REF

RENEWABLE ENERGY FOUNDATION

DISTRESSED POLICY CORRECTION:

NEW DIRECTIONS IN UK RENEWABLE ENERGY AND CLIMATE STRATEGY

John Constable

16 November 2015

Renewable Energy Foundation

- Energy policy think tank, and UK registered charity
- No political affiliation, supported by private donations and research contracts
- REF publishes searchable databases at www.ref.org.uk/energy-data
- Giving monthly performance data for UK renewable installations; FiT lists; GB electricity fuel mix by half hour since 2009

Talk Outline

- Part 1
  - –Survey of EU and UK Energy & Climate Policy
    - Greenhouse Gas Reduction
    - Energy Efficiency
    - Renewables Deployment and Costs
- Part 2
  - –Hidden Dangers of Energy Policies and Costs
    - Cost rendered in complex capital stocks
    - Mandated shift to energy with low Energy Return

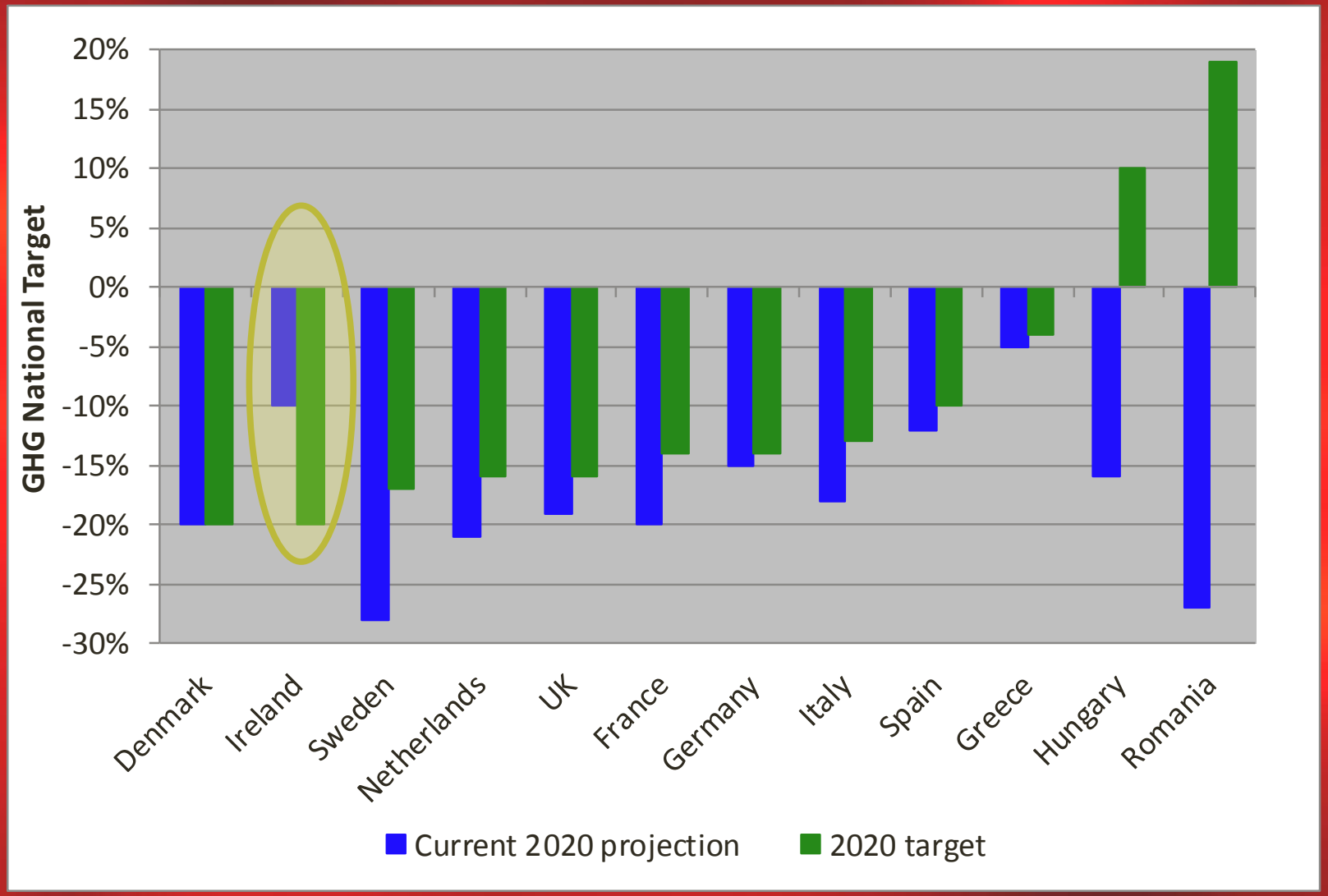
EU Climate & Energy Targets

- Sloganeering: “20-20-20 in 2020”
  - Not an engineer’s target…
- 20**%** cut in **greenhouse gas** emissions
  - from 1990 levels
- 20% of EU **energy** from **renewables**
- 20% improvement in **energy efficiency**
  - Calculated as 80% of the ‘Business as Usual’ prediction in 2007, to give EU 2020 target of 12,540 TWh Final Energy Consumption (FEC)
- All by 2020

GHG Emission Reduction Target

- EU emissions in 2013 were approximately 19% below 1990 levels
  - **Because of economic turbulence and leakage**
- 2020 projection is for 21% reduction in emissions compared with 1990 baseline
- Twenty-three member states on track; five are not: Luxembourg, Ireland, Belgium, Austria and Latvia
- But note: Germany, Luxembourg, and Poland failed to meet interim 2013 target

Progress towards GHG Target by Country



Source: Eurostat. Chart by REF.

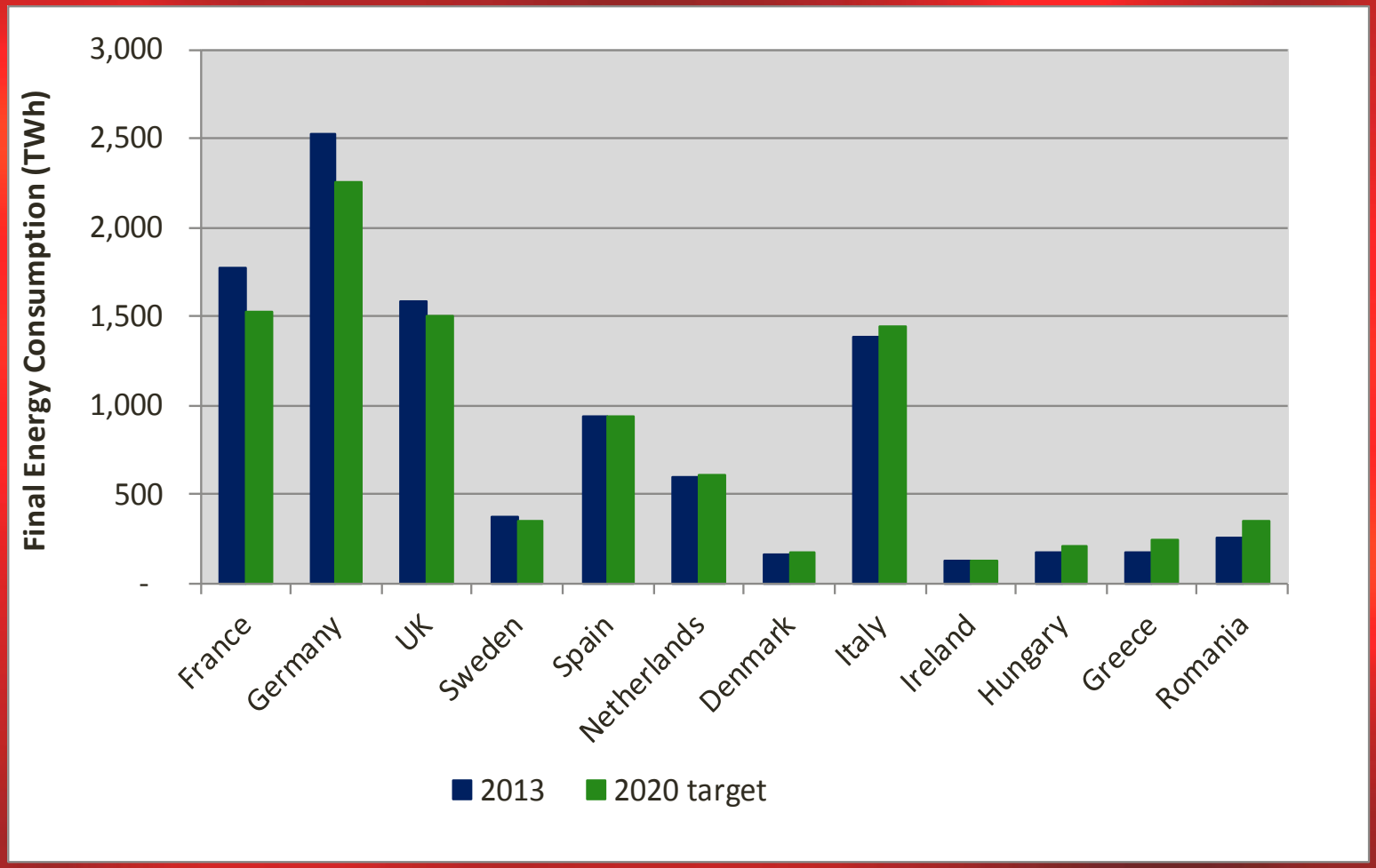
Energy Efficiency Target and Recession

- EU target energy consumption in 2020 no more than 12,540 TWh of final energy (cf 13,793 TWh 2005)
- Recession impacts highly significant, e.g. Greece is already 25% under the target level

Greece: Final Energy Consumption	TWh
2020 Target	238
2005 (Actual Consumption)	244
2013 (Actual Consumption)	178

Source: Eurostat. Table by REF.

Final Energy Consumption in 2013 and the 2020 Target



Source: Eurostat. Chart by REF.

