Interaction of technology and carbon markets

– a "full circle" journey around carbon policies

BP Madrid Forum, 2008 – promoting investment in low carbon technologies

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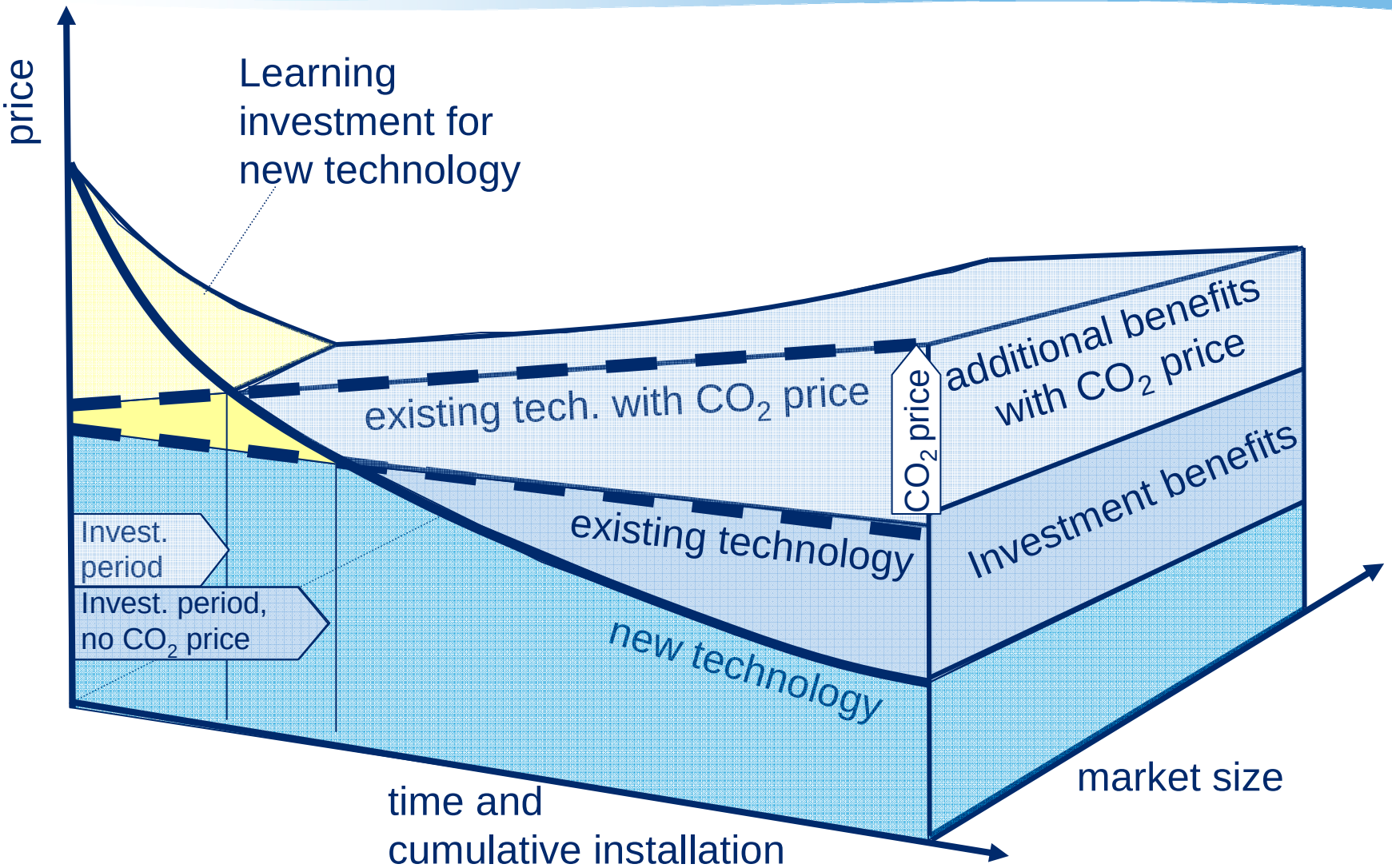
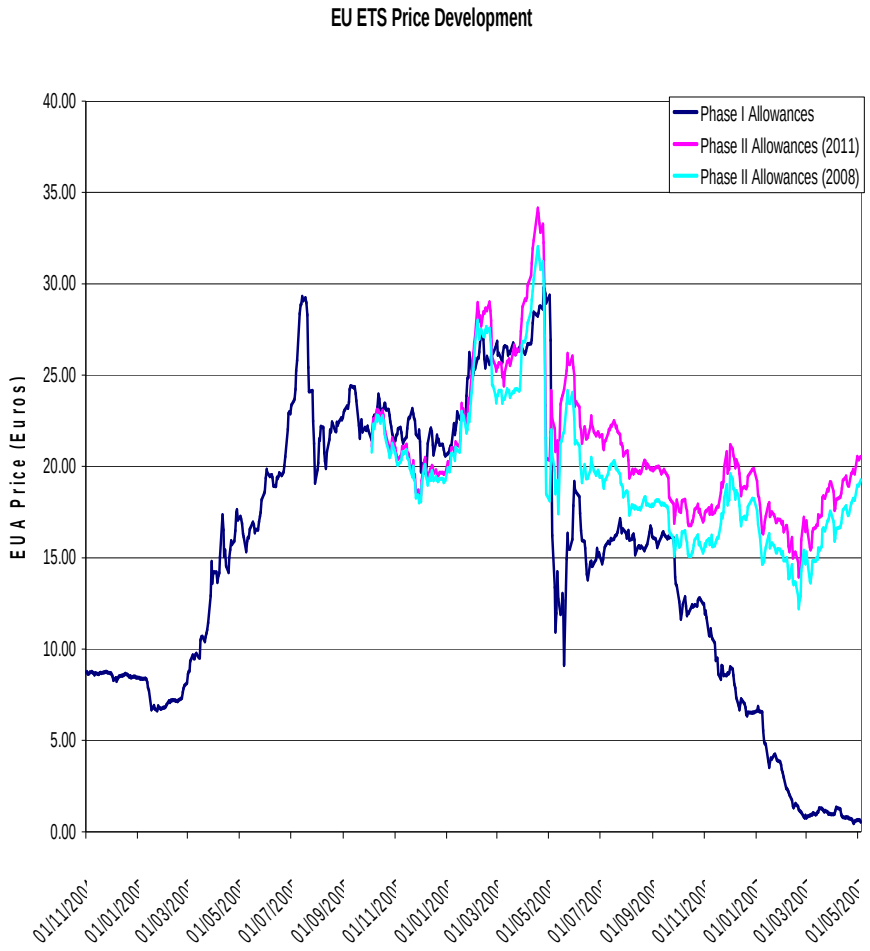
Outline

