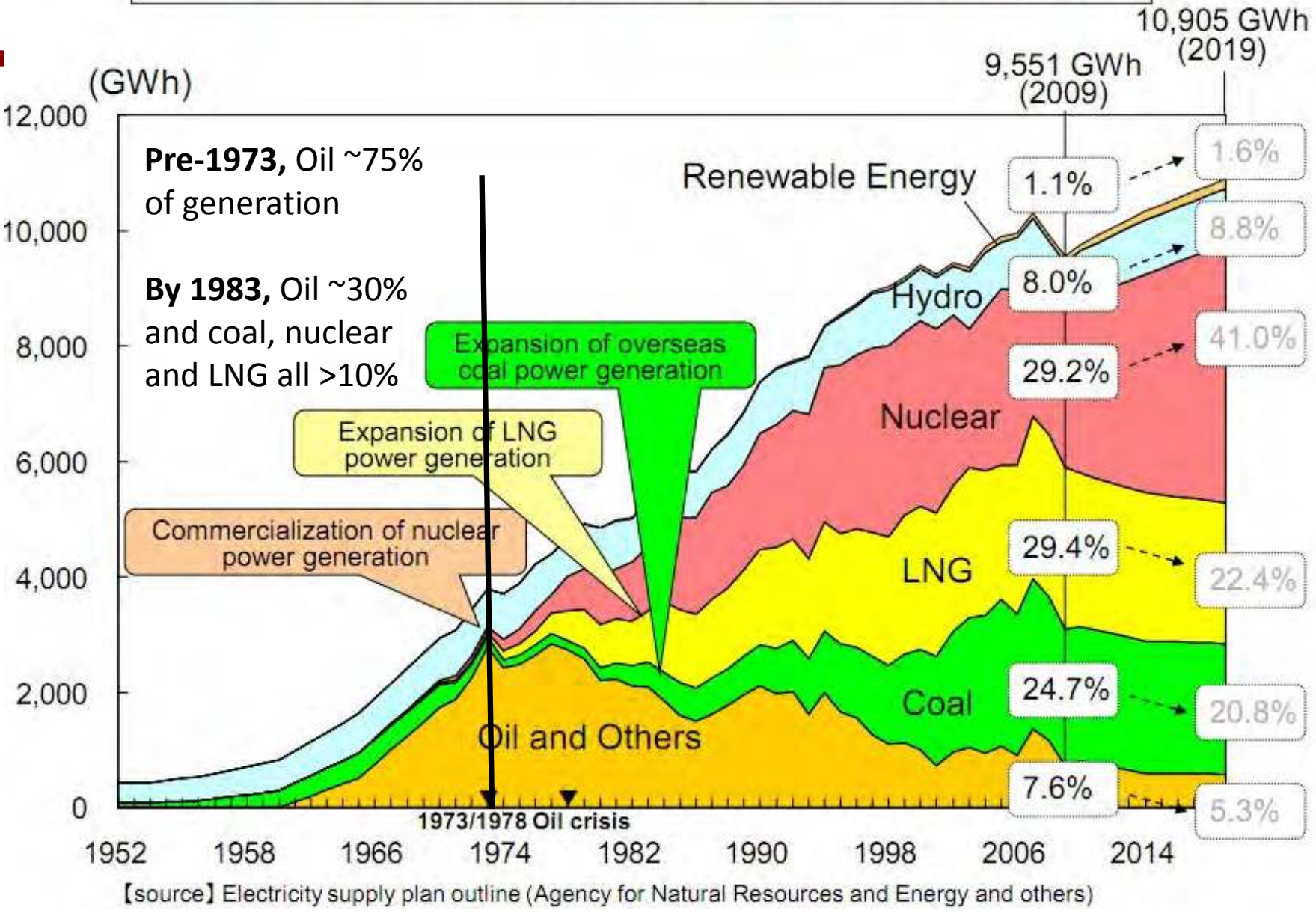


Source: EIA (2015)