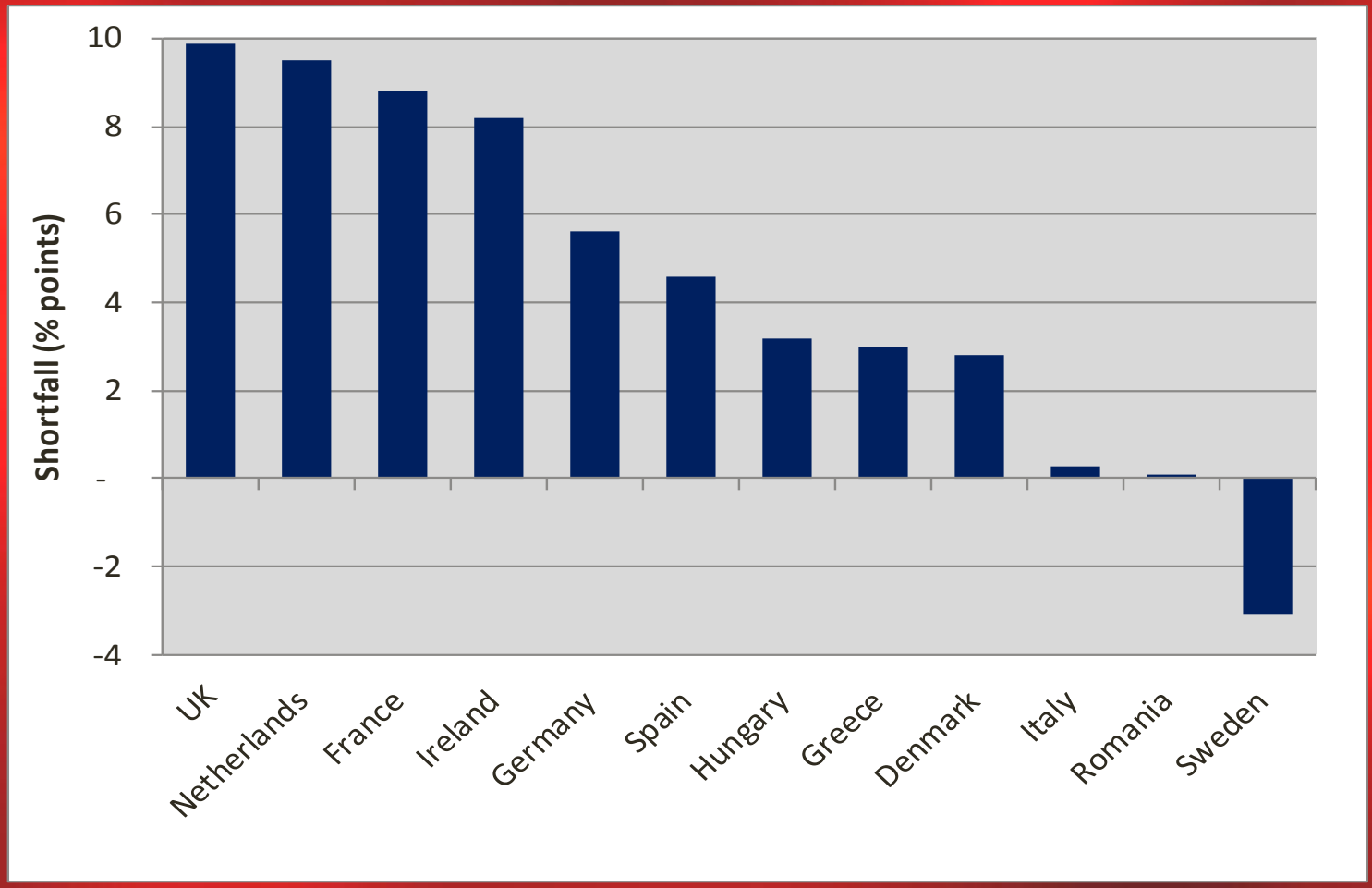
Legal Action and the Efficiency Directive

- In spite of effects of recession in reducing energy consumption throughout the EU, 27 member states face threat of EU legal action over energy efficiency (March 2015)
- 3 countries made no progress on implementation
  - Hungary, Greece, Bulgaria
- EC referred Hungary to the European Court of Justice seeking daily fines of €15,444 for not transposing the Directive by the June 2014 deadline

The EU Renewables Directive and the UK

- EU Renewables Directive (2009): 20% of EU Final Energy Consumption (FEC) to be renewable by 2020
- UK burden share: 15% of FEC (up from 1.5% in 2009)
  - Target is a % of an unknown quantity
  - Approximately 230 – 270 TWh must be generated from renewable sources in 2020
- Approximate composition:
  - Transport fuel: 45 TWh (10% of UK transport fuel)
  - Electricity: 120 TWh (~30% of UK electricity)
  - Heating and cooling: 70 TWh (~12% of UK H&C)

Progress in Renewable Energy in 2013



Source: Eurostat. Chart by REF.

A Moving Target…

	Germany	France	UK
2000 FEC	2,559 TWh	1,806 TWh	1,702 TWh
2013 FEC	2,527 TWh	1,769 TWh	1,586 TWh
% change	-1%	-2%	-11%
2020 Target (%)	18%	23%	15%
2020 Target on 2013 consumption basis (TWh)	455	407	238

Source: Eurostat. Calculations by REF.

UK Policies Supporting RE Deployment

Policy	Character	Source	Impact
Renewables Obligation	Income Support	Consumer bills	Regressive
Feed-in-Tariff	Income Support	Consumer bills	Regressive
Contracts-for-Difference	Income Support	Consumer bills	Regressive
System costs socialization	Avoided costs	Consumer bills	Regressive
Green Investment Bank	Capital Support	Increased tax burden	
EU ETS	Tax on fossil fuels favouring renewables indirectly	Consumer bills	Regressive
Climate Change Levy Exemption (cancelled 2015)	Income Support	Increased tax burden	
IHT Exemption	Indirect financial support	Increased tax burden	
CGT Deferral	Indirect financial support	Increased tax burden	

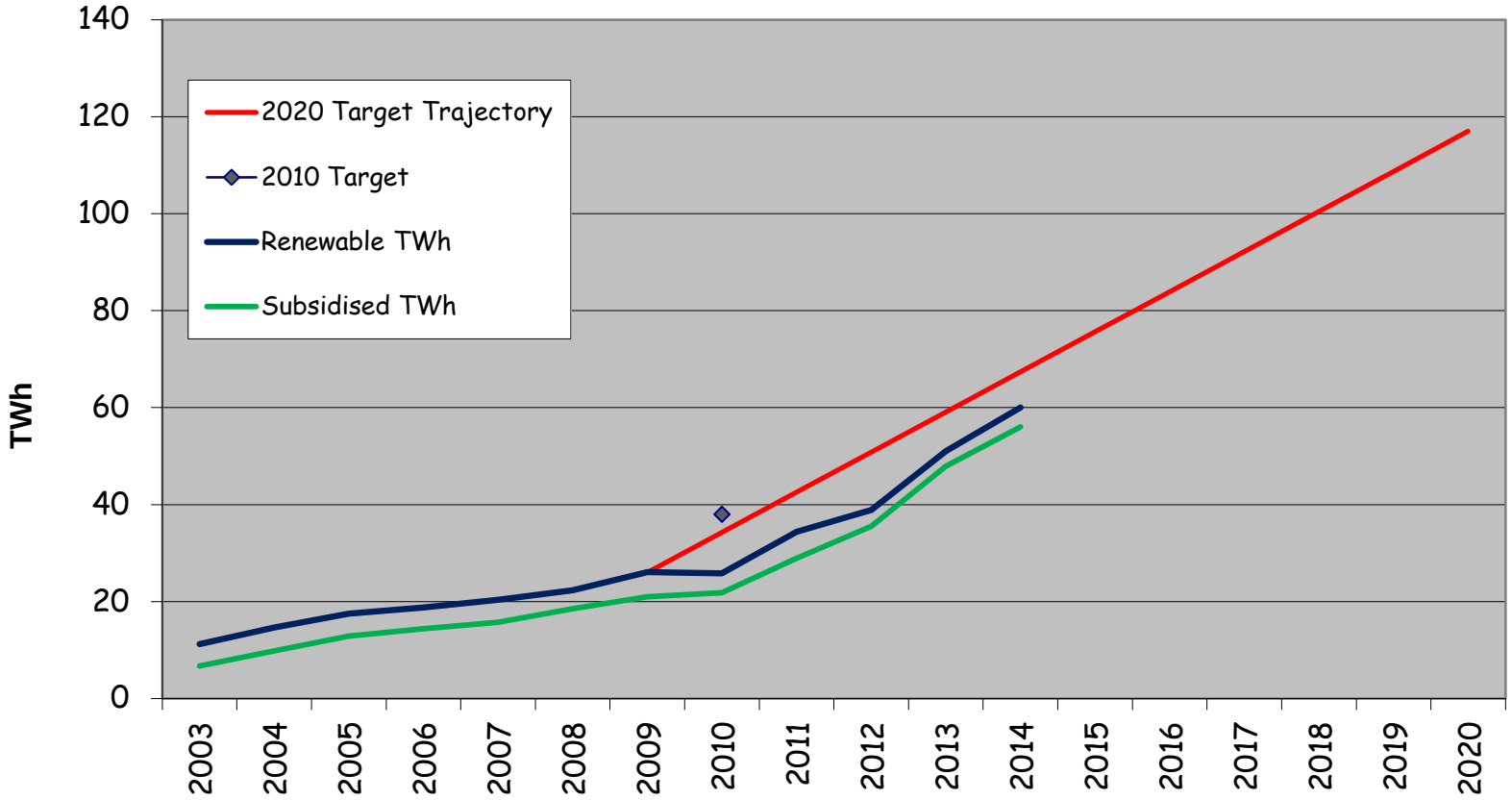
Renewable Obligation

- Obligation on electricity suppliers to use increasing proportion of renewable sources or pay a ‘fine’ (the ‘Buy-out’ price)

	2002	2008
Obligation	3%	9.1%
Buy-out price	£30 per ROC (per MWh)	£36 per ROC
Recycle payment	£16 per ROC	£19 per ROC
Total RO subsidy	£46 per MWh	£54 per MWh
Cost of CO_2 saved (assuming 1 ROC per MWh)	£95 per tonne	£113 per tonne

Source: Ofgem. Calculations by REF.

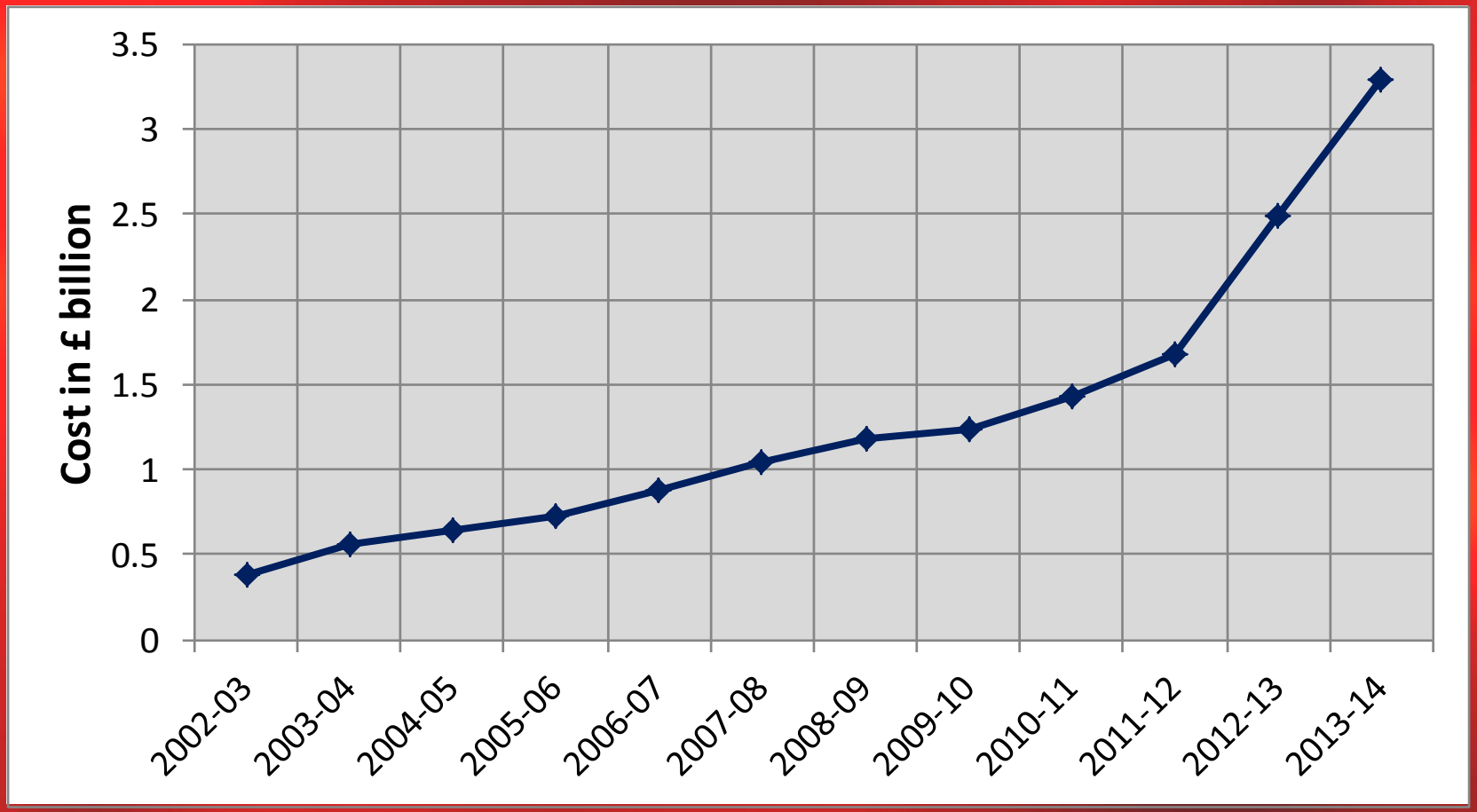
UK Renewable Electricity Target



Source: Ofgem. BM Reports. Chart by REF.