- Framing the problem: a look at, ideals, realities
- .. And theories
- Bridging the 'technology valley of death….'
- The Big Buts
- Conclusions: carbon markets and technology revisited

A view of the economic ideal
- robust & rising carbon prices will drive the learning investments required



Price volatility, future uncertainty and distortions are major obstacles to most investors ..



- The EU ETS is backbone of implementation and compliance, and focal point of global attention
- The EU ETS as it stands is effective at reducing operational emissions, but not supporting low carbon investment or innovation (perverse "new entrant" rules, post 2012)
- A few 'deep pocket strategic multinationals' can cope with fundamental uncertainties and factor in future action
- The vast majority discount the implications of carbon control policies that do not yet exist

Empirical fact: we are seeking innovation in some of the least innovative sectors in our economies

- Power generation (c.40% of CO2 on supply side):
  - Same dominant technology for 100 years
  - Utility R&D intensity < 0.3%
  - … declining close to zero in the aftermath of some liberalisation programmes
  - [expenditure in technology suppliers doesn't remotely make up the gap]
- Buildings, inc 'white goods' (c.40% of CO2 on demand side):
  - "Bricks and mortar" for centuries ..
  - V. little innovation in construction materials
  - + issues around tenant-landlord, public ownership, existing stock ..
- Contrast with R&D intensity of IT, Pharmaceuticals, typically 10-20% or more.

