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VNIVERSIDAD D SALAMANCA

European clean energy policy for the electricity sector

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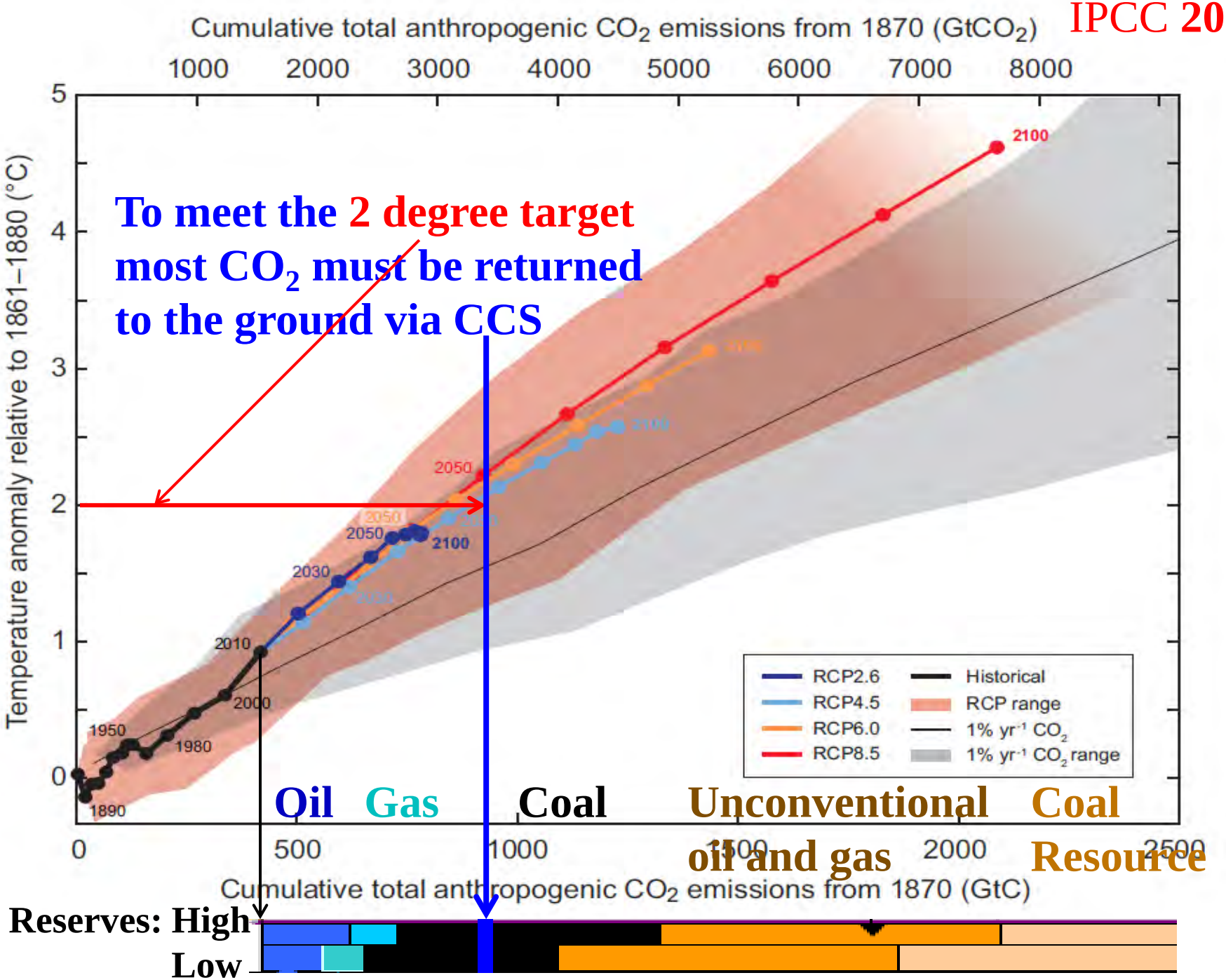
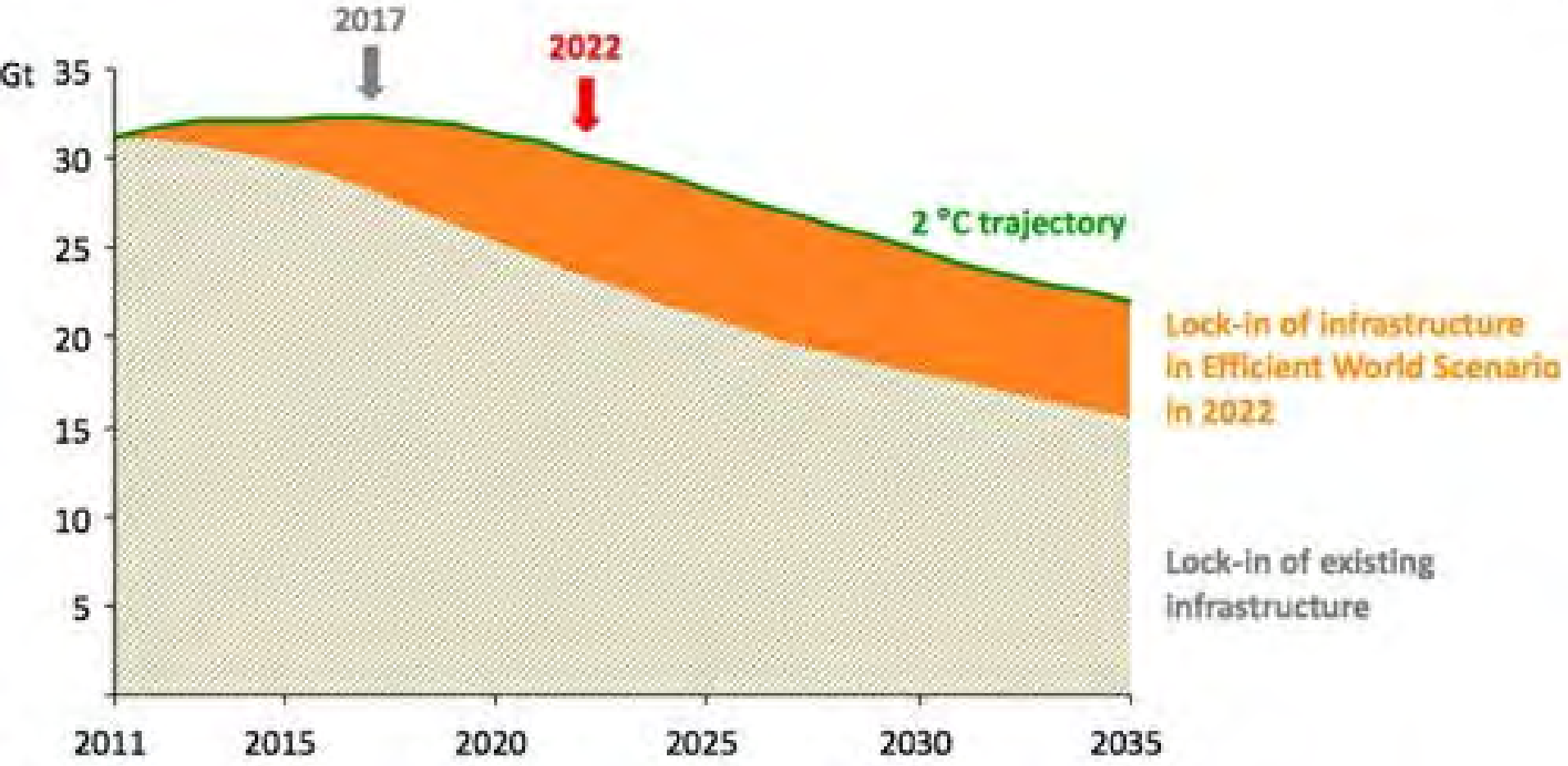
Outline

- The case for decarbonizing power
- The new Clean Energy Directives
- What implications for RES-E support?
- What implications for market design?
  - ⇒ long-term contracts, auctions
- What challenges for regulation?
  - – growing divergence between marginal & average costs
  - – tariffs and cost-recovery can cause major distortions
  - – regulators need to be more agile and smarter

IPCC **2013**


Cumulative total anthropogenic CO_2 emissions from 1870 ($GtCO_2$)
1000
2000
3000
4000
5000
6000
7000
8000
Temperature anomaly relative to 1861–1880 (°C)
0
1
2
3
4
5
To meet the 2 degree target
most CO_2 must be returned
to the ground via CCS
1890
1950
1980
2000
2010
2030
2050
2100
RCP2.6
RCP4.5
RCP6.0
RCP8.5
Historical
RCP range
1% yr⁻¹ CO_2
1% yr⁻¹ CO_2 range
Oil
Gas
Coal
Unconventional oil and gas
Coal Resource
0
500
1000
1500
2000
2500
Cumulative total anthropogenic CO_2 emissions from 1870 (GtC)
Reserves: High
Low