2015-2030: ~4 GW/year
~40 W/capita/year

www.egcfe.ewg.apec.org/publications/proceedings/CFE/Japan_2010/Session2_S3_Japan.pdf

Transition of power generation by fuel (Nationwide)



【source】Electricity supply plan outline (Agency for Natural Resources and Energy and others)

Past experience with energy transitions

- There are few examples where the 'energy transition' has lasted more than 10-15 years, since maintaining build rates of 50W/cap/yr will deliver on the order of 30GW for a country the size of France or UK over the course of a decade
- These 'transitions' will normally need to come at a time of exceptional upheaval and change in the energy sector
- The one 'event' which produced energy transitions in a number of countries roughly simultaneously was the 1973-79 oil crises, but in general these transitions have been driven by local context combined with technological opportunism

A charitable interpretation of Figueres et al (2017)

- "P… …what
  m… …e
  pr… …of
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- It… …war
  to… …ns
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  de… …o a
  w…
  - Ken Caldeira

Nice article by Carbon Brief on our Nature Comment, which also cites a couple of critical comments. Here's a quick response to those.

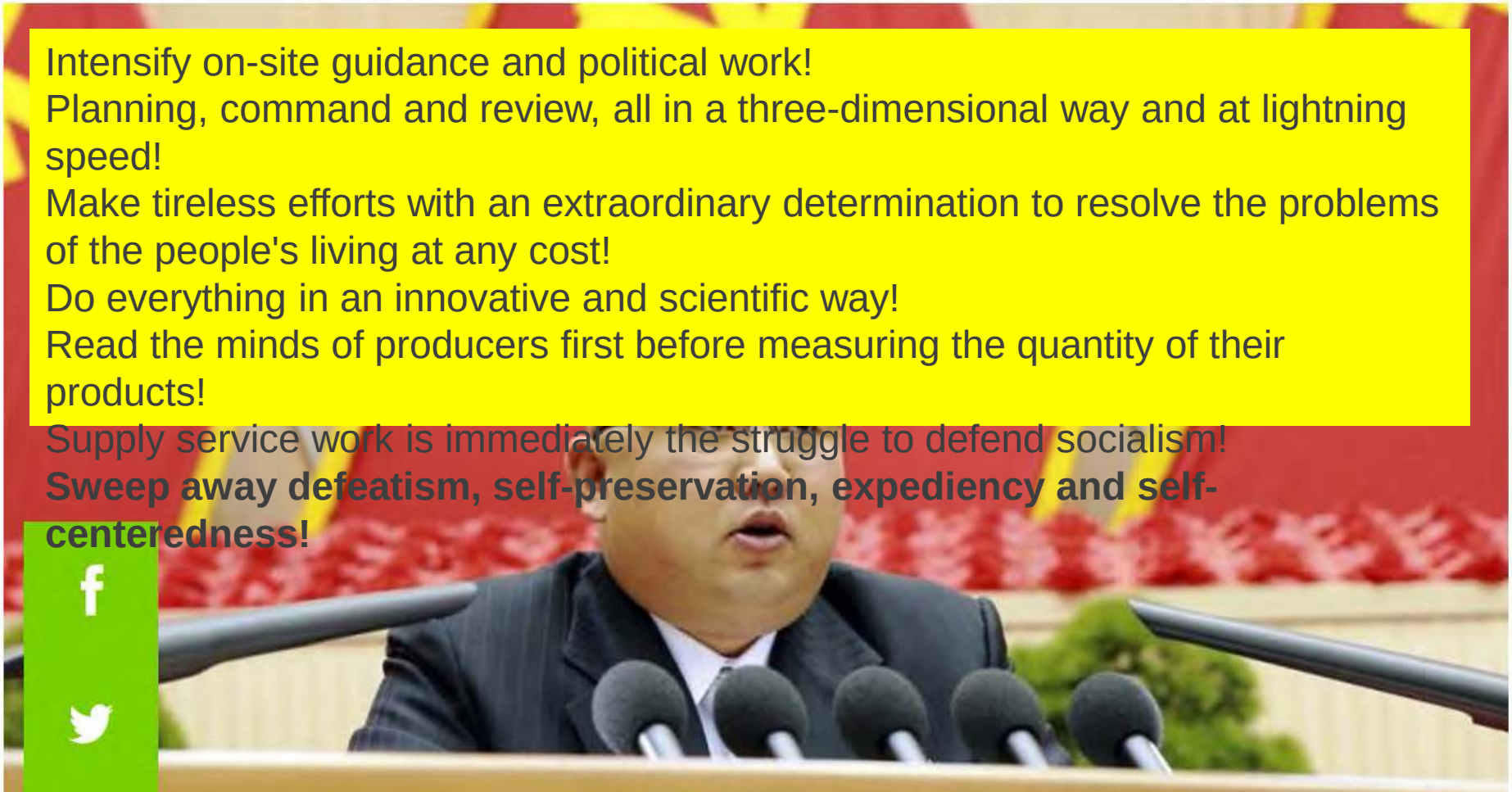
Ken Caldeira compares our proposals to wanting to end war by saying "all we need to do is put down our guns and open our hearts." That is just empty polemics. We are not appealing to people opening their hearts and magically all will be good. We present specific policy suggestions in six sectors (e.g. no new coal-fired power plants should be built after 2020). To be a helpful debate contribution, Ken would need to specifically address these proposals.