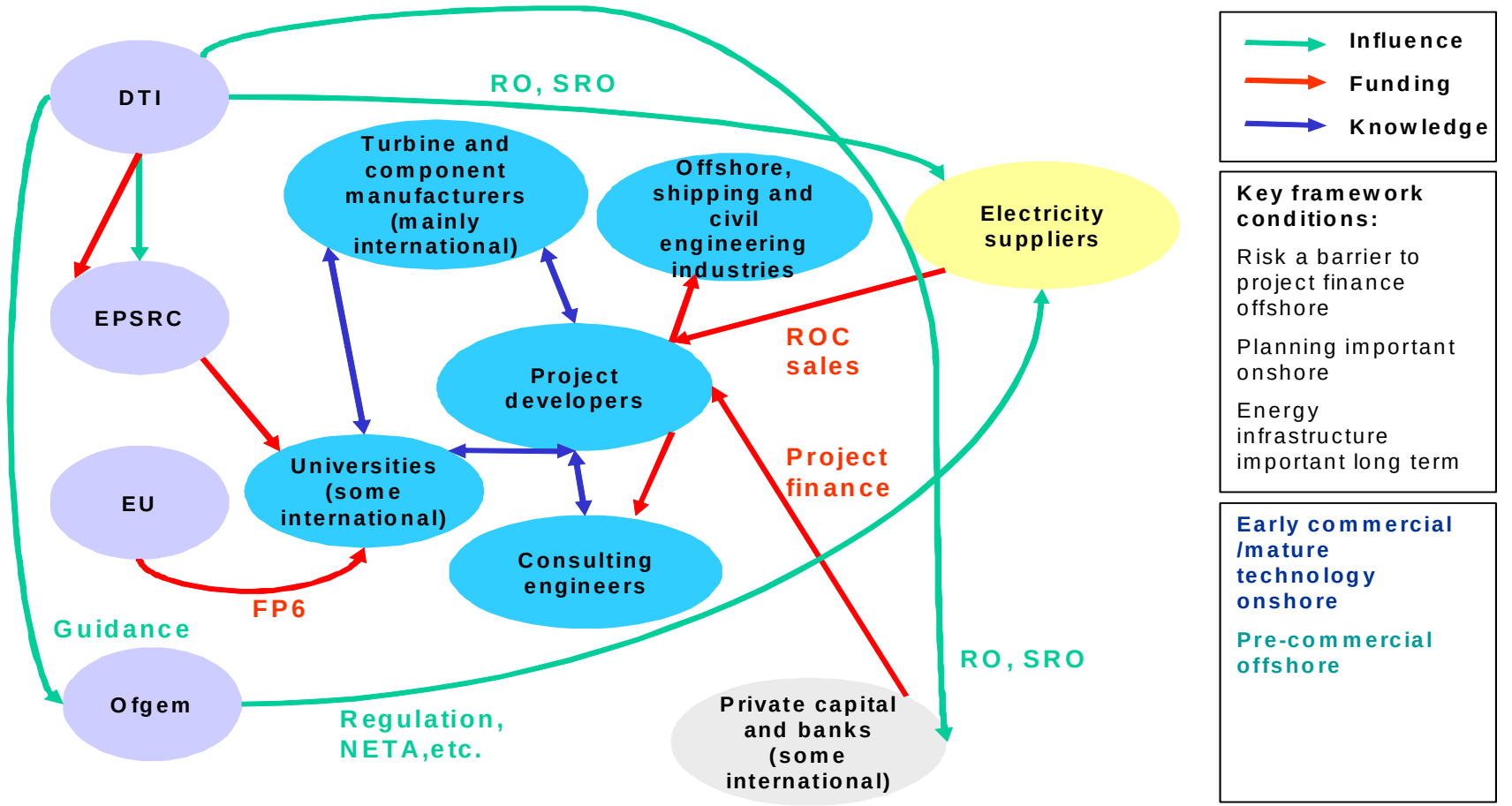
Some ‘high level’ theories & representations

‘For every complex problem there is an answer that is simple – and wrong’
(in this case, two)

- Even where market pull forces may dominate innovation, it is a long distance from ‘carbon pricing’ incentives to actual large-scale industrial innovative risk-taking, which would need
  - R&D-intensive industries
  - perfect R&D markets
  - long term certainty and policy stability on environmental pricing
  - Good communication between government, research, and industry
- Even in technology stages for which technology push dominates, *public R&D investment by governments* has mixed history and faces serious institutional dilemmas
  - ‘picking winners’
  - mutual programme dependencies (the ‘exit’ problem)
  - cooperation vs competition
  - policy displacement

‘For every complex problem, there is also an answer that is complex – and unuseable’