We are already locked in to high carbon emissions from past fuel choices



Source: IEA http://www.carbonbrief.org/blog/2012/11/favourite-graphs-from-iea

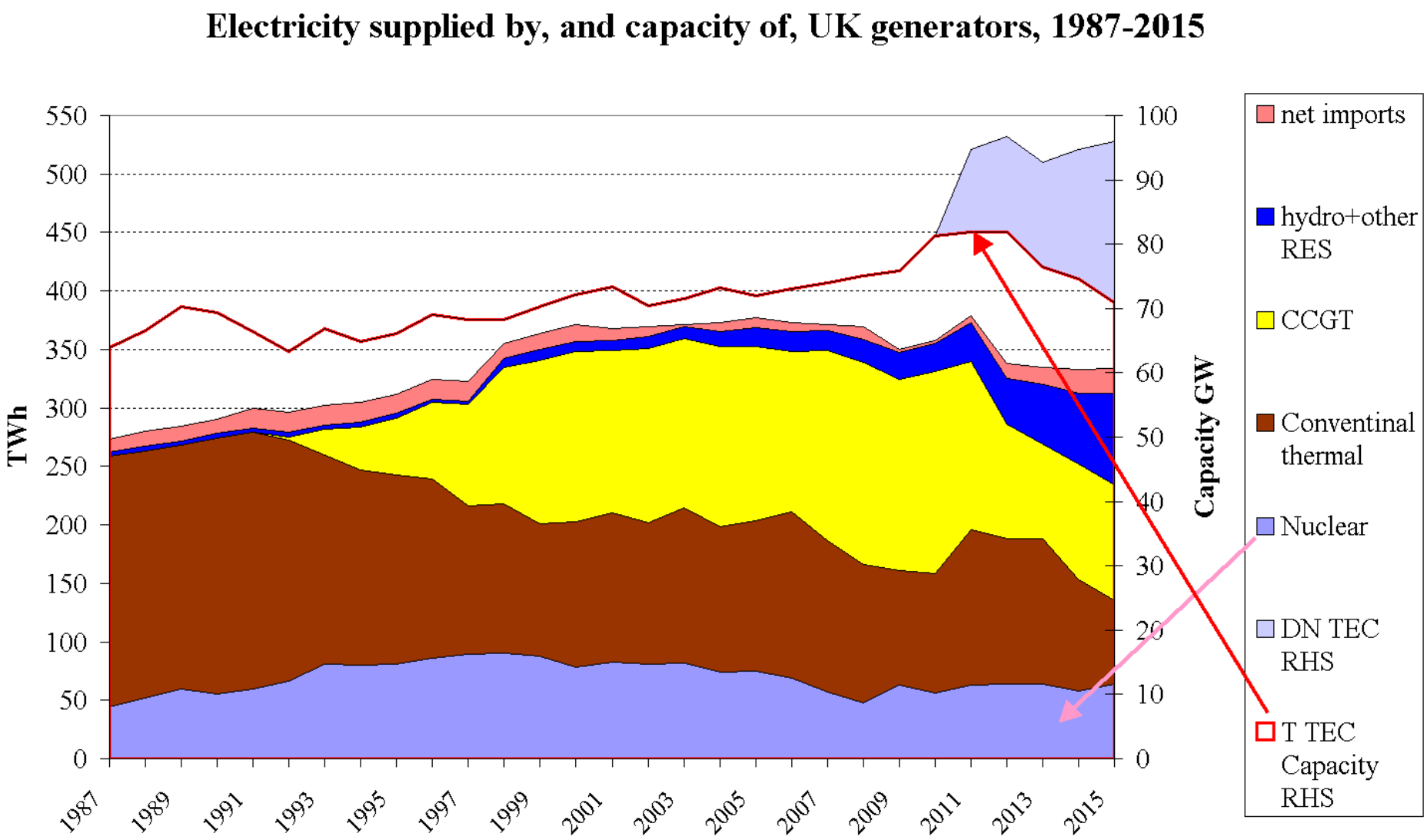
Decarbonising power

- **Power sector** key to decarbonising economy
  - –Large, easiest, and capital **highly durable**
- •Coal-fired electricity has more than twice the GHG emissions of gas *and* far higher air pollutants
  - – gas as transition fuel to the low carbon future
  - – But there is lots of coal => **CCS a long-run priority**
- Deployment has dramatically lowered cost of wind, PV
  - – justifies **support for R&D and deployment**
- Adequate carbon pricing could *lower* fossil fuel *prices*

⇒ hard to set the "right" carbon price

⇒ Need contracts and emissions standards?

UK generation decarbonizes



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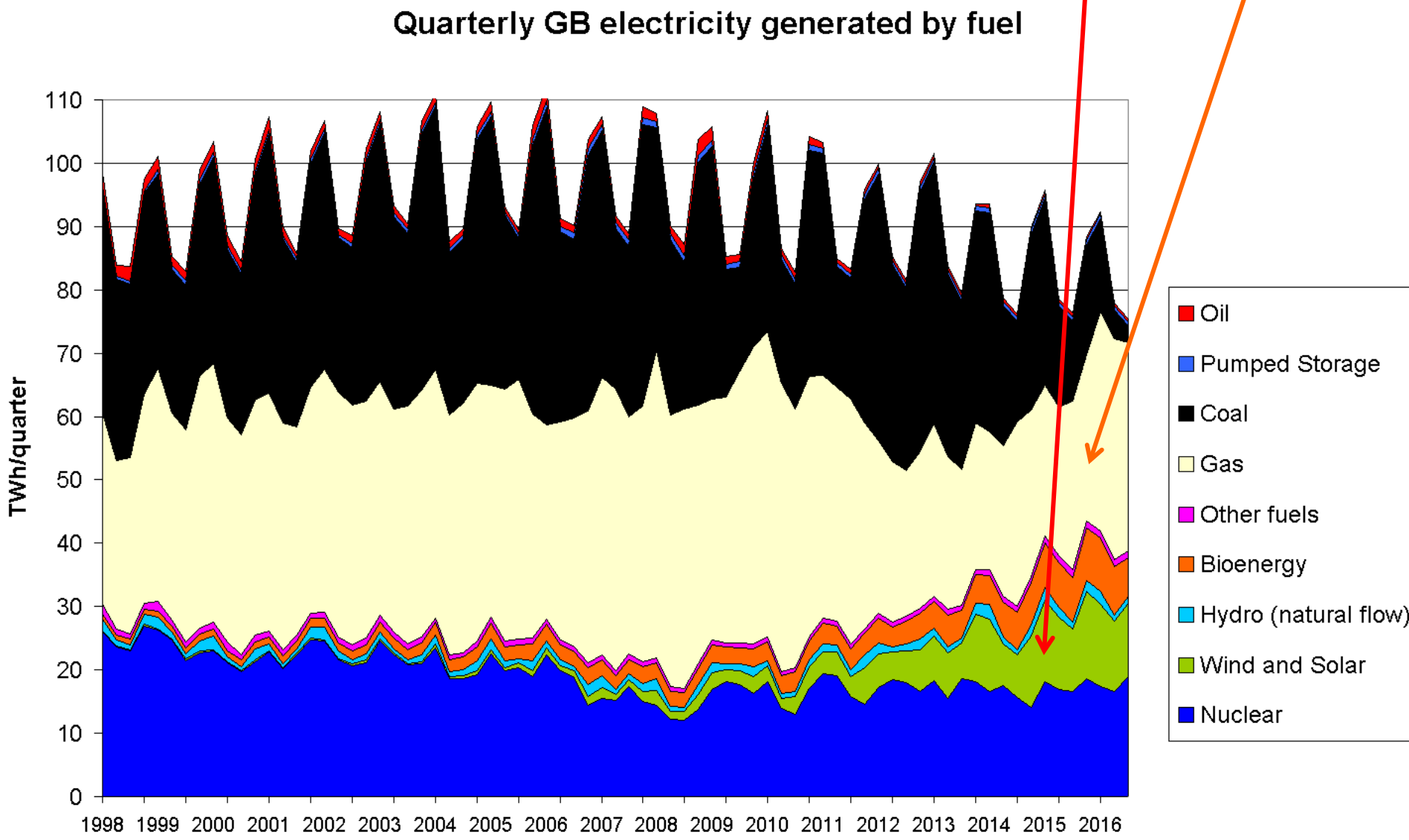
Coal displaced by wind & gas



Clean electricity policy

- 3 pillars of EU **Electricity policy**
  - – reliability, efficiency and **sustainability**
- 3 pillars of EU **Climate change policy**
  - – price CO_2 via **ETS, RES targets**, Strategic Energy Technologies (SET) Plan
- Energy Union 2015 called for reforms:
  - – **Clean Energy COM(2016) 860**;
  - – **Renewables** Directive COM(2016) 767
  - – Accelerating Clean Energy **Innovation** COM(2016) 763
  - – Proposed **reform of ETS** post 2020
  - – Others on energy efficiency, security, etc.