Oliver Geden claims that climate scientists have always said it is five minutes to twelve and will continue to do so after 2020. That again is a rather vague general criticism that avoids discussing our specific analysis, so it is not a helpful contribution to discussing climate solutions but just dismissive (not a new stance of Geden). As a matter of fact, we have said ten years ago that emissions need to peak by 2020 in order to stay below 2 °C, and we say so now, and if they haven't peaked in 2020 I will say it has become infeasible to keep global warming within the Paris limits. That is what our graph shows. It is simple emissions algebra.

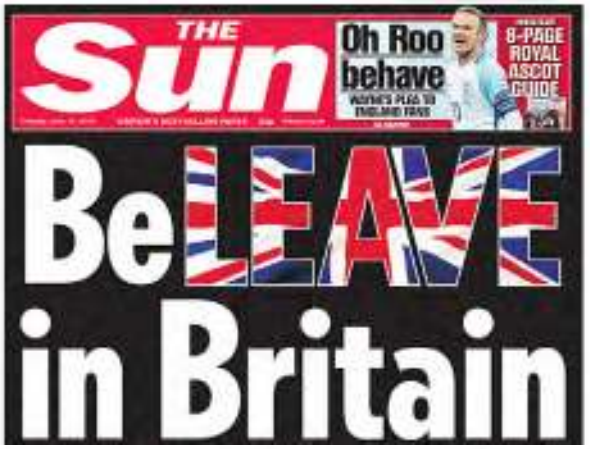
By the way: in my view defeatism is the new denial. Just another excuse for not doing anything to stop global warming.

Party Members Against 'Whining' And Having A Defeatist Attitude

BY **VISHAKHA SONAWANE** ON 12/27/16 AT 6:17 AM



Intensify on-site guidance and political work!
Planning, command and review, all in a three-dimensional way and at lightning speed!
Make tireless efforts with an extraordinary determination to resolve the problems of the people's living at any cost!
Do everything in an innovative and scientific way!
Read the minds of producers first before measuring the quantity of their products!
Supply service work is immediately the struggle to defend socialism!
Sweep away defeatism, self-preservation, expediency and self-centeredness!