Simplified ‘innovation systems map’ for wind energy in the UK

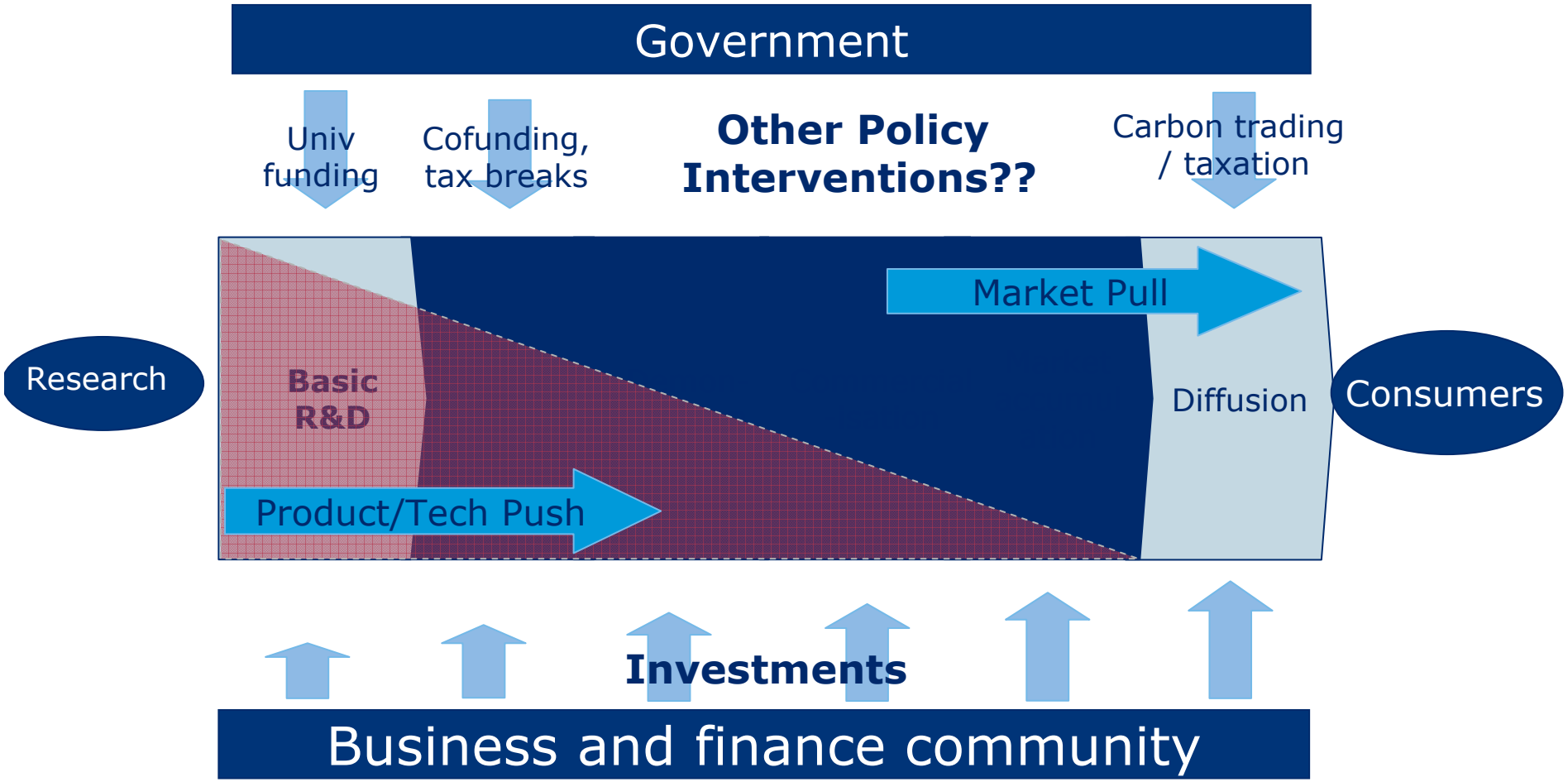


Source: Foxon et al., UK Innovation Systems for New and Renewable Energy Technologies: Drivers, barriers and systems failures, Energy Policy / report to DTI, 2004

Fundamental problems of purely technology-driven strategies

- Historical technology programmes have been problematic even at just national level
  - US synfuels, 'Synthetic Fuels Corporation'
  - UK 'Advanced gas-cooled reactor' programme
  - Ø Theory, 'social capture and mutual dependences'
- International coordination problems
  - Limited historical accomplishments
  - Ø Theory, 'competitive disincentives'
- Sectoral coverage
  - Diversity of end-uses
  - Ø Complexity and detail of negotiations?
- The fundamental economics of innovation
  - The centrality of market feedbacks and learning-by-doing
  - Ø What happened to market economics?