Energy Union Package 2015

- … renewable production needs to be supported through market-based schemes that address market failures, ensure cost-effectiveness and avoid overcompensation or distortion. Low-cost financing for capital intensive renewables depends on having a stable investment framework that reduces regulatory risk."
- Action Point 5: Creating a seamless internal energy market that benefits citizens, ensuring security of supply, integrating renewables in the market and remedying the currently uncoordinated development of capacity mechanisms in Member States ***call for a review of the current market design.***

Fourth (?) Energy Package

- Nov 2016: **Revised RES Directive** COM(2016) 767
  - 2016 29% of electricity is renewable (RES-E)
  - 2030 target 50+%; **€1 trillion investment needed**
  - price reductions 2009-15: PV 80%; wind 30-40%
- New RES-E has non-discriminatory grid access
  - Priority access rights grandfathered
- EU target RES energy share 27%, no MS targets
  - current plans will fall short => needs continued support

  => National energy and climate plans monitored

  => encourages MS to invest in RES in other MSs
  - MSs ***cannot fall below*** its 2020 target

RES-E support

- Aim to increase investor confidence:
  - Protection against retroactive changes (Art 6)
  - greater policy stability
  - market based cost-effective support (Art 4)
    - => Reduces risk that the support will need modification
  - mandatory move towards investments aid
  - mandatory ***partial*** cross-border participation (Art 5)
    - reflecting ***physical*** interconnection and regional support funds
  - while respecting MS right to choose energy mix and RES technologies to support

Revised RES Directive

Preamble to **revised RES Directive**

16. “When designing support schemes and when allocating support, Member States should seek to minimise the overall system cost of deployment, taking full account of grid and system development needs, the resulting energy mix, and the long term potential of technologies.”

26. …”(allow) Member States to count energy from renewable sources consumed in other Member States towards their own”

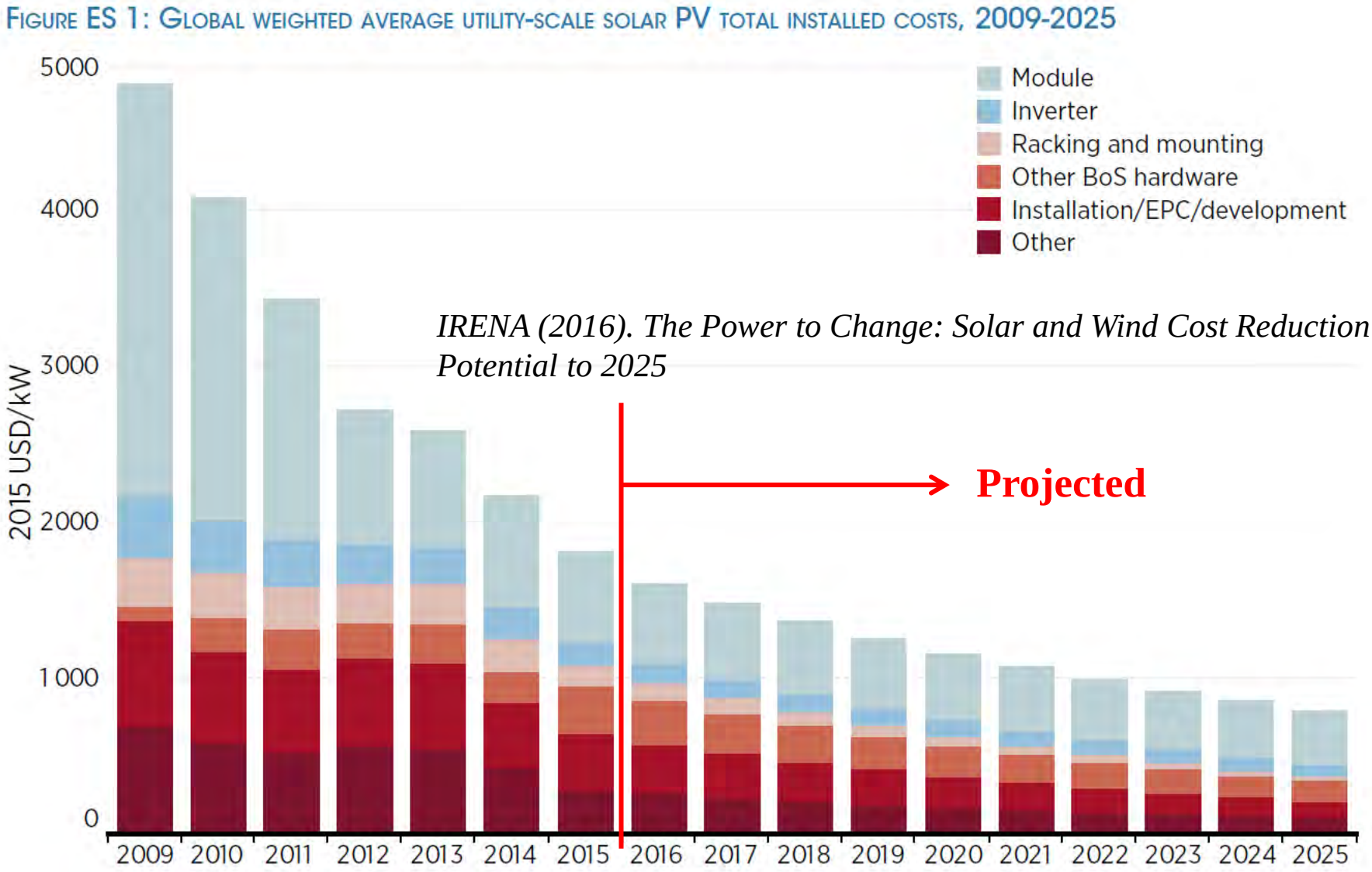
Criteria for market design

- Least **system** cost to meet reliability and CO_2 targets
  - Coordinate generation, transmission, distribution
  - Generation: timely delivery at right place, size, technology
  - Transmission: built, sized and used for efficient dispatch
- Liberalized markets need good price signals
  - ***Many of which are regulated (transmission, distribution)***
- Address missing markets to reduce missing money problem
  - Locational marginal pricing **LMP** - nodal not zonal pricing
  - Wholesale price = **SMC + CP** at each node (**LMP**)
  - **CP = LoLP*(VoLL – SMC); ∑LoLP=LoLE**
  - Ancillary service prices to incentivise efficient quality
- Location signals: long-term financial contract on LMP
- **Revenue shortfalls: Ramsey pricing on *final consumer***
- **Targeted subsidies, efficient risk sharing**

Revised RES Directive

- Art 3 proposes Union funds (financial instruments) to reduce cost of capital for RES projects.
- Art 4: ensure RES ***responds to market price signals*** and support is granted in an open, transparent, **competitive**, non-discriminatory and ***cost-effective*** manner
- Art 5: support (10+% of new capacity) open to installations located in ***other*** Member States
- Art 21: Small RES-E self-generators are not deemed energy suppliers; are paid market value of exports