THE Sun

THE SUN SAYS If Theresa May shared John Major's defeatist gloom, Brexit negotiations probably would end as badly as he predicts

Untangling Britain from 40 years of EU membership was always going to be hard, as many things worth doing are

COMMENT

By THE SUN

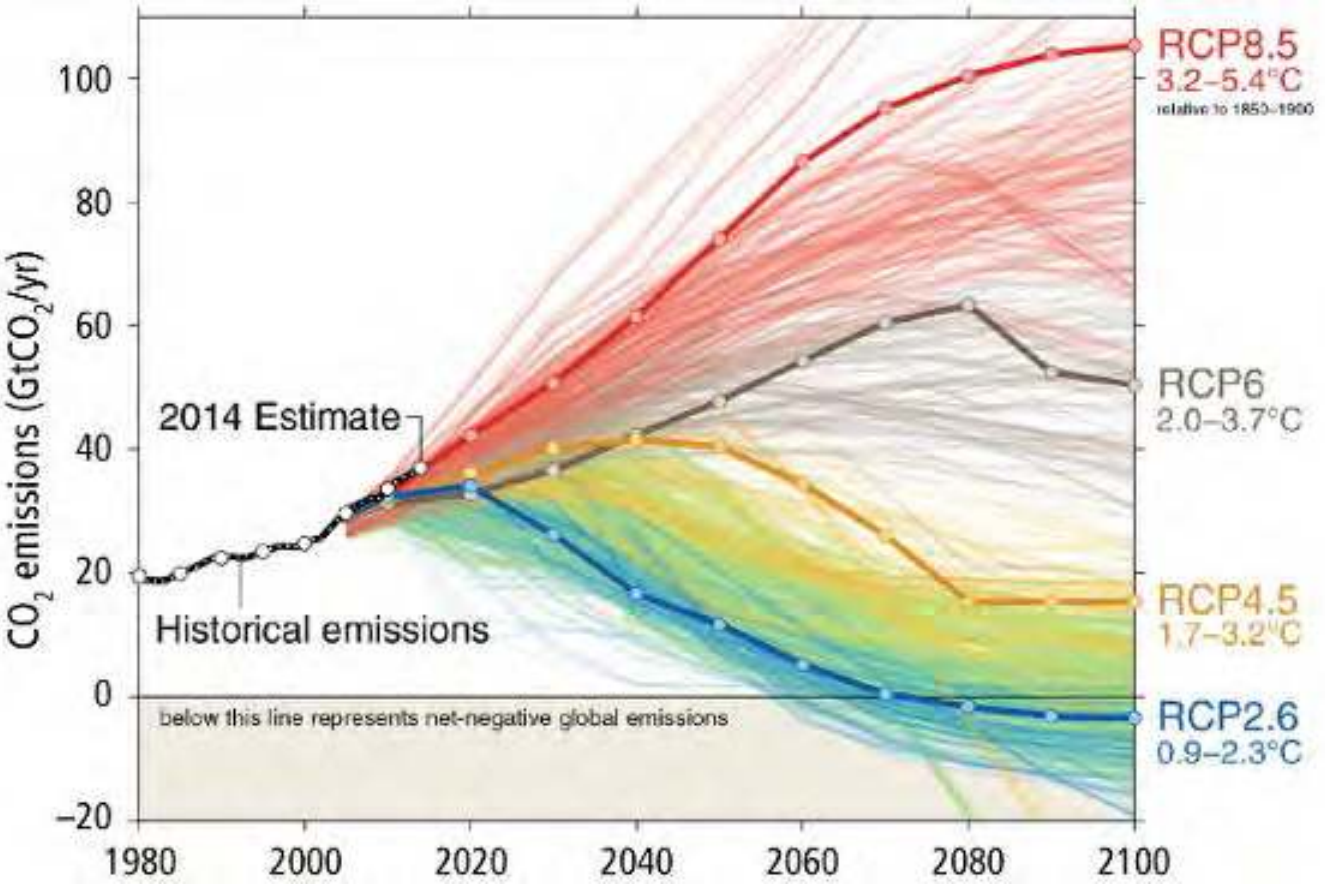
28th February 2017, 12:30 am | Updated: 1st March 2017, 2:59 am

Is Ken Caldeira right in being so charitable?