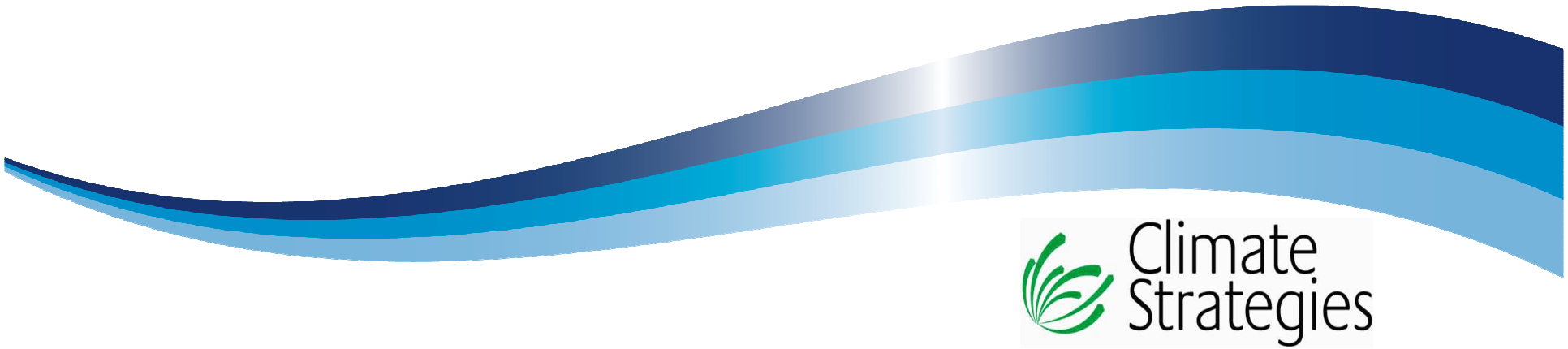
Market theory is blind to the innovation *process* – innovation assumed to emerge out of R&D and market pull, with government no-go zone in between