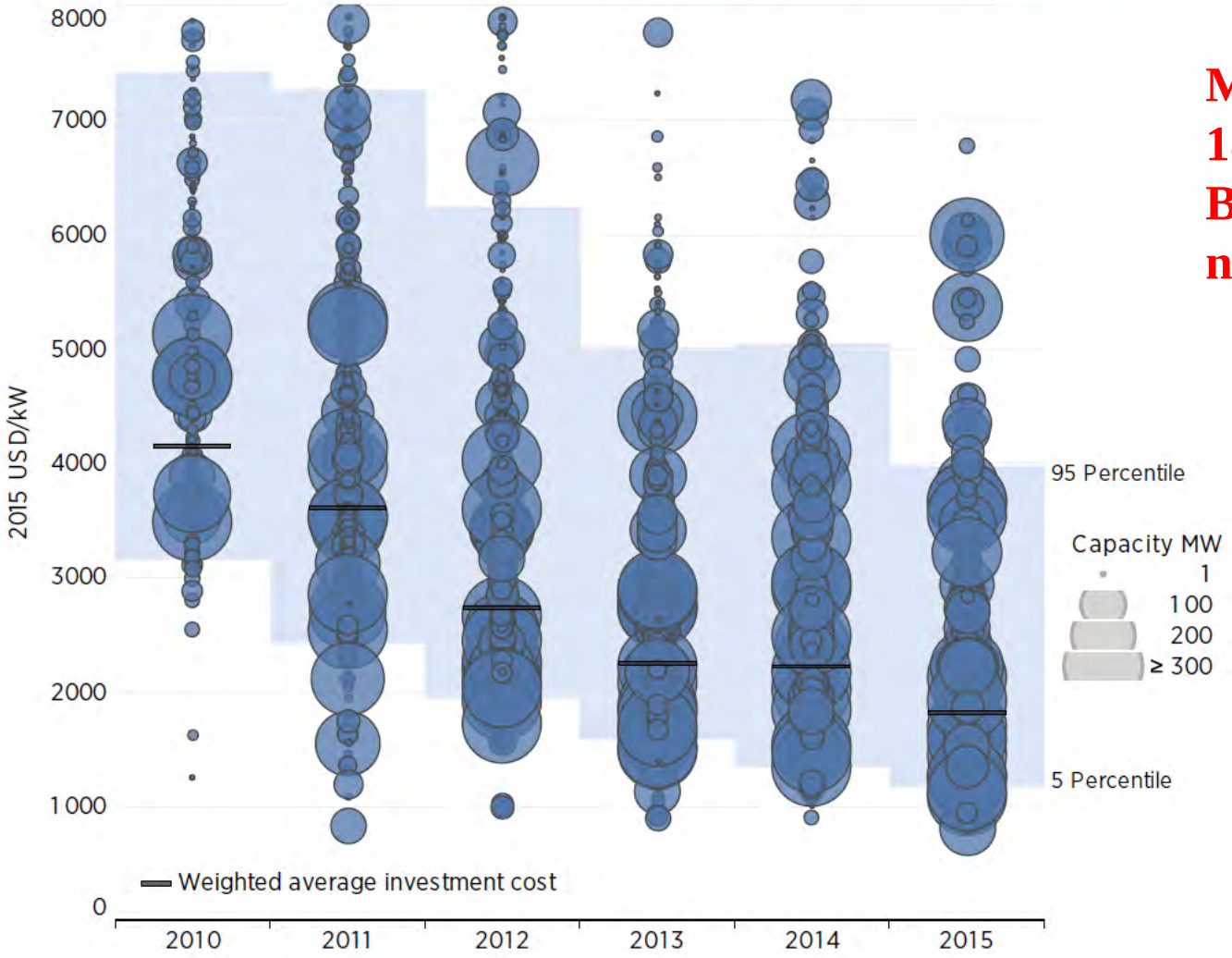
Dramatic fall in solar PV prices



IRENA (2016). The Power to Change: Solar and Wind Cost Reduction Potential to 2025

PV learning rates are high econs of scale important

FIGURE 4: TOTAL INSTALLED PV SYSTEM COST AND WEIGHTED AVERAGES FOR UTILITY-SCALE SYSTEMS, 2010-2015



Source: IRENA Renewable Cost Database.

Module learning rate 18-22%
BOS cost excl inverter now 60% of total

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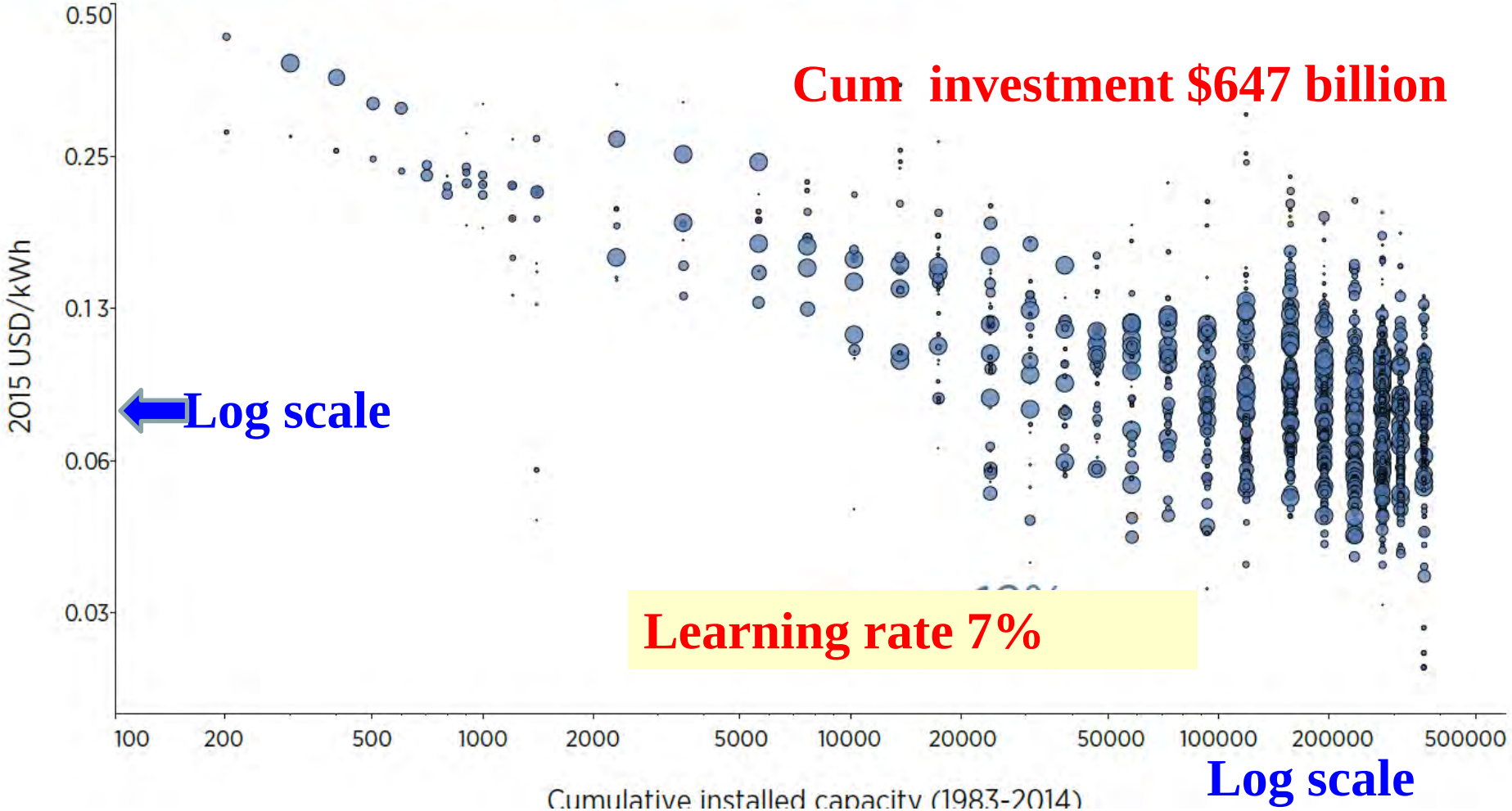
On-shore wind: taller towers give higher capacity factors

FIGURE ES 3: GLOBAL ONSHORE WIND LEARNING CURVE ANALYSIS, 1983-2014



Cum investment $647 billion

Log scale

Learning rate 7%

Log scale

Source: *IRENA (2016*

Post 2020 RES-E support

- Learning spill-overs need remuneration
  - Almost entirely from making and installing equipment

⇒ Contract €***X***/MWh for ***N*** MWh/MW, Auction determines ***X***

Reasons:

- Subsidy targeted on source of learning = ***investment aid***
  - Reduces cost of capital and risk via debt finance
  - Addresses failure to set right CO_2 price
- Exposes RES to current locational spot price
  => incentivizes efficient location, connection
- Does not amplify benefits of high wind/sun
  - Not over-reward favoured locations with same learning
- **Auction** better than bureaucrats at minimizing cost

RES CfD 2015 auction results

Technology		admin price	lowest clearing price	2015/16	2016/17	2017/18	2018/19	Total Capacity (MW)
Advanced Conversion	£/MWh	£140	£114.39			£119.89	£114.39	
Technologies	MW					36	26	62
Energy from Waste with	£/MWh	£80	£80				£80.00	
Combined Heat and Power	MW						94.75	94.75
Offshore wind	£/MWh	£140	£114.39			£119.89	£114.39	
	MW					714	448	1162
Onshore wind	£/MWh	£95	£79.23		£79.23	£79.99	£82.50	
	MW				45	77.5	626.05	748.55
Solar PV	£/MWh	£120	£50.00	£50.00	£79.23			
	MW			32.88	36.67			69.55