UK Renewables Subsidy Cost

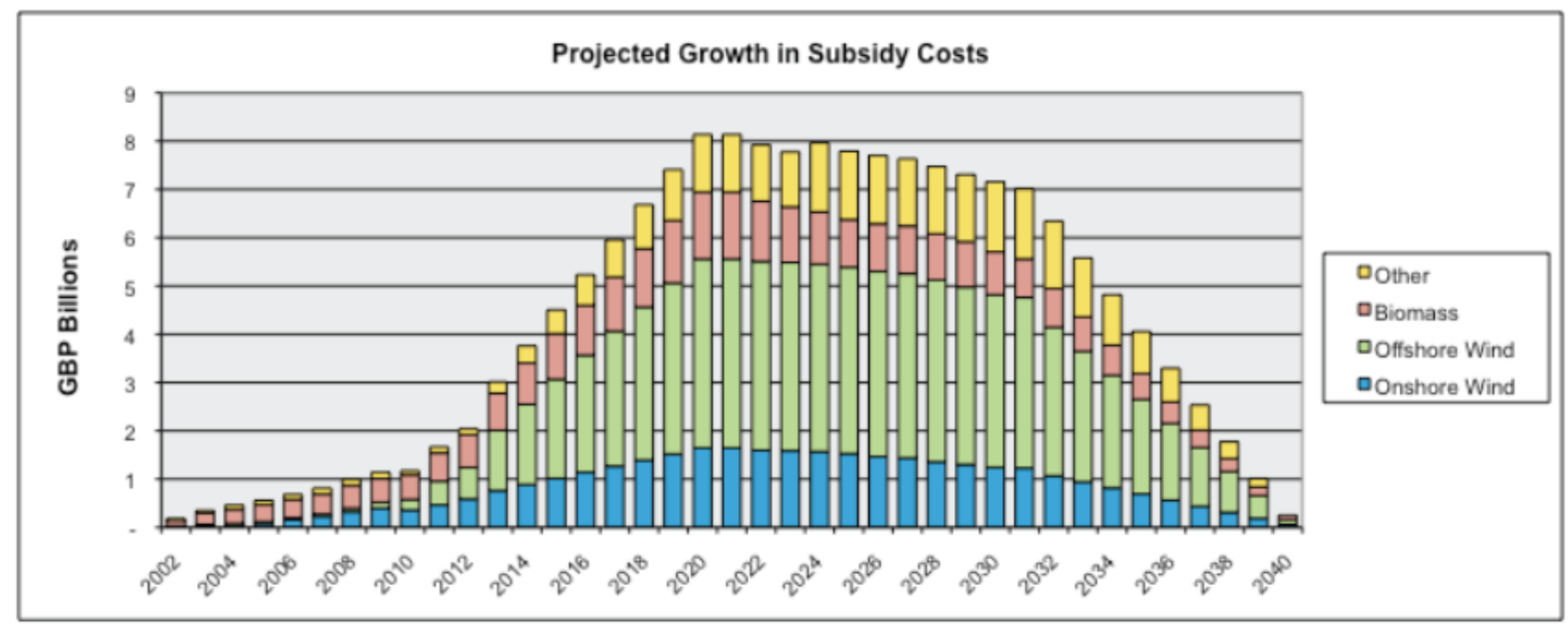
- Cumulative Cost: 2002–2014: £15 bn
- Estimate in 2014/15 ca. £4 billion



Source: Ofgem subsidy claim records. Calculations and chart by REF.

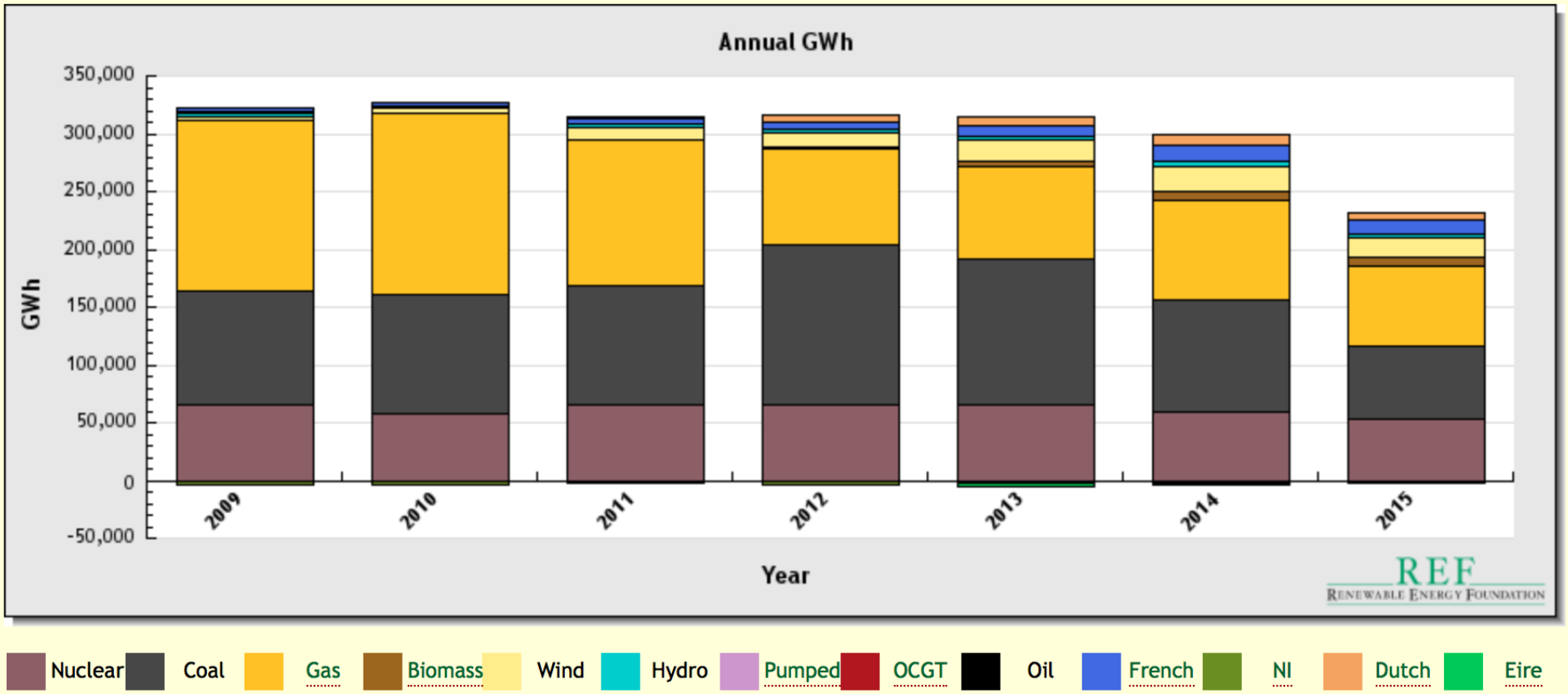
Renewable Electricity Cumulative Subsidy 2002–2040

- Assumptions: Current subsidy levels; no new capacity after 2020; DECC technology pipeline projections
- Cumulative subsidy Cost 2002–2040: ca £162bn



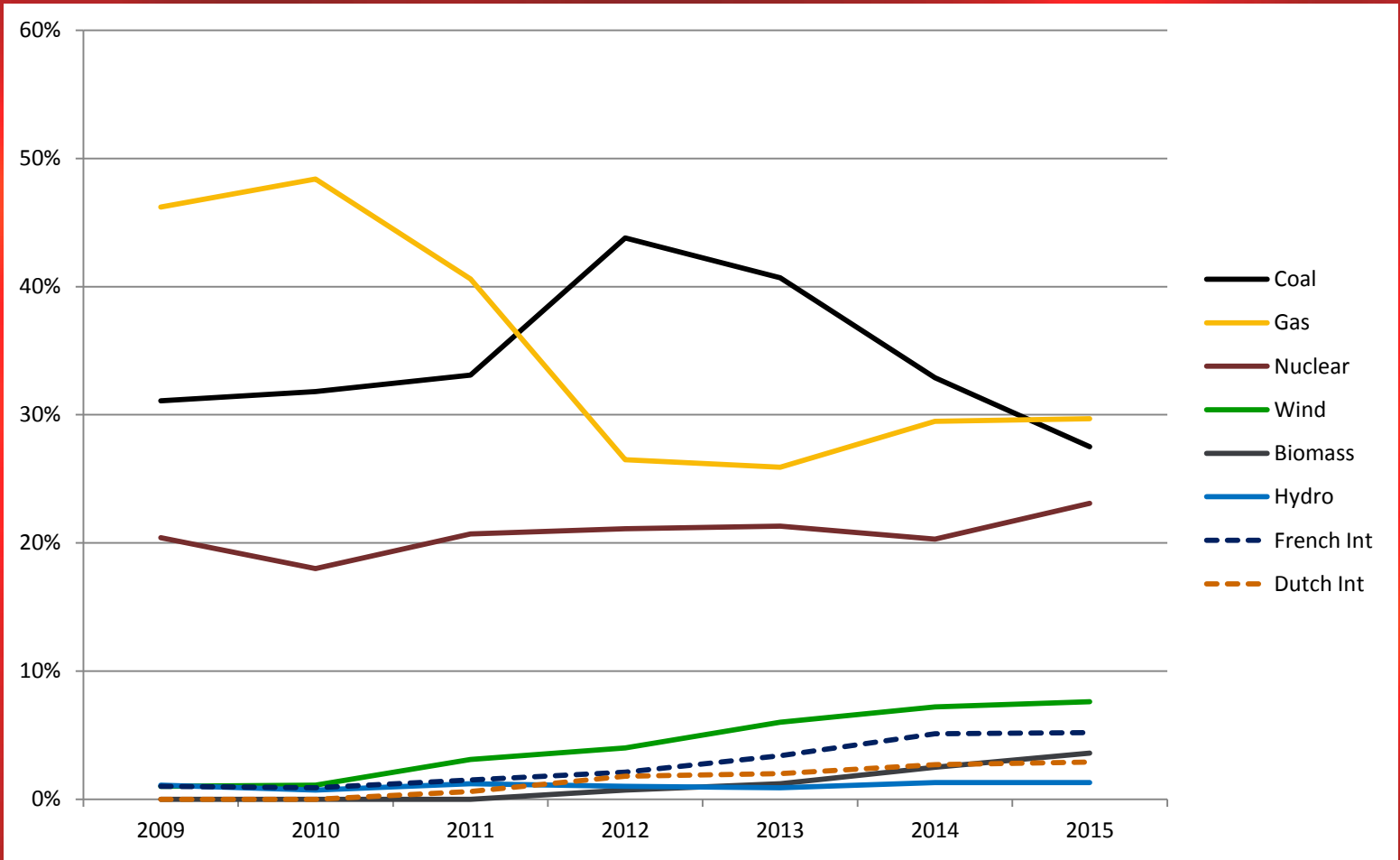
Source: REF. Based on DECC's pipeline projections in *Renewable Energy Roadmap* 2013.