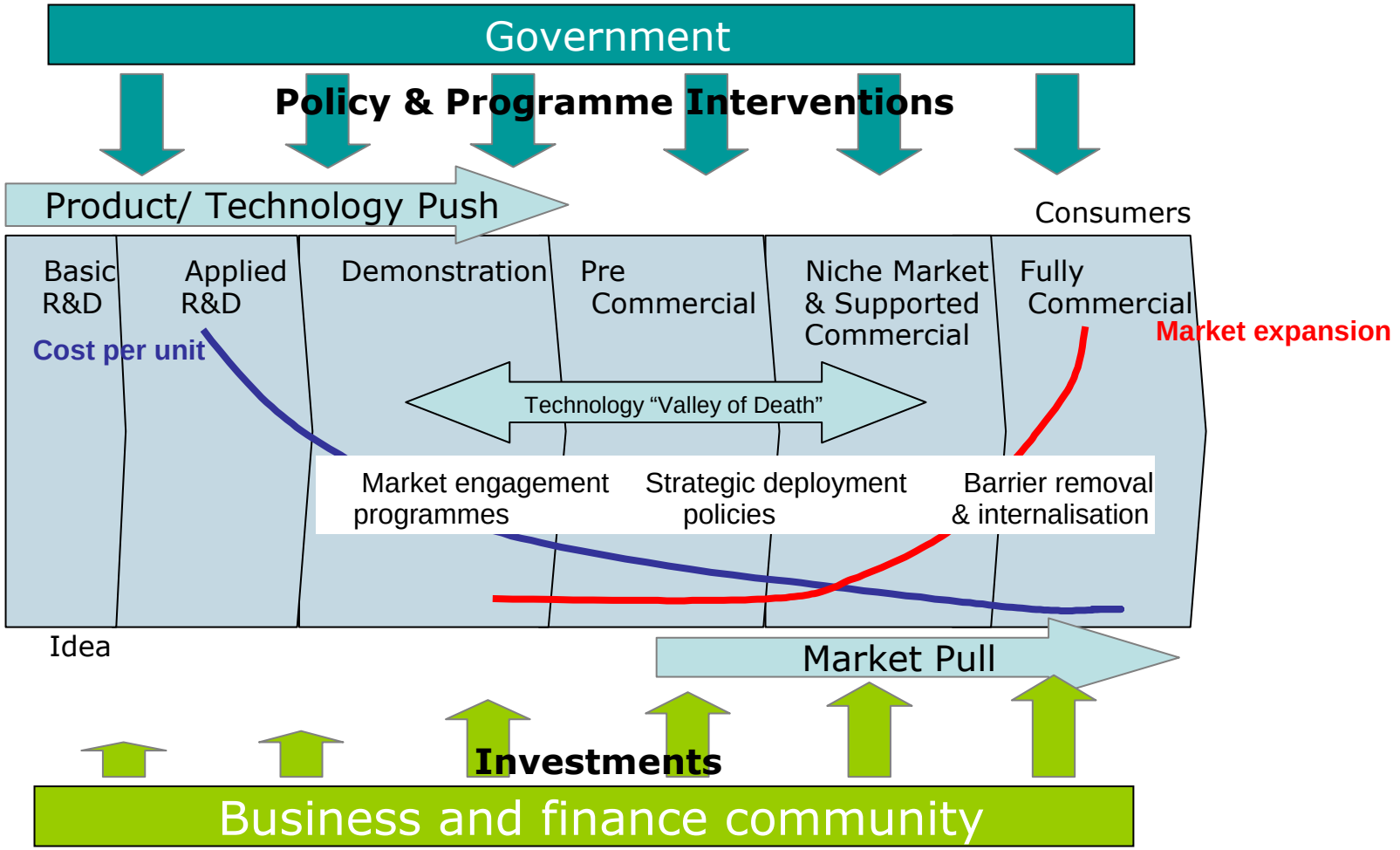
Carbon caps / price incentives cannot *on their own* deliver long-run solutions

- There are too many complexities and imperfections in energy demand systems (especially buildings and transport - but also industry)
- The innovation chain is too long, complex and imperfect for prices to deliver adequate innovation even if prices could be forecast
- In practice, the uncertainties are too deep (and political resistance too fierce) to establish long-run carbon prices now; but
- Industries (& finance communities) are too remote from science and governmental decision-making to act substantively on the basis of hypothetical and contested future political processes to internalise climate damage costs