- What are the advantages and disadvantages of overambition informed by weak analysis (or more realistically, weak analysis driven by overambition)?
  - Optimistic case: 'stretch goals' encourage greater efforts than otherwise and help drive emissions down below the counterfactual
  - Neutral case: emissions almost entirely driven exogenous factors and national contexts so little if any impact
  - Pessimistic case: disappointment or disillusion at missing targets leads to greater cynicism, manipulation of data and diversion away from slow, difficult progress in reducing emissions and runs the danger of ignoring necessary conditions that require longer term effort (reforming markets, fighting battles over subsidy reform, avoiding backlash over higher consumer bills, etc)

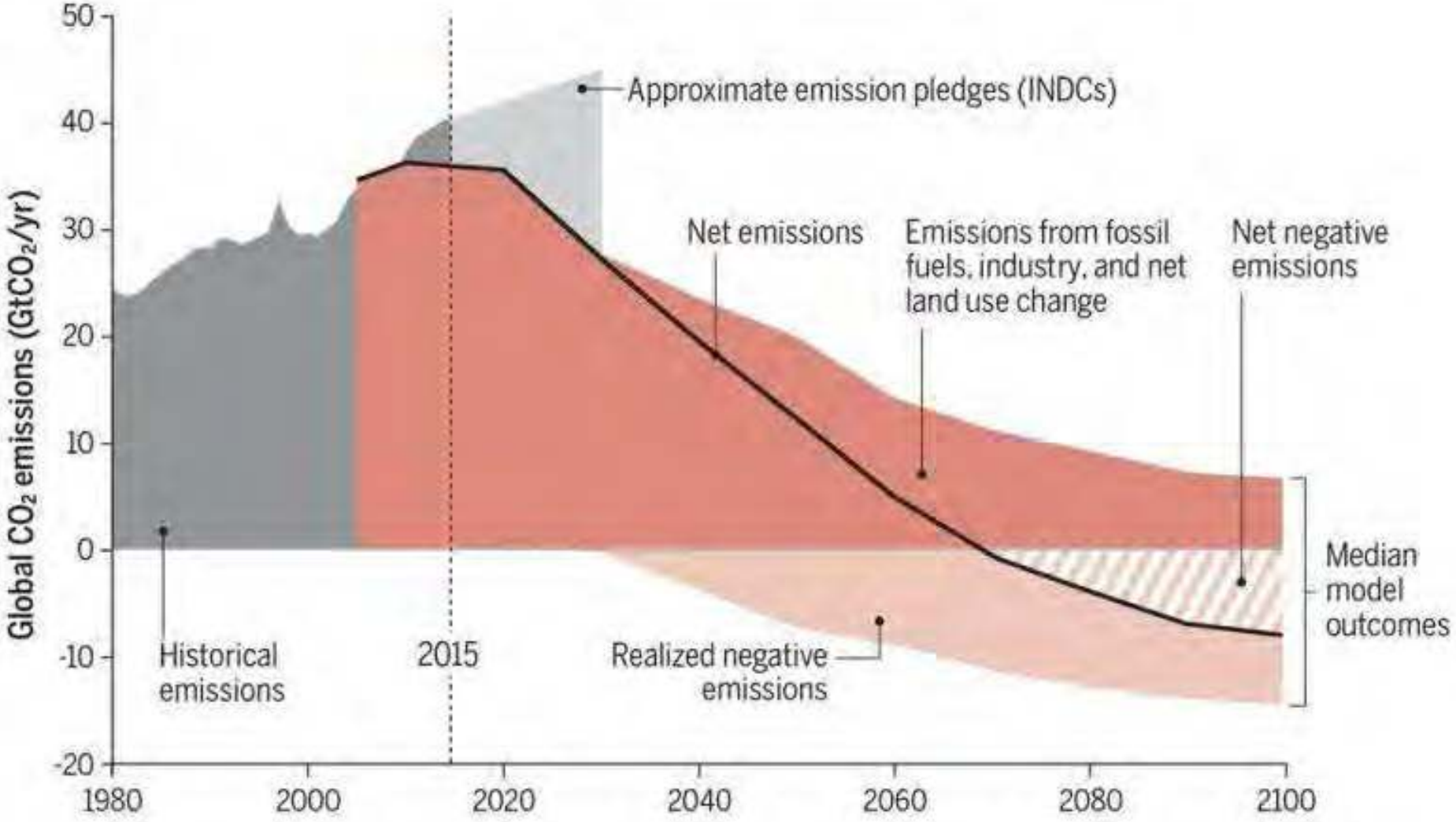
How do most models deal with likely overshoot?