UK Electricity Fuel Mix 2009 to 2015 (GWh)



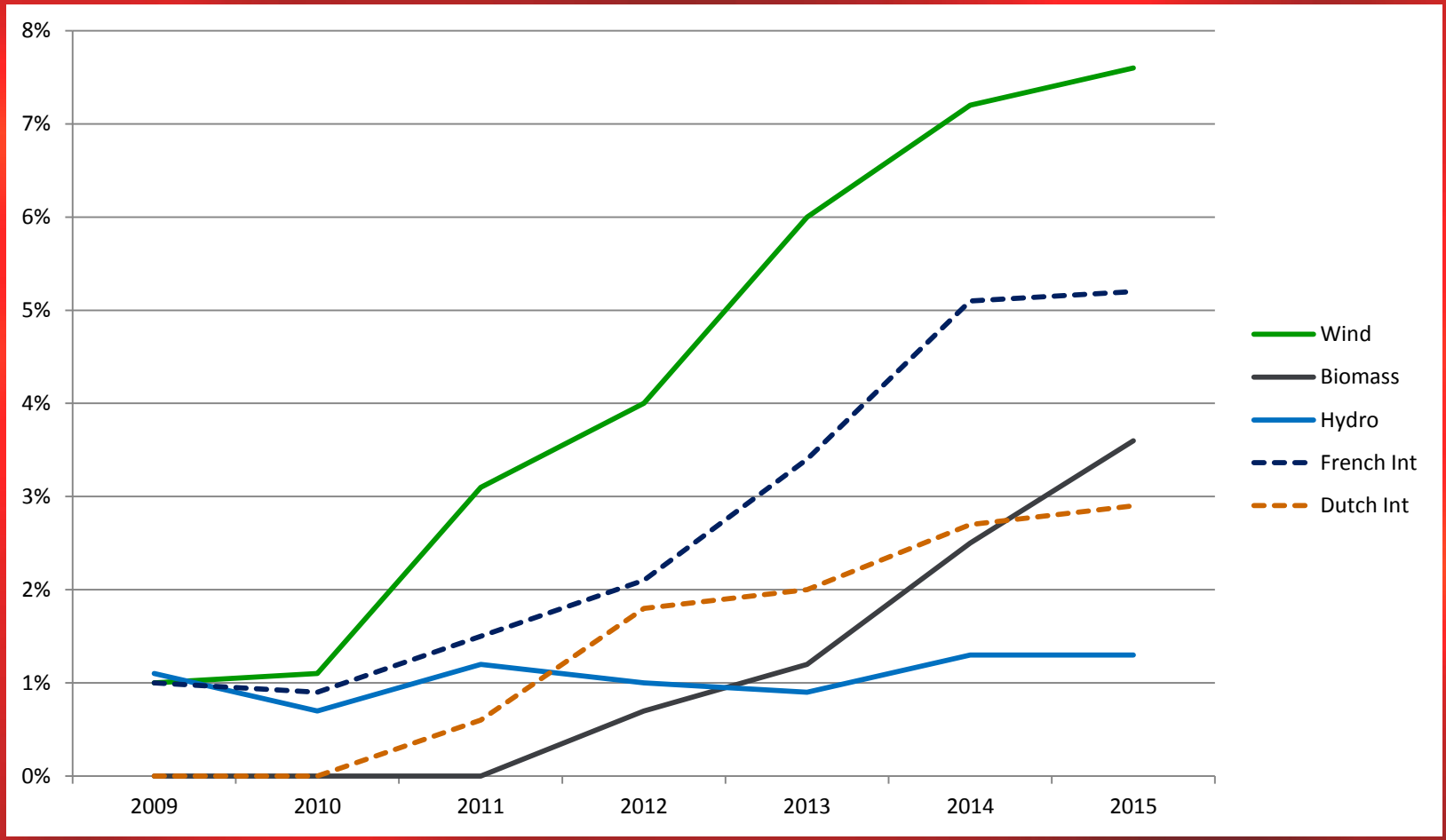
Source: GB Transmission System Demand (MWh). BM Reports. Chart by REF.

UK Electricity Fuel Mix 2009 to 2015 (%)



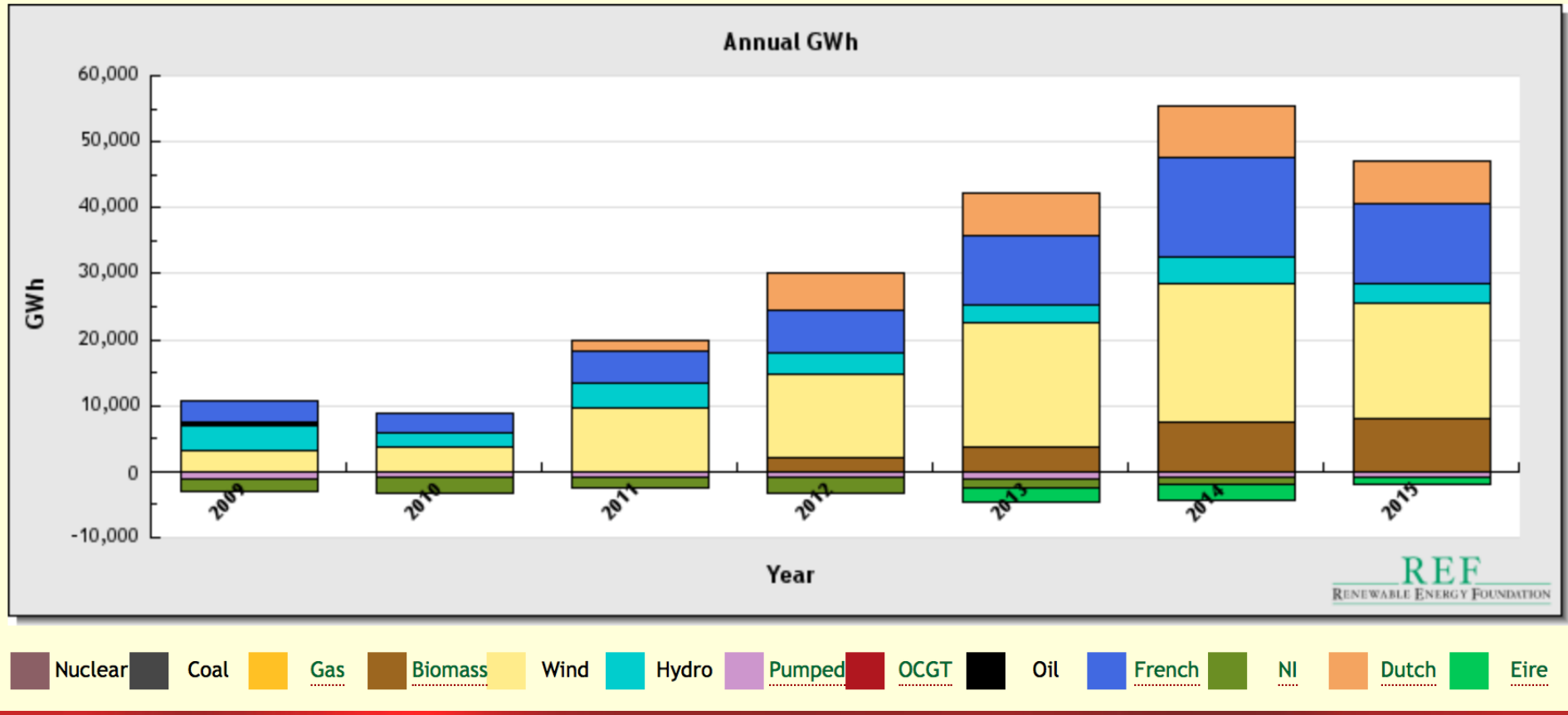
Percentage of Transmission System demand (MWh).Source: BM Reports. Chart by REF

UK Electricity Fuel Mix: Renewables and Interconnectors 2009–2015 (% of demand)



Percentage of Transmission System demand (MWh). Source: BM Reports. Chart by REF.

UK Electricity Fuel Mix (2009-2015): Renewables and Interconnectors (GWh)

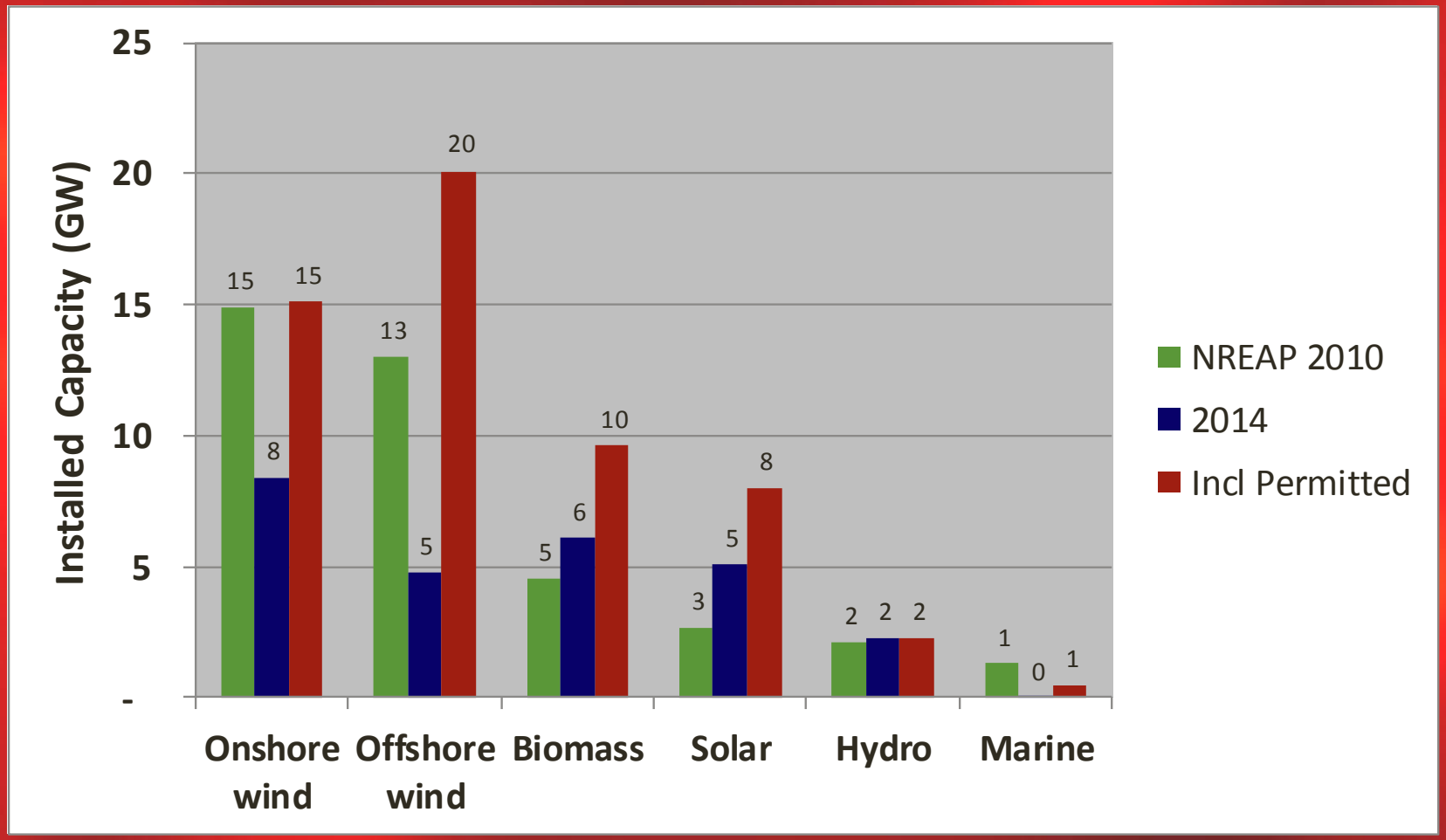


Renewables and Interconnectors. Percentage of Transmission System demand (MWh).
Source: BM Reports. Chart by REF.