Bridging the ‘technology valley of death’ - overview

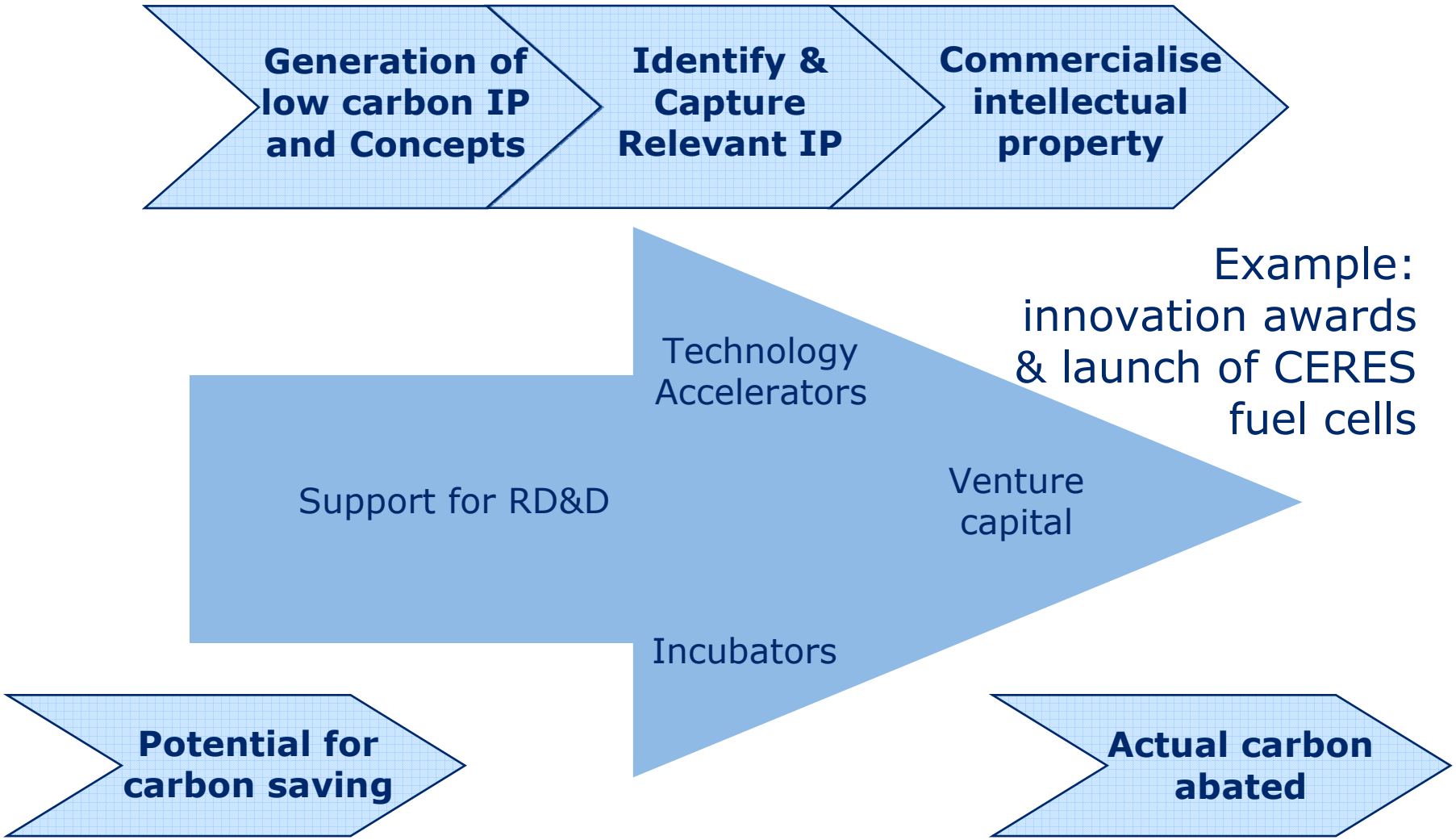


Diverse policies of market engagement and strategic deployment are needed to help technology traverse the 'innovation chain'