Source: DECC (2015)

Foolish bid - withdrew

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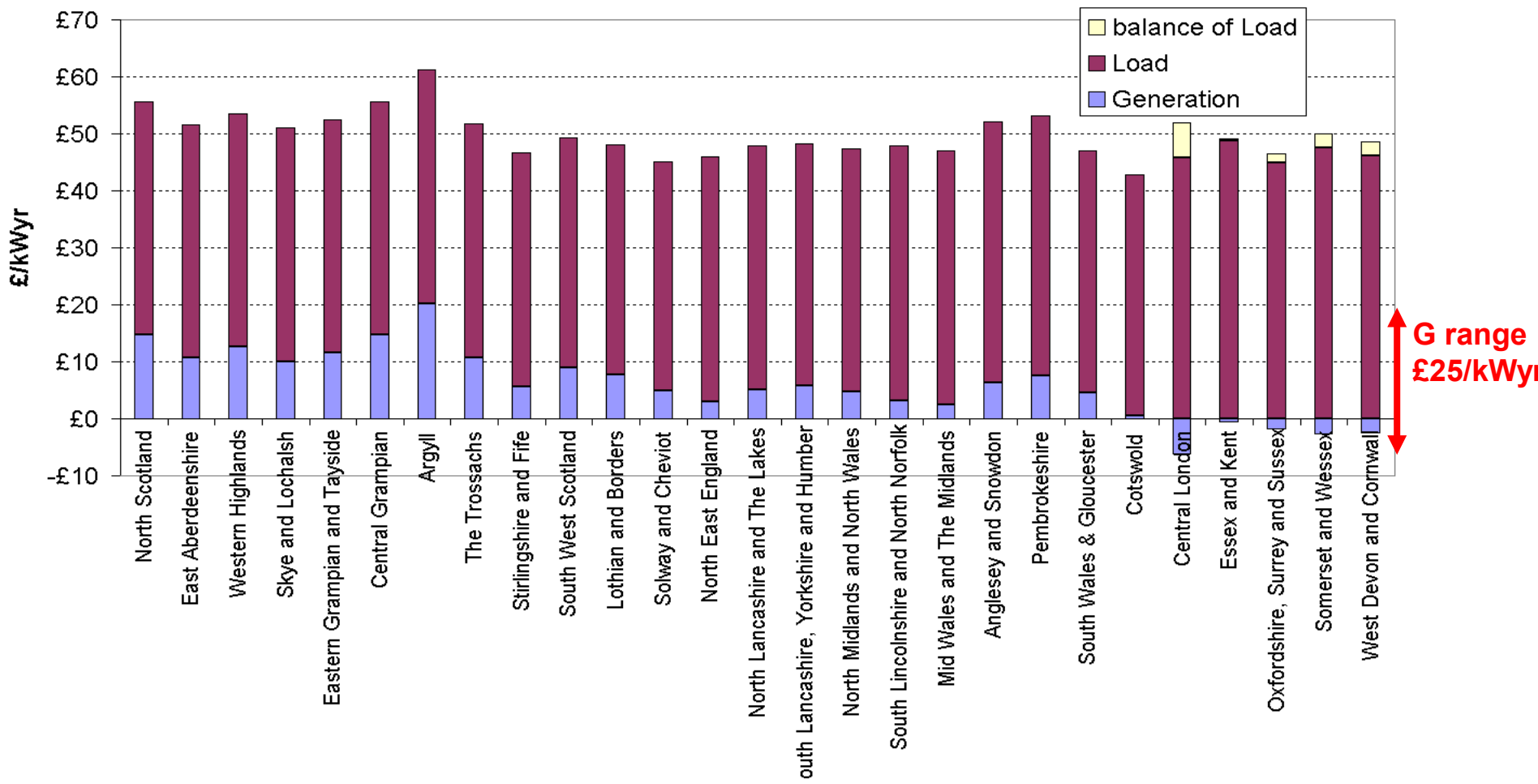
GB TNUoS (Network) charges



Location choices under LMP and spot pricing for wind

N: 2,500 hrs/yr

With ROCs wind farm inefficiently locates at N

P_N £35/MWh

=>£87.5k/MW/yr

=>£212.5k with ROC

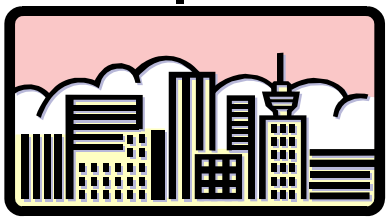
ROC = £50/MWh

T cost £15/ MWh

Pay wind for availability + average spot price => efficient E

E: 2,000 hrs/yr

C: £50/MWh



P_E £49/MWh

=>£98k/MW/yr

=>£198k with ROC

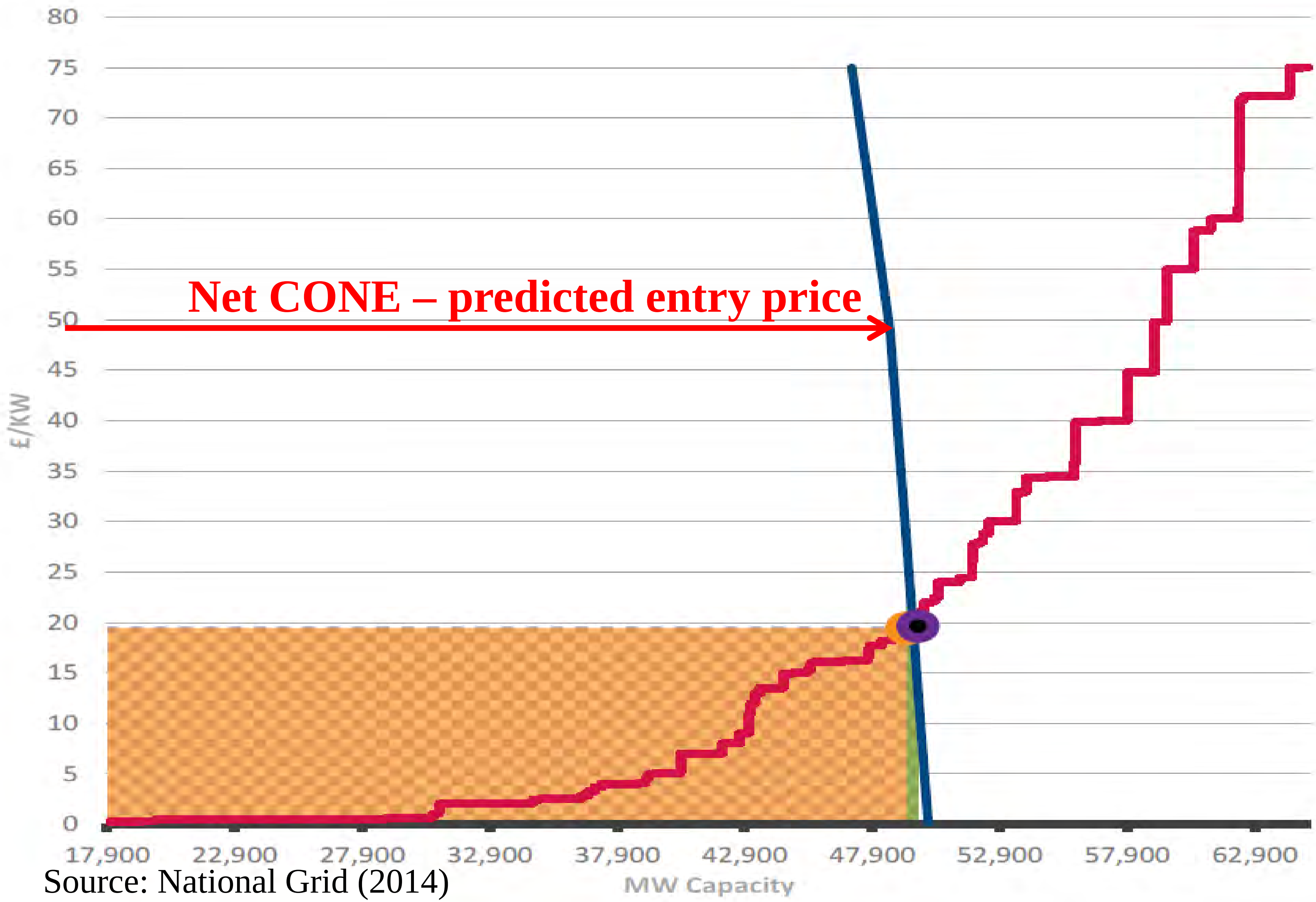
Capacity auctions

- Ambitious RES targets need flexible back-up
  - Normally comes from old high-cost plant = coal
    - EU Large Combustion Plant Directive 2016 limits coal
    - Integrated Emissions Directive further threat to coal
    - GB Carbon price floor + hostility to coal => close old coal
  - high (pre-2015) EU gas prices and low load factors
    - gas unprofitable, new coal prohibited by GB EPS
- Future prices now depend on uncertain policies
  - on carbon price, renewables volumes, other supports
  - on policy choices in UK, EU, COP21, …

Long-term contracts the solution?