Virtually all <2C scenarios require net-negative emissions



Fuss et al (2014) Betting on Negative Emissions, *Nature Climate Change*

An updated view on NETs



Anderson & Peters (2016)

Plan B or Plan Z: NETs as Moral Hazard

"The beguiling appeal of relying on future negative emission technologies (NETs) is that they delay the need for stringent and politically challenging polices today – they pass the buck for reducing carbon on to future generations… But if these Dr. Strangelove technologies fail to deliver at the planetary scale envisaged, our own children will be forced to endure the consequences of rapidly rising temperatures and a highly unstable climate."
Kevin Anderson & Glen Peters, The trouble with negative emissions, *Science* 14 Oct 2016: 354(6309): 182-183.

To believe there is a genuine moral hazard from NETs would require a belief that we would have carried out a massive and more costly decarbonisation programme were it not for the allure of NETs but now will not.

A call for radical action

- The logic put in place by the Paris objective(s) would lead us to the conclusion of the need for dramatic transformation of the energy sector
- Simply claiming a need for dramatic increases in investments and deployment of new technologies on a scale and with a speed never experienced heretofore may be more diversionary than salutary
- These 'commentaries' or blueprints might be better placed to focus on the changes needed in the underlying political economy that would be needed for these ambitions to become remotely politically viable

Thanks!

David Reiner
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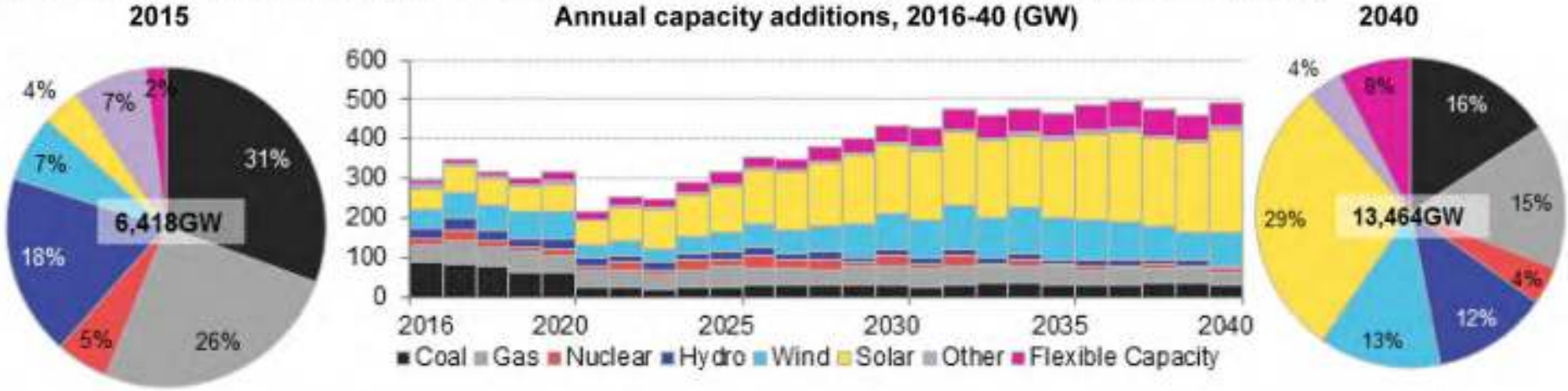
BNEF view of the energy transition

Figure 1: Global installed capacity in 2012 and 2040 and projected capacity additions, by technology (GW)



Source: Bloomberg New Energy Finance. Note: Flexible capacity includes power storage, demand response, and other potential resources.