UK Fuel Mix: Main Stories

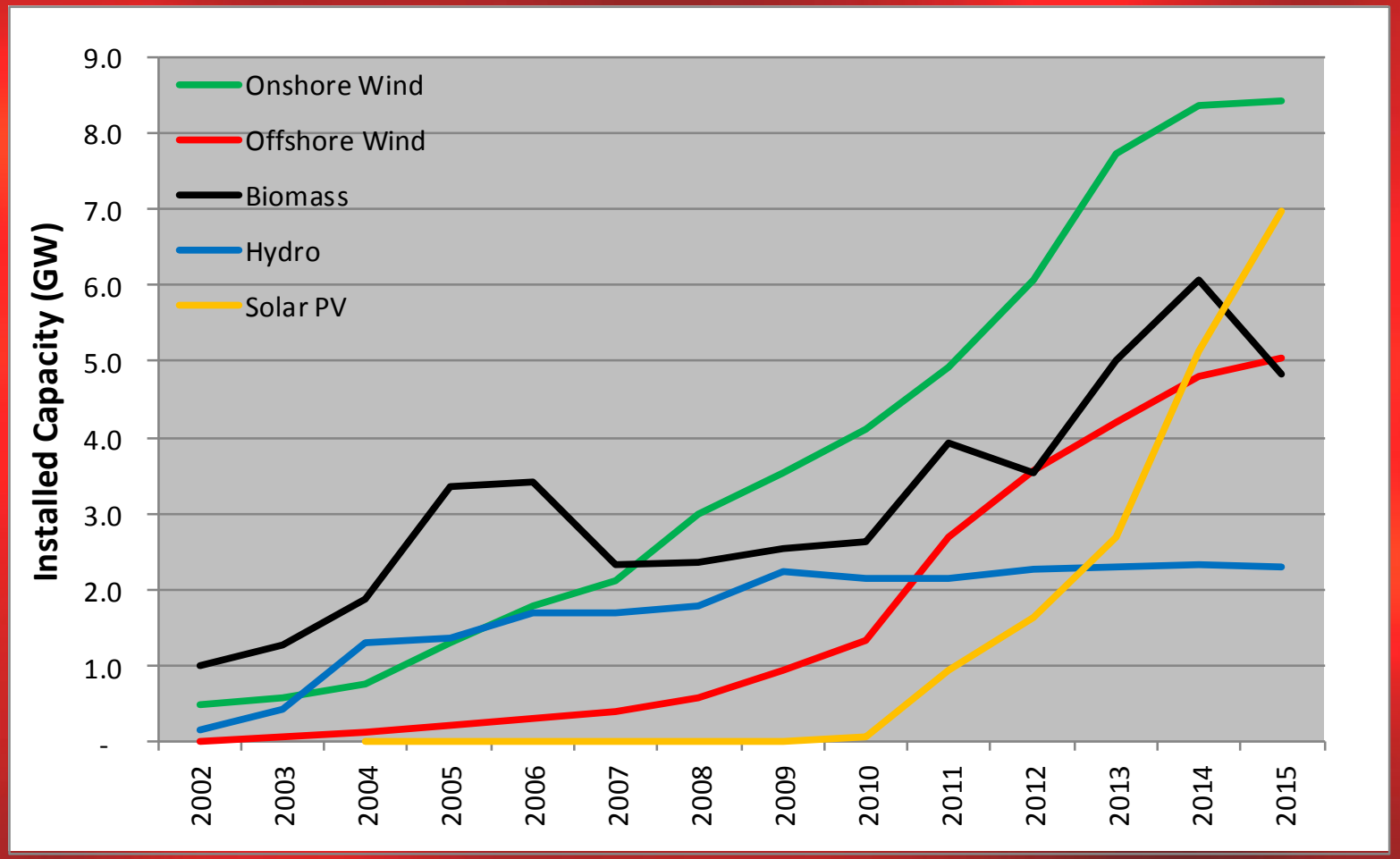
- Fall in demand for electricity
  - Mainly due to recession
  - Efficiency measures? Yes, but continued low demand suggests fundamental economic ill-health
- Fall in coal use as EU Large Combustion Plant Directive takes effect
  - But note, only weak recovery in gas generation
- Major growth in wind and solar generation
  - Caused by subsidies
- Major growth in electricity imports
  - Caused by price differential

Subsidy and Renewables Sector Overheating



Source: Chart by REF. Data from DECC, Renewable Energy Planning Database; and *National Renewable Energy Action Plan* (NREAP) 2010.

Operational Renewable Electricity Capacity 2002–2015 by Technology



So0urce: DECC REPD. Chart by REF

UK Renewables Target Overshoot

	Biomass	Hydro	Solar	Marine	Waste	Offshore Wind	Onshore Wind	Total
Operational (GW)	3.8	0.5	5	0	0.8	5.1	8.4	23.7
Under Construction (GW)	0.4	0	0.2	0	0.2	0	2.2	3
Awaiting Construction (GW)	3.2	0.1	3.3	0.5	0.7	15	4.7	27.4
Total Consented Capacity (GW)	7.4	0.5	8.5	0.5	1.7	20.1	15.3	54.1
Submitted to Planning (GW)	0.3	0	2.6	0	0.1	1.8	6.2	11
Load Factor	66%	36%	10%	8%	68%	34%	26%	
Est. output from consented capacity (TWh)	43	1.7	7.4	0.4	10.1	59.9	34.7	**157.2**
Est. output from in-planning capacity (TWh)	1.6	0	2.3	0	0.8	5.4	14	24.1

Source: DECC REPD, October 2015; Calculations by REF

UK Renewables Overshoot

- 54 GW of capacity consented
  - Of which 23 GW is operational
  - Includes 20 GW of offshore wind (5.1 operational), which is 7 GW in excess of NREAP projections
  - 8.5 GW of solar (6 GW in excess of NREAP projections)
  - 15 GW of onshore wind, as projected in NREAP, but there is 6 GW still in the planning system
- Output of consented capacity = 157 TWh
  - 43% in excess of 110 TWh target for electricity
  - **NB: No budget for overshoot in LCF. Excess likely to be in range of £2 billion (30% overshoot)**

Levy Control Framework under Strain

- 2020 LCF budget set at £7.6 billion, but forecast to reach ca. £9bn (2011 prices)
- Current forecast suggests cost will reach £13 billion (actual) in 2020:

2.7 Environmental levies							
	£ billion						
	Estimate	Forecast					
	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Carbon reduction commitment	0.6	0.8	0.7	0.6	0.6	0.6	0.5
Warm homes discount[1]	0.0	0.3	0.3	0.3	0.3	0.3	0.4
Feed-in tariffs[1]	0.0	1.1	1.3	1.5	1.7	1.9	2.1
Renewables obligation	3.1	3.9	4.7	5.3	5.9	6.1	6.3
Contracts for difference	0.0	0.1	0.3	0.6	1.1	2.3	3.1
Capacity market	0.0	0.0	0.0	0.0	0.6	1.1	1.3
Environmental levies	3.6	6.0	7.3	8.3	10.2	12.3	13.6

[1] The ONS have yet to include Warm Homes Discount and Feed-in Tariffs in their outturn numbers.
Note: This is consistent with the 'Environmental levies' line in Table 4.5 of the July 2015 *Economic and fiscal outlook.*

Source: Office of Budget Responsibility, *Economic and Fiscal Outlook*, July 2015.

DECC: 2020 Electricity Price Policy Impacts

- Overshoot would exacerbate already severe price impacts.
- Even if within LFC…
- Domestic Households
  - Low fossil price scenario: + £55/MWh (+ 42%)
- Medium Sized Businesses
  - Low fossil price scenario: + £53/MWh (+77%)
- Even in DECC's High Fossil Price scenario prices rise by 30% to 45% due to climate and other policies

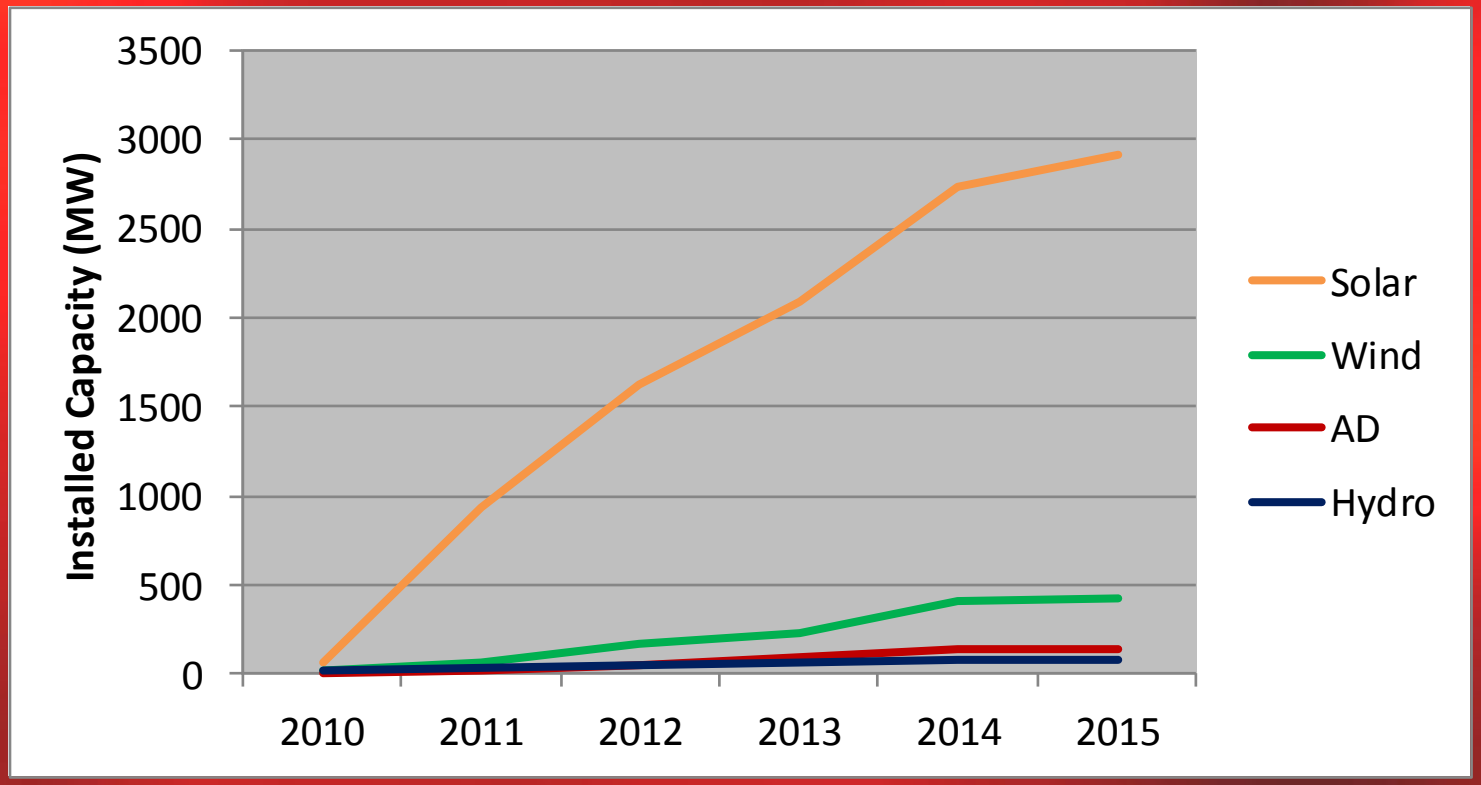
Source: DECC, *Estimated Impacts of Energy & Climate Policies on Prices and Bills* (2014)

Controlling Spending: UK Govt. Actions

- End support for new large scale onshore wind
  - Early closure of Renewables Obligation, but legislation has been blocked in the House of Lords
- Remove subsidies for new large solar PV
- Reduce subsidies for new small scale solar
- 400 MW cap on subsidy guarantees for dedicated biomass
  - And likely exclusion of all biomass from guarantees in future
- *Retrospective cut for all existing sites:* **Remove Climate Change Levy (CCL) exemption for renewables (worth £0.3 to £0.5bn per year in 2015/16 to Treasury)**

Subsidy tariffs repeatedly adjusted to attempt to control costs… and cool sector… without success

- Renewables Obligation (RO): 1 ⟶ 74 tariffs
- Feed in Tariff (FiT): 21 ⟶ 385 tariffs



Source: DECC. Chart by REF.