=> Auctions for contracts

GB 2014 Capacity Auction



Source: National Grid (2014)

Flaws in GB Capacity Procurement

- Transmission-connected generation TG ***pays*** G TNUoS
  - And 50% of BSUoS
- Distribution-connected generation DG ***receives*** L TNUoS
  - And avoids BSUoS
- TNUoS G + L charge roughly constant across zones
  - Rapidly rising from £20/kWyr to £66/kWyr

=> represents ***extra*** £53/kWyr embedded benefit in 2018/19

=> DG gets £73/kWyr and TG gets £20/kWyr

=> efficient locational charge = 10-20% total charge?

- Rest is revenue levy to pay for grid

=> should be levied on gross not net final consumption

Massive distortion

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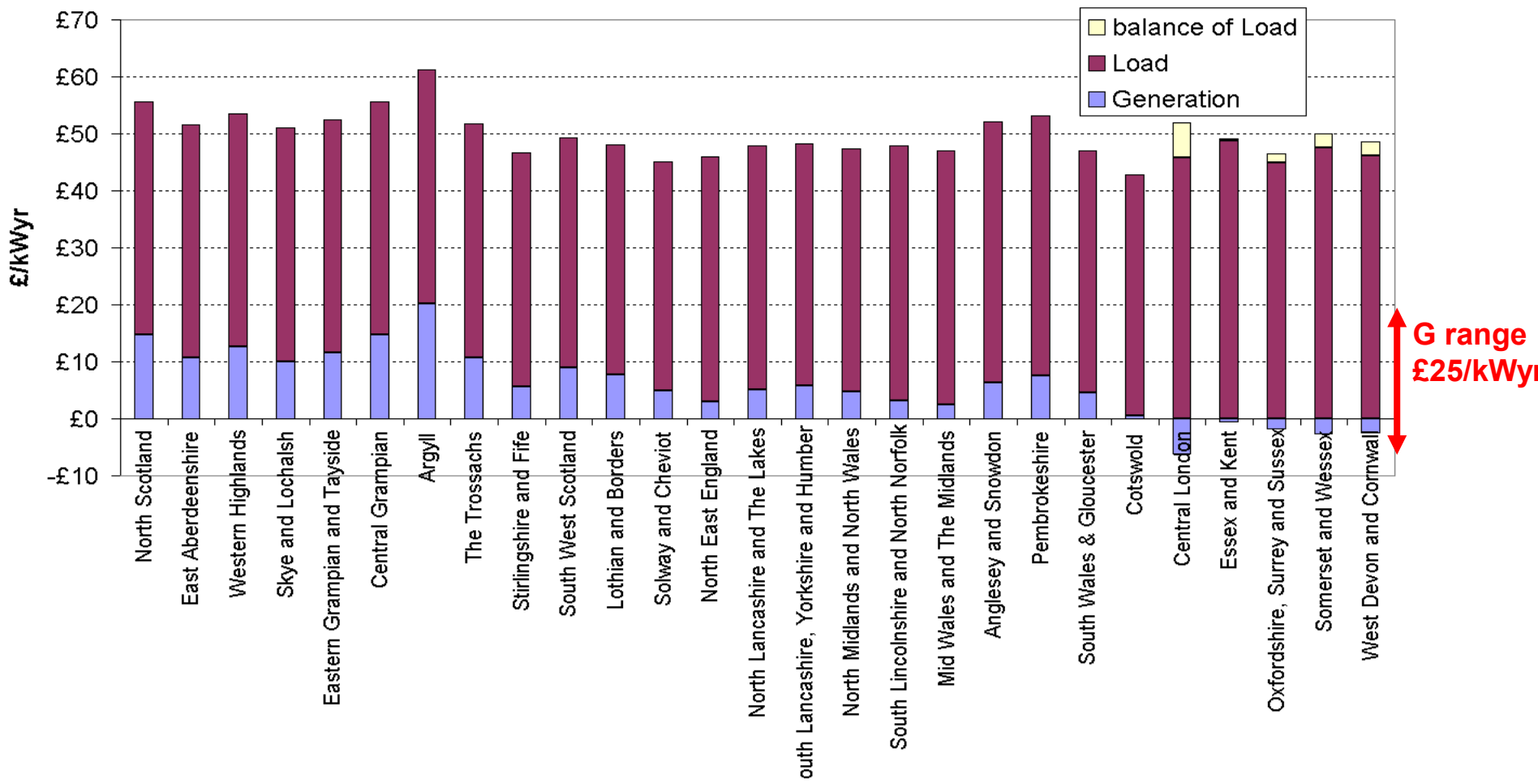
GB TNUoS (Network) charges



Efficient tariffs

- Distinguish efficient price and resulting short-fall in required revenue
  - Efficient peak T price is marginal expansion cost
  - At best 30% average cost, less if demand falling
- Ramsey-Boiteux pricing => "tax" inelastic demand
- Diamond-Mirrlees: tax only final consumers

⇒ T&D revenue shortfall on final consumption ***not*** net demand (at GSP or premises)

⇒ reduces embedded G benefit from £60 to < £10/kWyr

⇒ **Regulator**s need to compute efficient T&D tariffs

⇒ and move faster. Auction in 1 day grants 15-yr contract

Correcting the CO_2 price

- ETS CO_2 price is neither adequate, durable nor credible
  - –Reforms to date had no impact
- setting the right CO_2 price is difficult
  - – social cost of future harm hard to estimate
  - – break-even price highly sensitive to price of fossil fuel
- Ideally fossil generation should pay corrective tax
  - – GB has ***carbon price support-*** brings EUA price up to “right” level
- If not use emissions performance standards?
- Or, RES subsidy = shortfall in efficient wholesale price?

But auctioned capacity subsidy simpler

Setting the carbon price

For supporting zero-carbon generation:

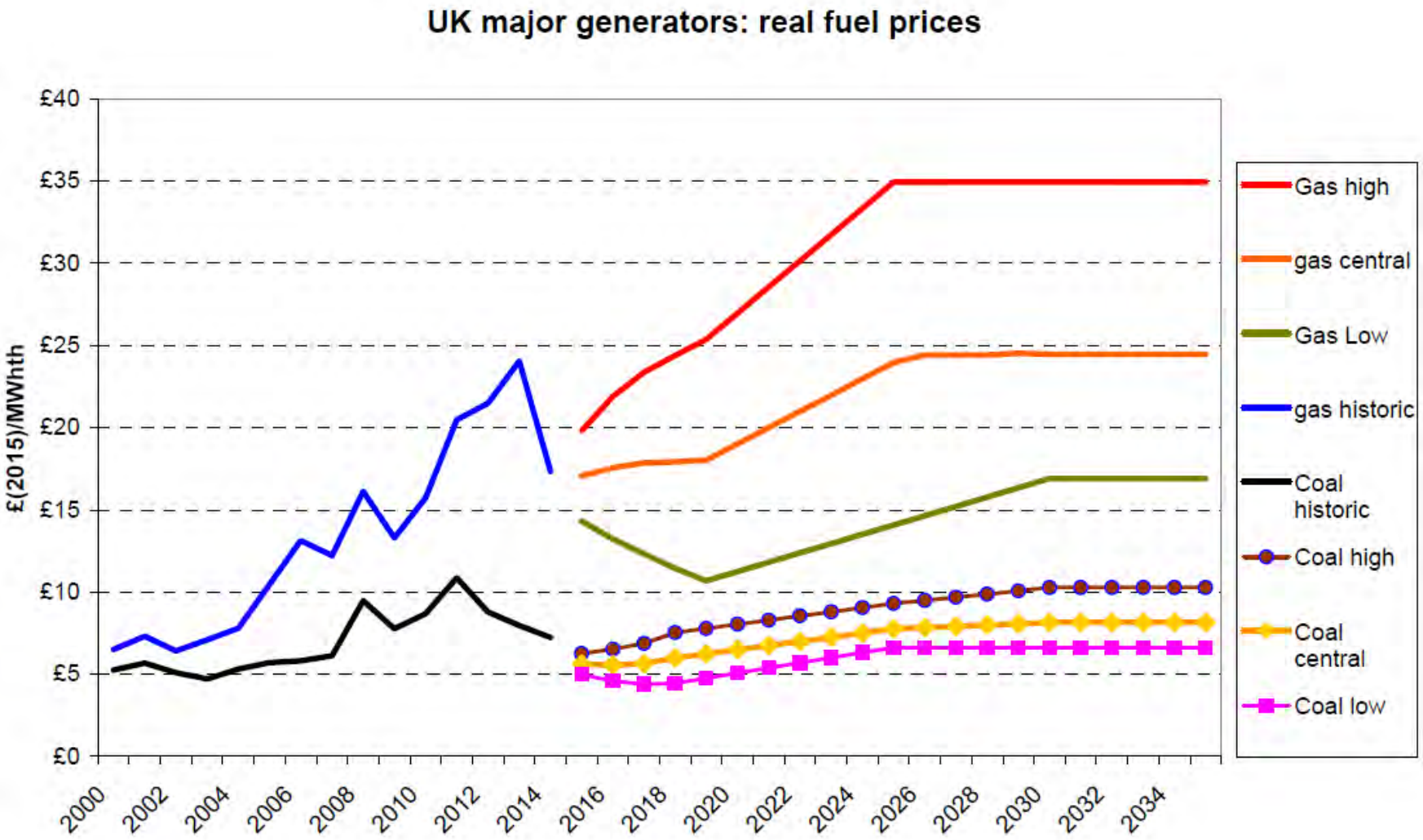
- CO_2 intensity of natural gas is 0.19 tonnes/MWh_{th}
- Gas price ⬇ \$1/MWh_{th} => CO_2 price ⬆ \$5.3/tonne
- CO_2 intensity of coal is 0.34 t/MWh_{th}
- Coal price ⬇ \$1/MWh_{th} => CO_2 price ⬆ \$2.9/tonne
- Prices of both coal and gas very volatile
  - UK 2020 gas price range: £15.7/MWh_{th} => CO_2 range £82/t