Further Problems: Unintended consequences (A)

- RO not designed to subsidise ‘large hydro generators’
- A ‘large hydro generator’ defined in legislation as one “which has, or has had at any time since 1 April 2002, a declared net capacity of more than 20 MW”.
- Approx 60MW of hydro lost immediately through down-rating to under 20 MW
- Kinlochleven – 93 years old – capacity cut from 30 MW to 19.5 MW

Unintended Consequences (B)

- Investment signals for conventional generators destroyed
  - But conventional generation still required to meet peak load
- No investor appetite even for CCGT investments
- Government responded with:
  - Contracts for Difference for Nuclear (£92.50)
  - Capacity Market (costing £1.3 billion a year in 2020)
  - Industrial load shedding contracts

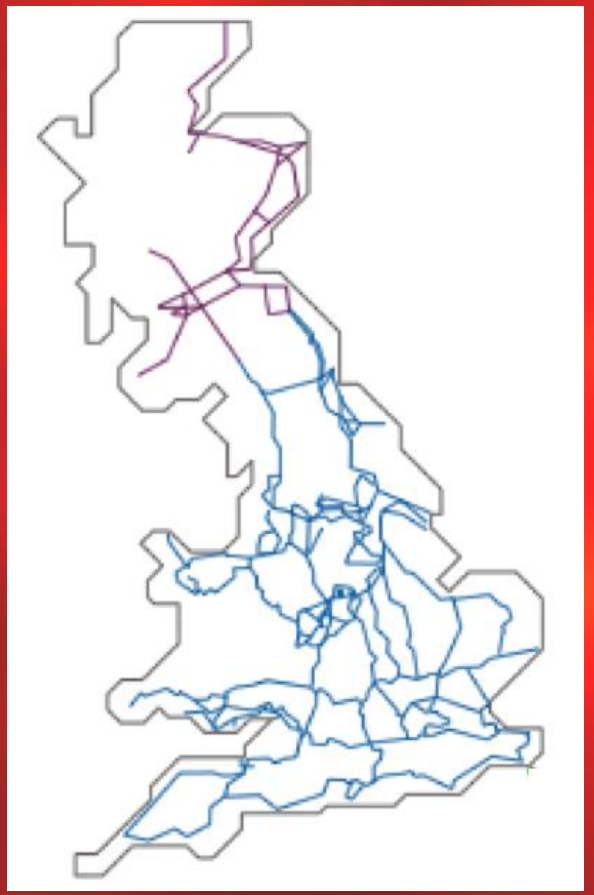
Further Problems: Cost of abating CO_2 emissions

	Cost per tonne CO_2
Roof mounted solar PV	£250 - £980
Free-standing solar PV	£180
Small onshore wind (<500 kW)	£400
Large onshore wind (> 1 MW)	£90
Offshore wind	£180
Dedicated biomass	£130
Hydro	£0 - £90 - £450
Anaerobic digestion	£180 - £250
Incinerated municipal biomass	£0

Source: Ofgem, DECC. Calculations and chart by REF.

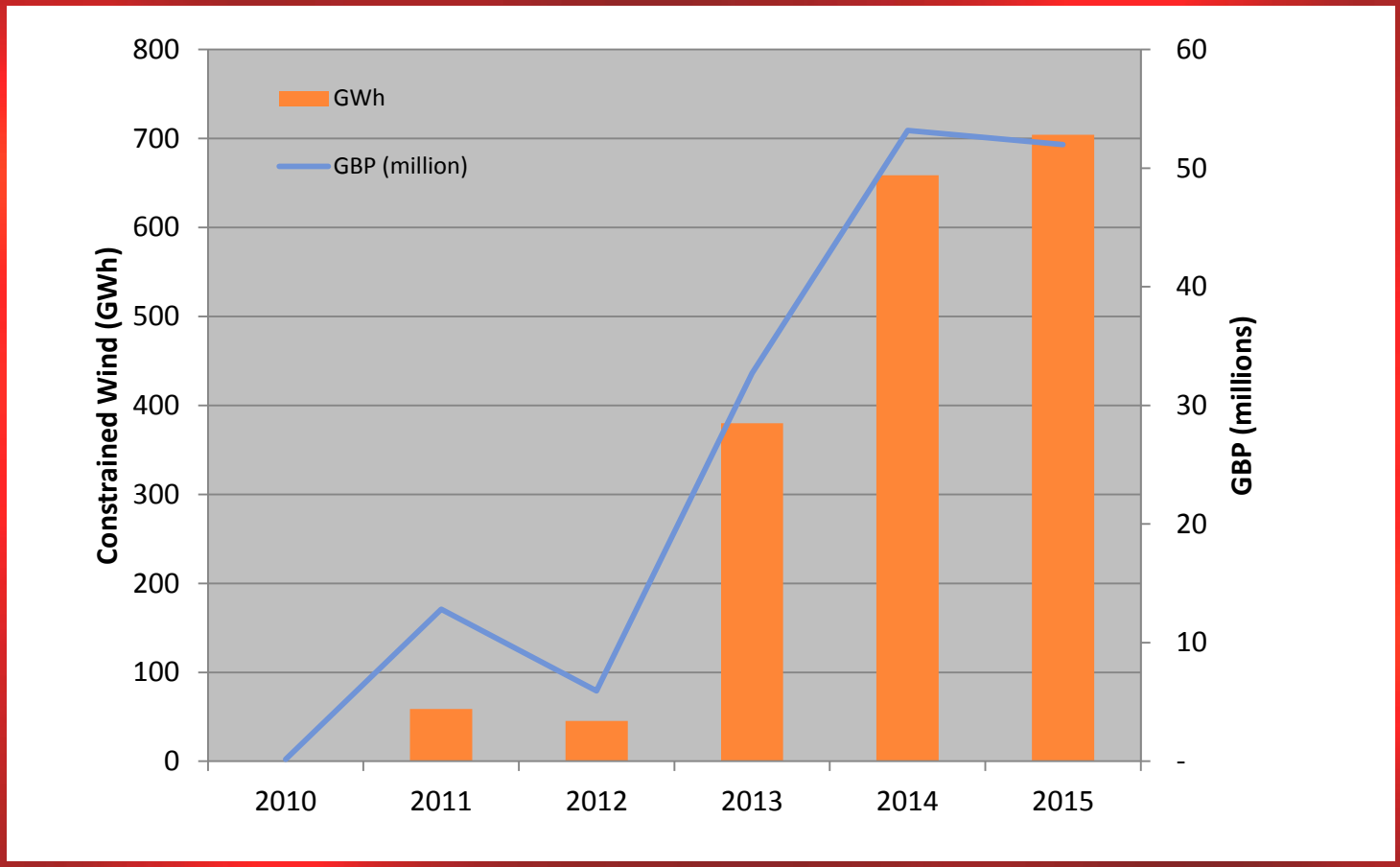
Further Problems: Integration Problems: Constraint Payments to Wind Power

- Total 2010 to Oct. 2015: £156m
- **Almost all in Scotland**
- Average price in 2015 to reduce generation: **£74/MWh**
  - **Nearly double the lost income**
- **But "constraining wind off the system may be cheaper than building more network"**
  - Colin Gibson, Former National Grid Power Networks Director



The UK HV Network
Source: National Grid

Wind Constraints: As at October 2015



Source: BM Reports; Chart and calculations by REF

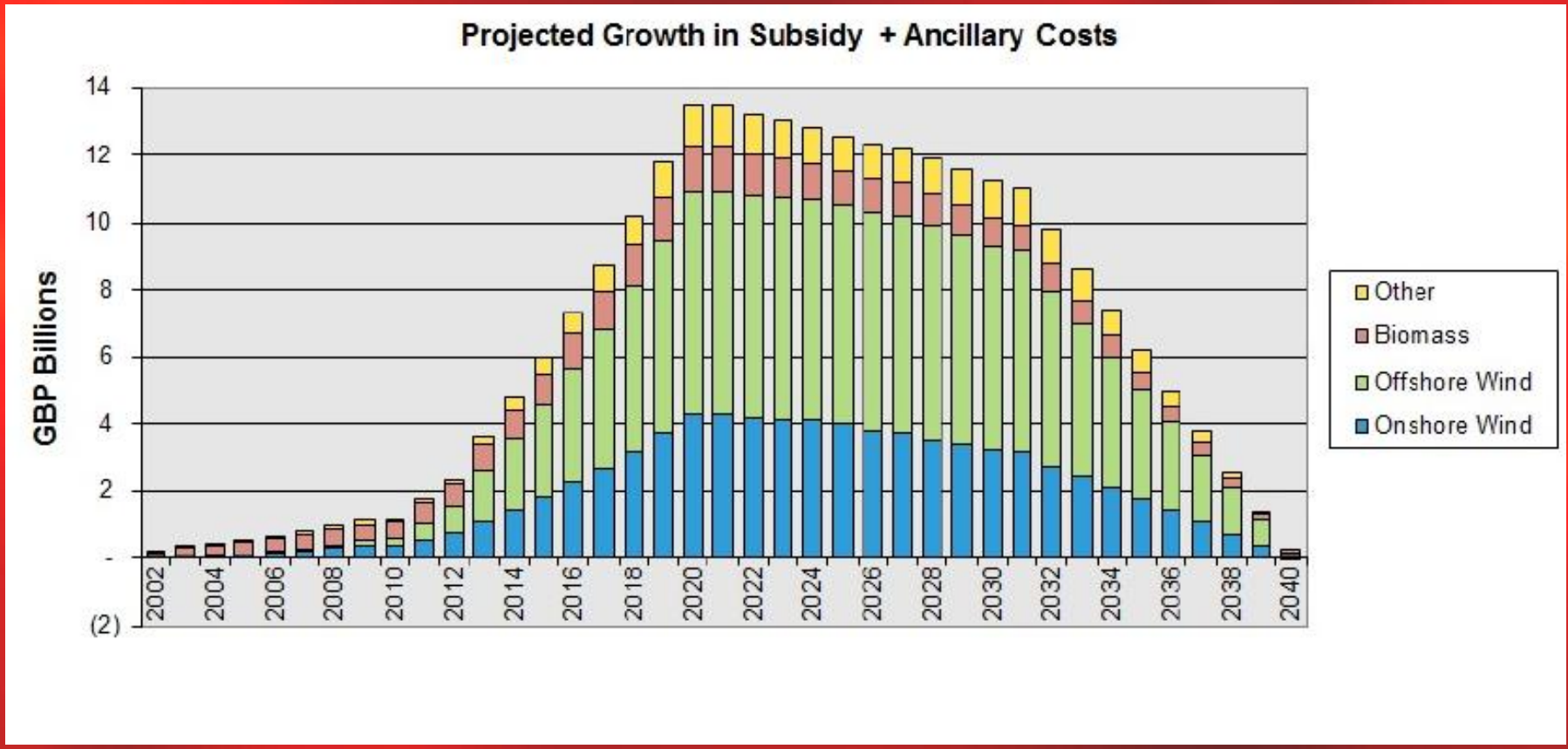
Wind Power System Integration Costs: Grid, Balancing, Security of Supply

Technology	Subsidy (£/MWh)	System Cost (£/MWh) *over and above* the system cost of conventional generation	Total (£/MWh)
Onshore Wind	£45	£75	£120
Offshore Wind	£95	£64	£159
Biomass (Conversion)	£50	£0	£50
Biomass (Dedicated)	£75	£0	£75

Source: Colin Gibson, "Levelised costs estimates for electricity generation", (Institute of Engineers and Shipbuilders in Scotland: 2011): http://www.iesisenergy.org/lcost/

Subsidy + Wind Integration Costs

Total Cost 2002–2040: ca. £256bn

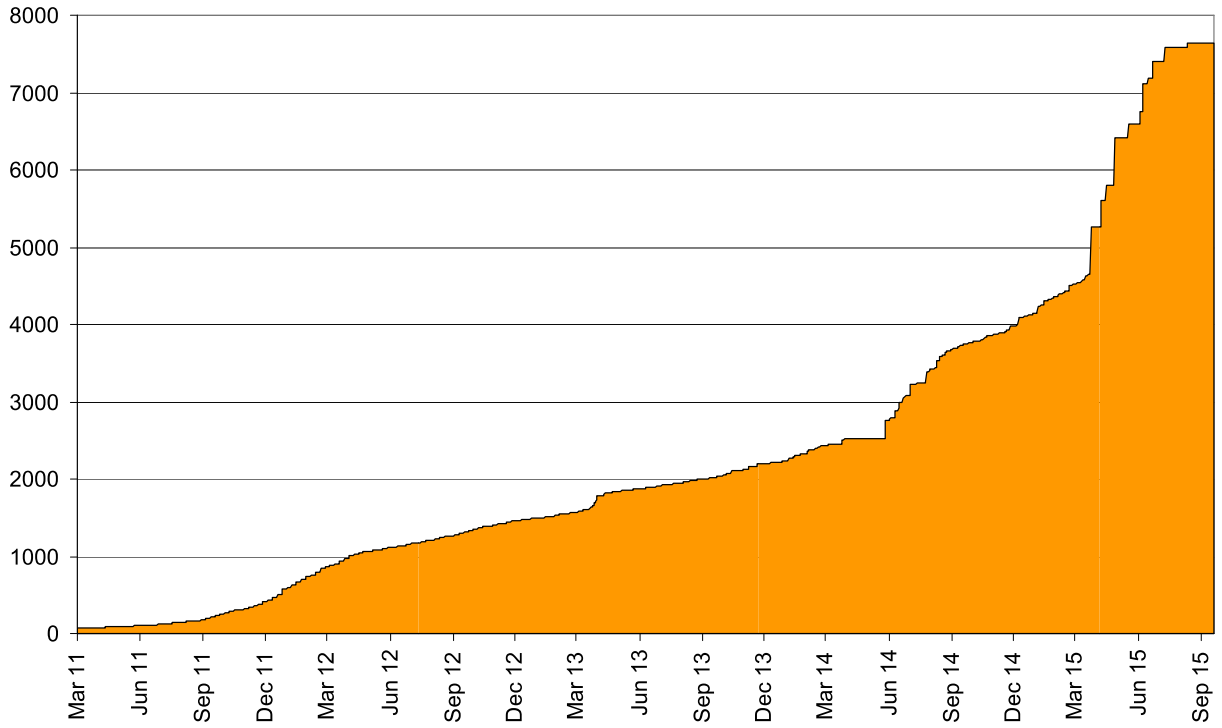


Source: REF. Based on DECC Pipeline projections. Ancillary costs based on Colin Gibson for IESIS (2011).

Integration Problems: Solar

nationalgrid

Growth in Solar Generation



Source: National Grid, Operational Forum, 20.10.15

Solar PV in 2015

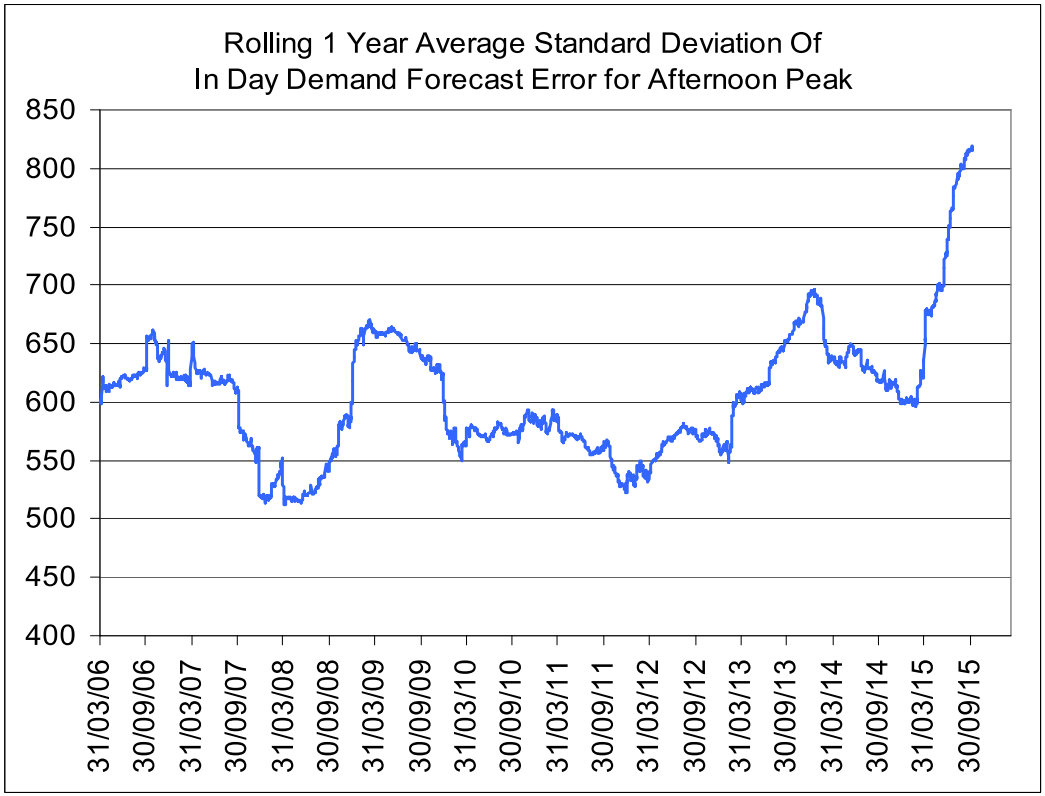
- Max energy in one day: 64.9 GWh
- Peak PV generation: 6.96 GWh
- Peak share of daily energy demand (MWh) met by PV: 8.6%
- Peak share of half-hourly load (MW) met by PV: 19%
- Increasing volatility of Transmission System demand
  - 3,860 MW difference in PV on consecutive days
  - Up 1,320 MW increase in PV output in 30 minutes
- Increasing reliance on weather forecasts in demand forecasting

  - *Source: National Grid, Operational Forum, 201.10.15*

Errors in Solar Forecasts…

nationalgrid

Increasing Uncertainty



Errors in solar radiation forecasts lead to errors in demand forecasts

Source: National Grid, Operational Forum, 20.10.15

Part 1: Summary/Conclusions

- Setting realistic targets far out into the future is difficult
- Subsidies to deploy existing technologies are a costly mistake
- **Distressed policy corrections are very expensive**
- Annual subsidy costs and system costs are very high
  - Very high cost per tonne of CO_2 abated
    - Not economically compelling to developing world
- The current energy and climate policies are extremely unstable due to high costs
  - **Only low cost emissions reductions have any political future**
  - **Invention and innovation policies required if low emissions energy systems are to be acceptable**

Part 2: Dangers of Energy Taxes and Levies

- Obvious
  - Short term cost (annual)
  - Premature technology adoption on a broad scale, leading to mal-investment
  - Suppression of invention and innovation
  - Failure to achieve emissions reductions that set an economically compelling example
  - Long term, cumulative, cost
- Hidden
  - **Costs rendered in capital structures, leading to long term economic poisoning**

Hidden Dangers: Scale of the Problem

- Transport Fuel Tax
  - £27 billion a year
  - 60% of the pump price
- Renewables Obligation and Feed-in Tariff
  - £4 billion a year at present
  - Rising to ca. £8 billion a year in 2020
    - More if LCF is breached…
  - Cumulative total since 2002 approx. £15 billion
  - Cumulative total 2002 to 2040 (assuming LCF not breached and no new subsidy contracts after 2020): £160 billion

Not the End of the World?

- Domestic Energy Efficiency
  - "[…] taken together [i.e. subsidies plus efficiency drives], the Government's policies mean that household bills will be on average 11%, or £166, lower in 2020"
- Energy as share of commercial costs
  - "For most businesses, direct energy costs are a relatively small proportion of total costs. […] around 2.5% of total costs for UK manufacturing as a whole."
    - Source: DECC, *Estimated Impacts* (2013)
- Factor substitution
  - "If we use less energy we will need to increase other inputs, e.g. more and better capital investment, or improved technique, if labour productivity is to be maintained."
    - Adair Turner, *Just Capital* (Pan Books: London: 2001), 286.

Efficiency Measures?

- Capital cost of energy efficiency is high
- Efficiency measures may not work
- Rebound Effect
  - *"[…] it is wholly a confusion of ideas to suppose that the economical use of fuels is equivalent to a diminished consumption. The very contrary is the truth."*
    - *The Coal Question* 1865

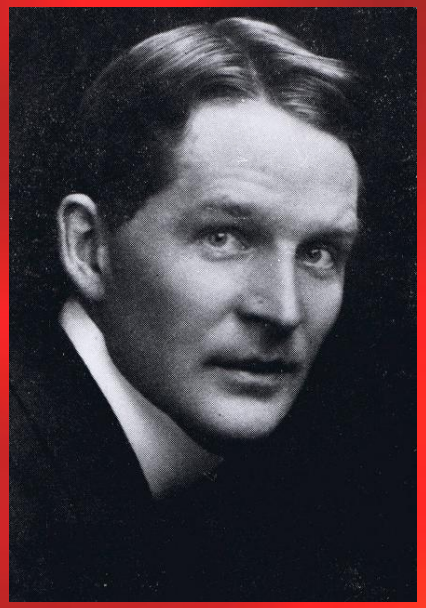
W. S. Jevons (1835–1882)

Energy Share and Factor Substitution

- Instantaneous energy share (ca. 5%) does not reflect the importance of energy in the economy…
  - **Energy consumed over time accounts for all other inputs**
- Thus factor substitution for energy is an illusion
  - **All factors are the result of earlier energy inputs**

The Ontology of Wealth

- "[Wealth] is a form or product of energy"
- "The flow of energy should be the primary concern of economics"
  - Frederick Soddy, *Wealth, Virtual Wealth, Debt* (1926)



Frederick Soddy FRS
Nobel Prize for Chemistry, 1921

Economic growth in a system is a reduction of that system's entropy (increase in improbability) as a result of energy conversion.

The Ontology of Wealth

Economic growth in a system is a reduction of that system's entropy (i.e. an increase in the improbability of the system) as a result of energy conversion.