⇒setting a CO_2 price highly sensitive to fuel price

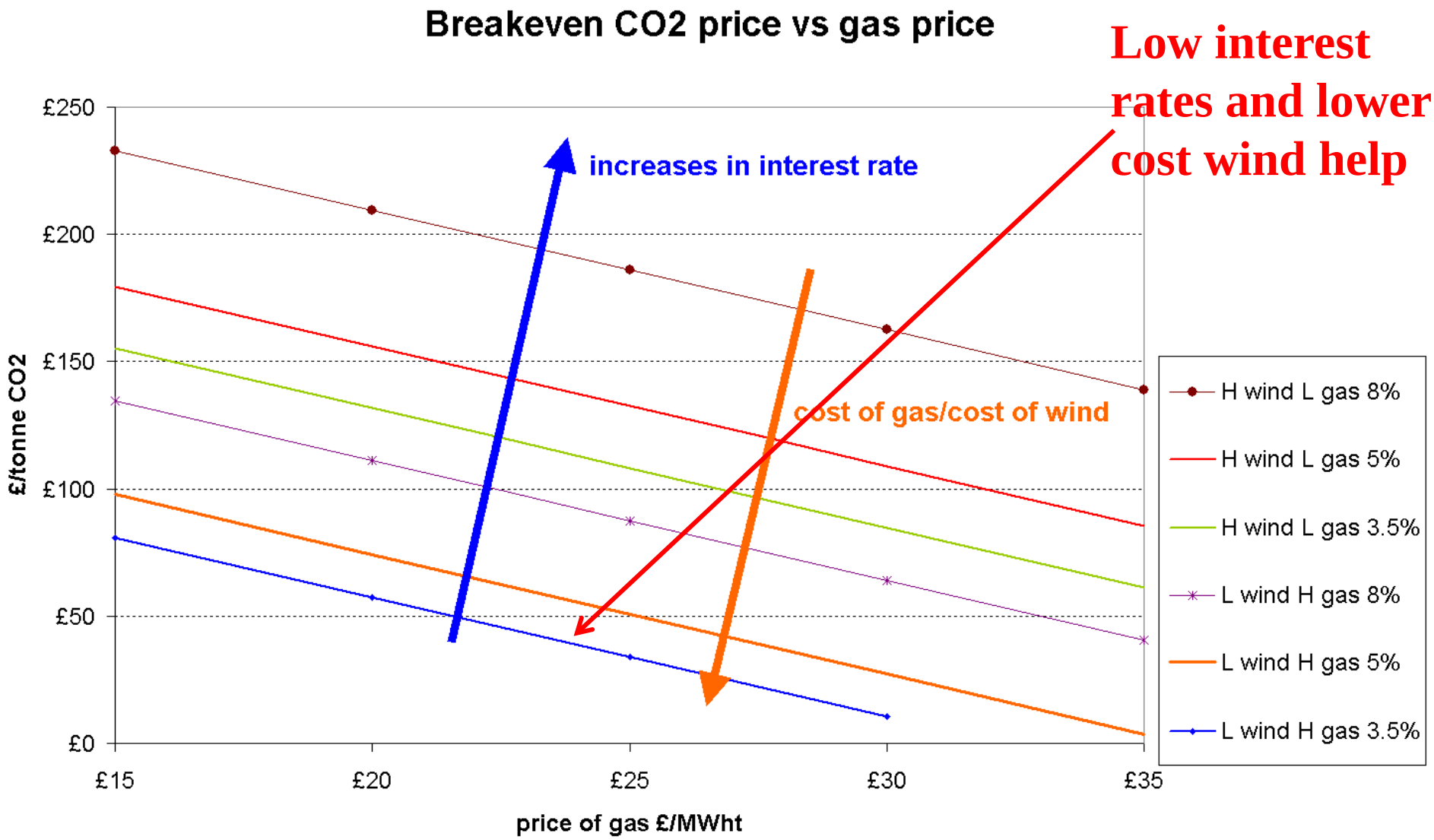
For switching from coal to gas:

- Gas price ⬆ \$1/MWh_{th} => CO_2 price ⬆ \$3.9/tonne

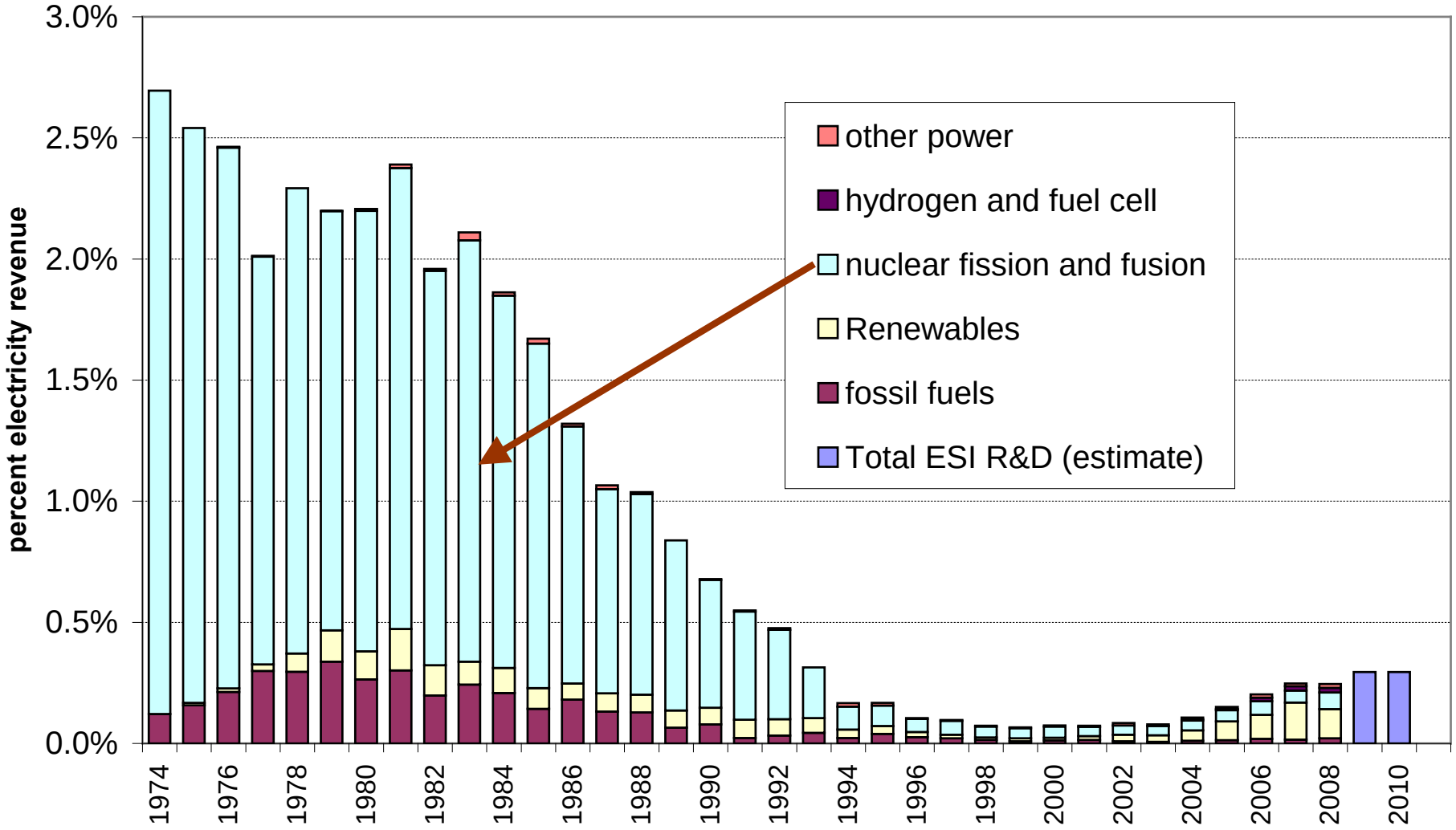
Future energy price projections



Hard to set the "right" carbon price



UK Electricity R&D intensity



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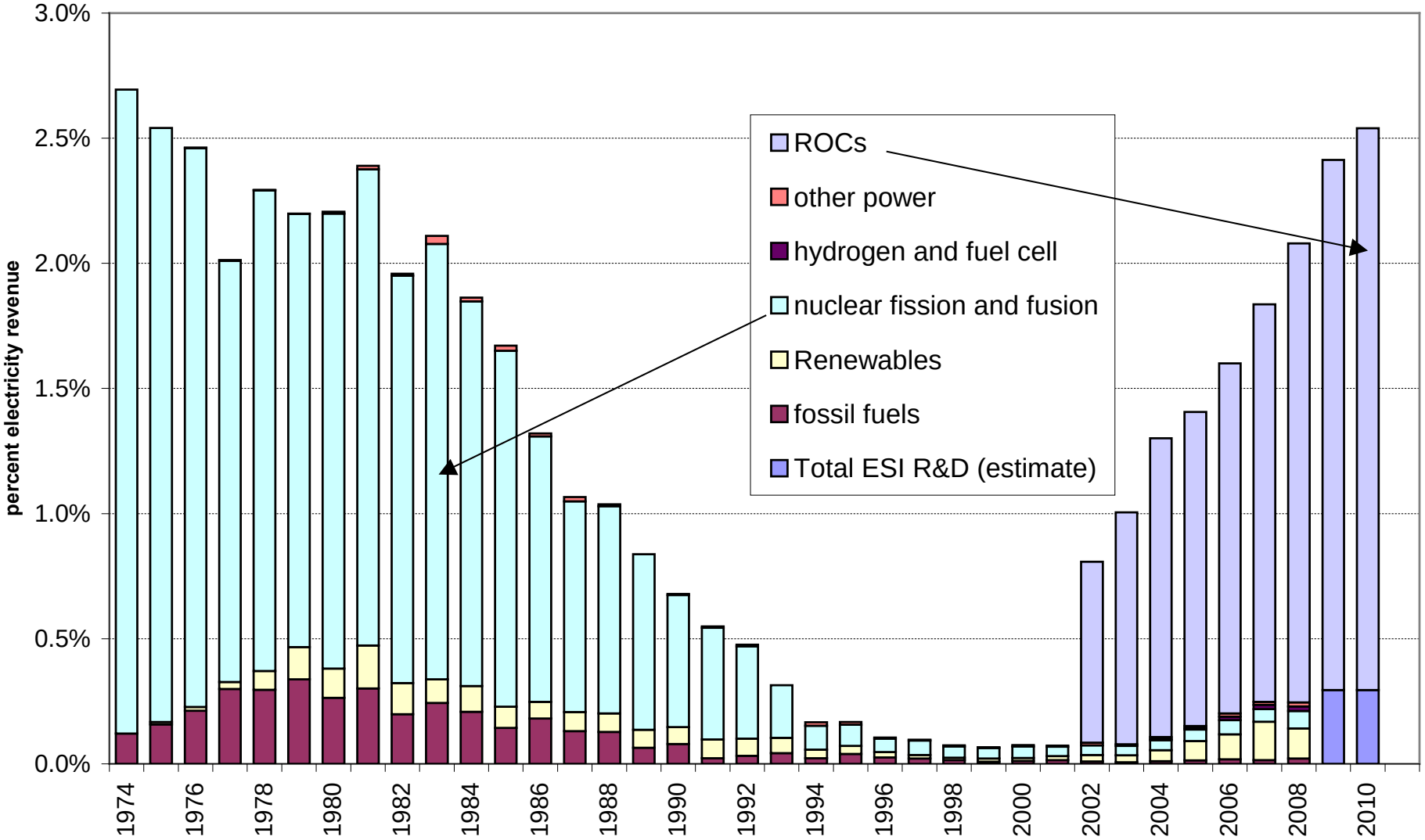

Accelerating Clean Energy Innovation COM(2016) 763

- Third pillar of climate policy was the **Strategic Energy Technology (SET) Plan**, updated 2015
  - – Doubled low carbon innovation spending 2007-15 (from low level)
  - – supported via Horizon 2020 (Energy Demo projects), European Fund for Strategic Investments, NER, etc.
  - – prospective **2021 Innovation Fund** to imitate ARPA-E
  - – but too little funding - **€1 trillion for RES** investment, **€ 10 bn for clean energy research**
- success of original **20-20-20 Directive** was ***club funding***
  - – Each MS allocated a target RES share and then funds it
- Do the same for clean energy funds *including* ***innovation***

  Specify share of GDP, funds allocated by competition
  - – support cost for RES as well as R&D – **EU-wide auction**

Public economics applied to cost recovery

- Need an efficient way of raising revenue shortfall

=> Ramsey mark-up: cause equi-proportional demand fall

=> Diamond-Mirrlees: distortions on final consumption

- Efficient retail tariffs more often closer to wholesale prices

=> cost-recovery mark-ups on less elastic demand

=> embedded generation (e.g. PV) paid same as other RES **adjusted for marginal T&D costs and losses**

=> **avoid net metering**: domestic generation paid efficient price, consumption pays additional cost-recovery charge

- encourages efficient scale/location of RES

The good, the bad and the ugly

- Good: Each jurisdiction is facing similar problems
  - ***and trying out a variety of solutions***
- Learning from elsewhere and experimenting essential

⇒ challenge funds to try new ideas and test regulations

⇒ copy Ofgem's Network Innovation Competitions

- Bad: Auctions + new technology => rapid irreversible decisions
  - need smarter, quicker responses to ensure tariffs are suitable
- Ugly: tension between efficient and "fair" pricing can led to inefficient ***and*** inequitable outcomes

Conclusions

- The priority is to decarbonise electricity
  - –To avoid long-term lock-in
  - – EC Clean Energy Directive identifies **good principles**
  - **=> clear guidance for good policy instruments**
- Setting a carbon price is problematic
  - – complementary instruments and contracts needed
- Subsidiarity – MS's design RES & CRM policies
  - – market responsive requires auctions and good network tariffs
  - – **auctions and contracts** avoiding trade distortions between MSs
- Solidarity – MS agree **joint funding for innovation**
  - – fund public goods like innovation, learning from general taxation
  - – allocated funds raised competitively across all MSs

Acronyms

CCS	Carbon Capture and Storage
CfD	Contract for Difference
CONE	Cost of New Entry
CP	Capacity payment
CRM	Capacity Remuneration Mechanism
DG	Distribution-connected Generation
ETS	Emissions Trading System
FTR	Financial Transmission Right
GHG	Greenhouse gas
GSP	Grid Supply Point (connection to grid)
G	Generation
L	Load
LMP`	Locational Marginal Pricing (Nodal pricing)
LoLP	Loss of Load probability
LoLE	Loss of load expectation in hrs/yr = reliability standard
MS	Member State
R&D	Research and Development
RES	Renewable energy/electricity supply
RES-E	Renewable energy supply in electricity
ROC	Renewable Obligation (i.e. green) Certificate
SMC/P	System Marginal Cost/Price
T&D	Transmission and Distribution
TG	Transmission-connected generation
TNUoS	Transmission Network Use of System, G =Generation, L=Load
VOLL	Value of Lost Load

References to the EU *Clean Energy* proposals

- http://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition gives links to the various directives
- Clean Energy For All Europeans, COM/2016/0860 final at http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1481278671064&uri=CELEX:52016DC0860