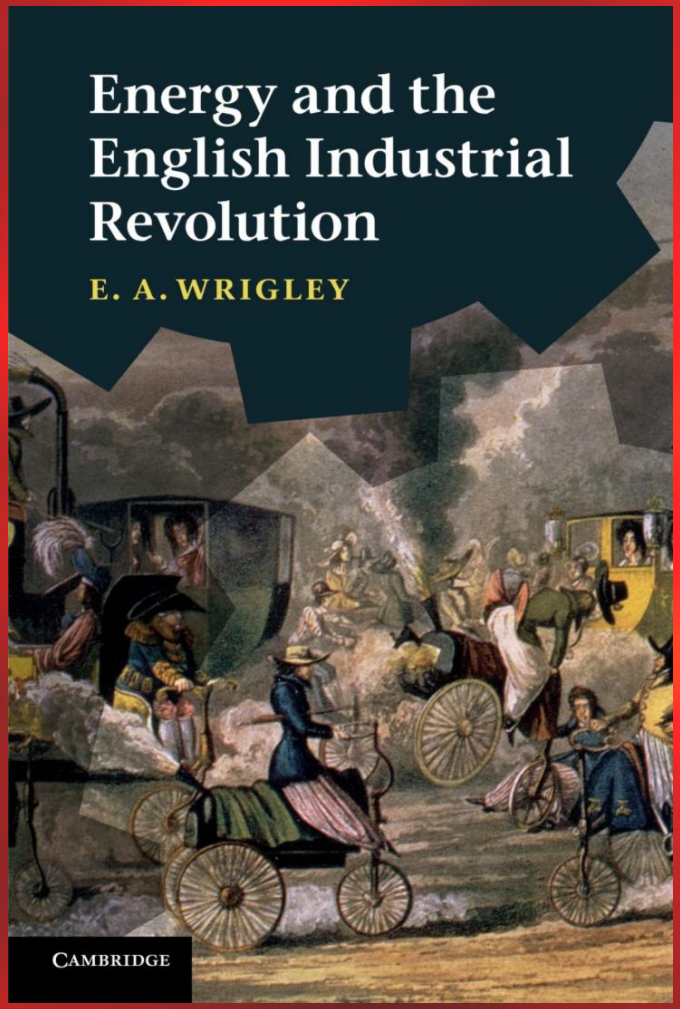
Energy is No Ordinary Input

- "Coal in truth stands not beside but entirely above all other commodities. It is the material energy of the country—the universal aid […] With coal almost any feat is possible or easy; without it we are thrown back into the laborious poverty of early times."
  – *The Coal Question* (1865)

W. S. Jevons (1835–1882)

Escaping the Organic Economy…

- "The 'laborious poverty'[…] to which most men and women were condemned did not arise from lack of personal freedom, from discrimination, or from the nature of the political or legal system"
- "It sprang from the nature of all organic economies. […] the plant growth in question represented the bulk of the sum total of energy which could be made available for any human purpose."
  - *Energy and The English Industrial Revolution* (Cambridge 2011), 239.

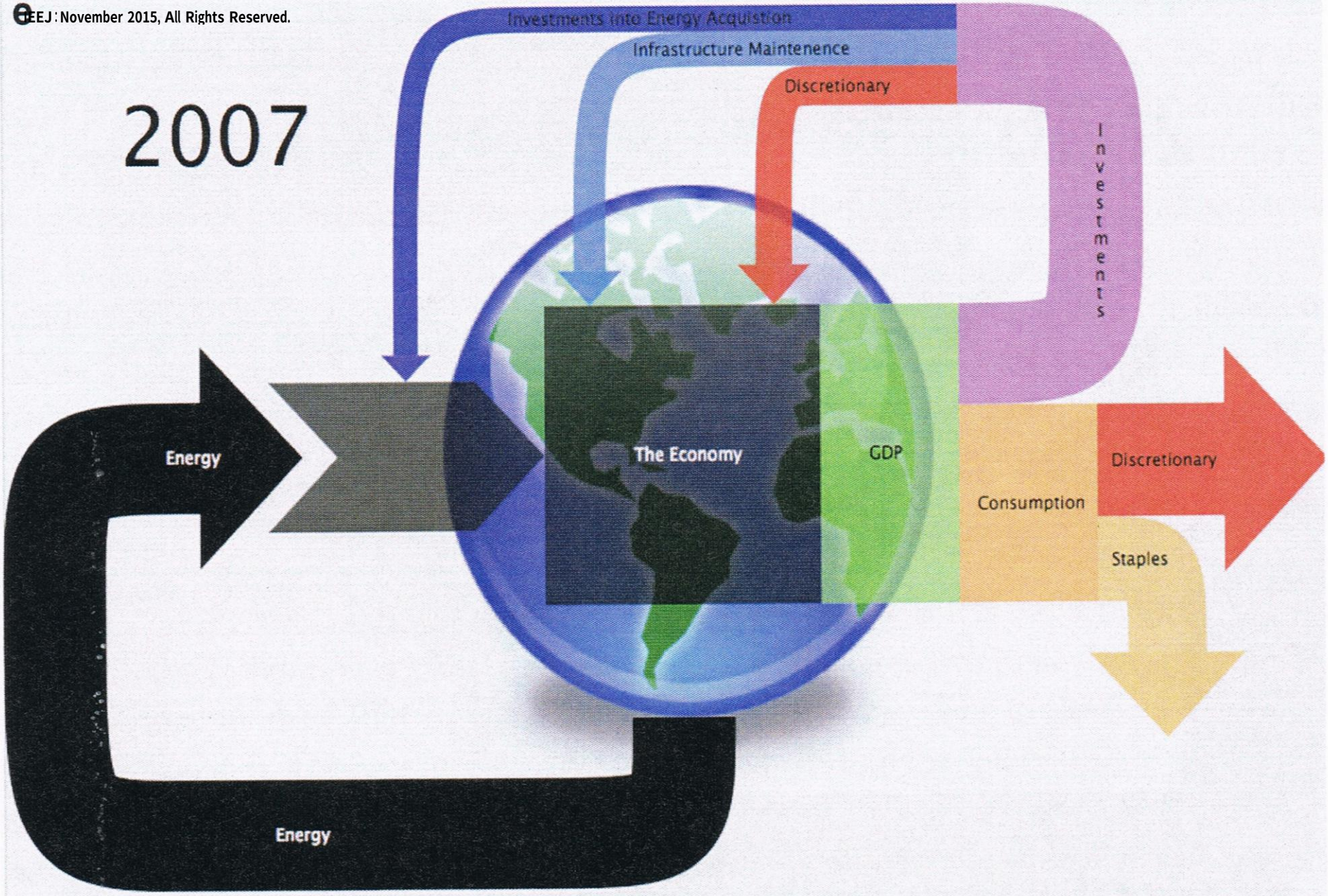


The Thermodynamic Ontology of Wealth

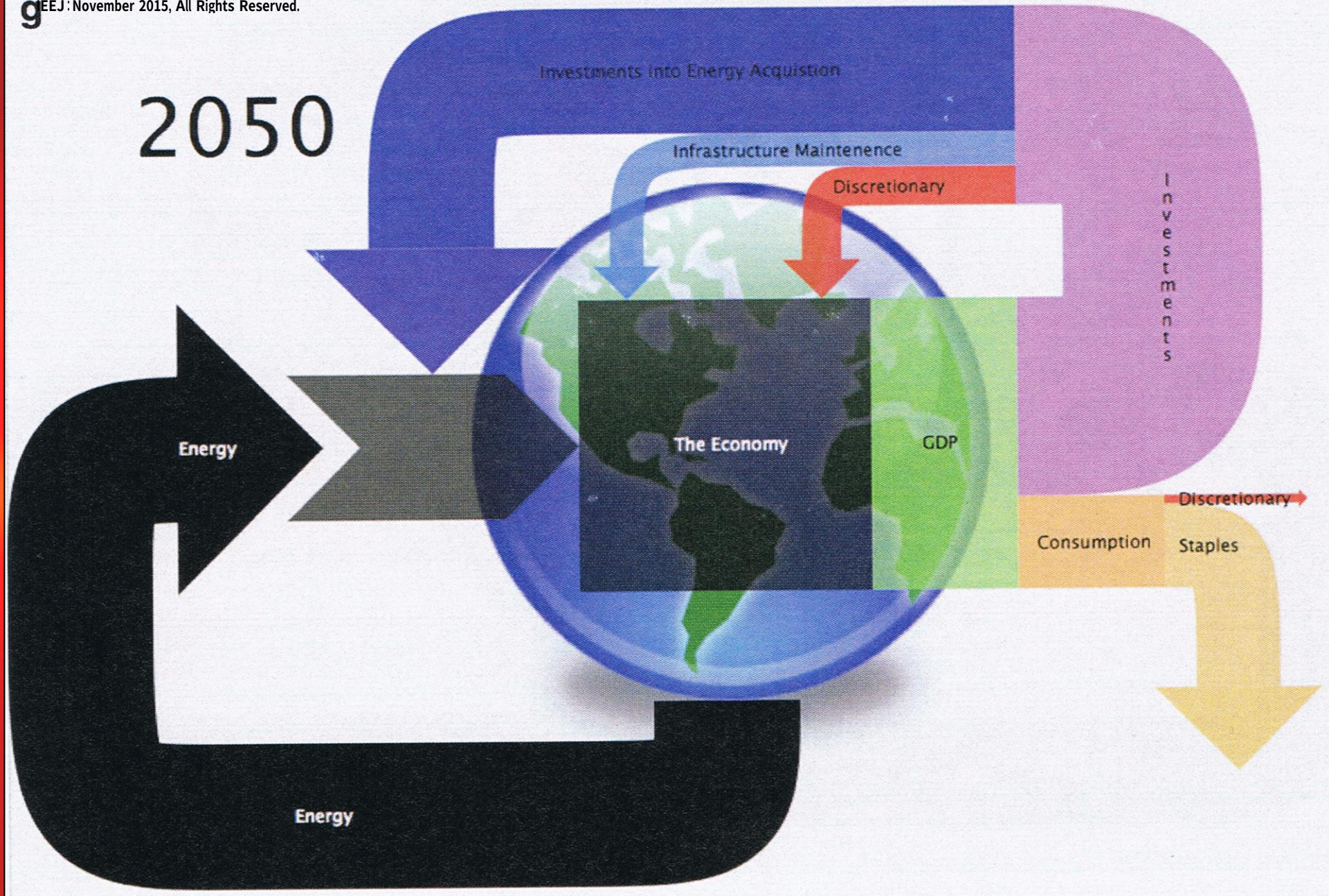
- When the world is ordered in accordance with human requirements, this is *wealth*, and only energy can bring it about
- This valuable order can be analysed as *improbability*:
  - *Complex structure*: A refrigerator for example, or improved land, but also ideas and institutions
  - *Timeliness*: The glass of cool water in the desert is valuable because it is improbable in that location at our hour of need, and only the use of energy can make its delivery certain
    - Constable, "Thermo-Economics", journal of the Economics Research Council: http://www.ref.org.uk/images/PDFs/jc_thermoeconomics_erc_21_08_14.pdf
- There is no substitute for energy, which is *rendered* as complexity in all inputs without exception

Limits of the Organic Economy…

- "The 'laborious poverty'[…] sprang from the nature of all organic economies. […] the plant growth in question represented the bulk of the sum total of energy which could be made available for any human purpose."
  - *Energy and The English Industrial Revolution* (Cambridge 2011), 239.
- Organic economies have a Low Energy Return on Energy Invested (EROEI) → Poverty
- Fossil economies have a high EROEI → Wealth



Source: Charles Hall et al, *Energy and the Wealth of Nations* (Springer 2012)



Source: Charles Hall et al, *Energy and the Wealth of Nations* (Springer 2012)

The Long Term Dangers of Expensive Energy

- A forced energy transition against the cost gradient drives energy resources into the energy generation sector itself, reducing their availability for other purposes.
  - Also concentrates capital wealth and political power (see the pre-coal economies…)
- The smaller surplus of energy is now more expensive, and as this surplus is used to repair and refresh capital, so the use of that capital itself becomes more expensive, an effect that will gradually but inevitably reduce general prosperity over time.
  - Constable, “Thermo-Economics” (2014)

Part 2: Conclusion

- Taxes and levies on energy should be avoided
- A coerced energy transition ahead of the learning curve and against the cost (energy density) gradient is hazardous and human wellbeing
- Even if the policies stop now, OECD economies are all to some degree poisoned with high cost capital stocks resulting from decades of taxation and levies.
- Flushing with very cheap energy is the only remedy

Energy and Resource or Capital Crisis?

- There is no shortage on earth of *free energy* (thermodynamic sense: available to do work)
- With sufficient free energy we will never lack for resources of any kind
- But capital erosion (wealth destruction) may prevent access to and use of the available free energy
- Think of Alexander the Great…

Source: *Wall Street Journal* (2008). Oil seep in N. Iraq.

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