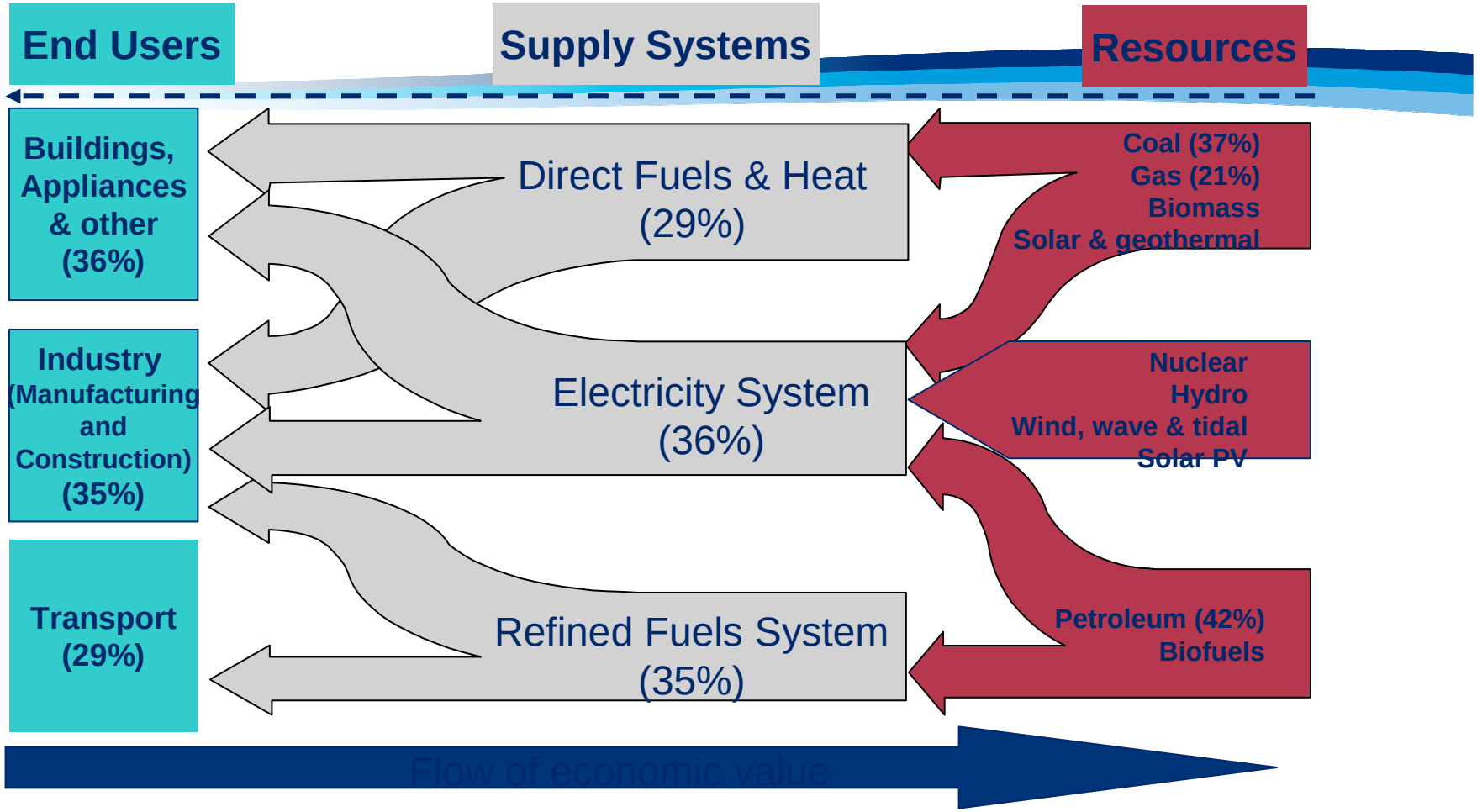


Bridging the innovation chain requires a mix of instruments, some funding-led ..

Carbon Trust support for innovation through the pipeline



Getting specific: the diversity of technologies and systems



The data show the % of global energy-related CO2 emissions associated with the different parts of the energy system (including emissions embodied in fuels and electricity). Note that patterns vary between regions (eg. industry is lower and transport higher in developed economies), and the sectors are growing at different rates (over past 30 years, energy demand for buildings:industry:transport has grown at 2.6%:1.7%:2.5% annual average (LBNL ref)

Note: Some small flows that comprise under 1% of global energy flows (eg. electricity and natural gas contributions to transport) are not shown **End Users:** Source: IEA. 'Non-electric energy industries' (emissions from refineries, gas etc) allocated 4:1:2 to transport:industry:buildings etc.
Supply Systems: Electricity System data IEA; Refined Fuels %CO2 assumed equal to Petroleum % CO2; direct fuels and heat is the residual.
Resources: Source EIA

Appropriate investments and supports will depend upon many characteristics

Example from Carbon Trust Technology Assessment

Rising scale increases risks and reduces credibility of funded vs market solutions

Estimated impact on carbon emissions

High

Low

Monitor • Nuclear fission • Ultra-high efficiency CCGT • Smart metering • Wind • Building controls • Waste to energy • Fuel Cells (Transport, Baseload power • Biomass for Transport • Industry (Alternative Equipment) • CO2 sequestration	**Focus** • Buildings (Fabric, Ventilation, Cooling, Integrated Design) • Industry (Combustion technologies, Materials, Process control, Process intensification, Separation technologies); • Hydrogen (Infrastructure, Production, Storage and Distribution); • Fuel cells (Domestic CHP, Industrial and Commercial) • CHP (Domestic micro, Advanced macro) • Biomass for local heat generation
Limited • Intermediate energy vectors • HVDC Transmission • High Efficiency Automotive Power Systems • Nuclear fusion • Cleaner coal combustion • Solar thermal electric • Low head hydro • Tidal (Lagoons, Barrages) • Geothermal	**Consider** • Solar Photovoltaics • Solar water heating collectors • Photoconversion • Wave (Offshore, Near shore devices and shoreline) • Biomass for local electricity generation • Tidal stream • Coal-bed methane • Electricity storage technologies • Buildings (Lighting, Existing building fabric, Existing building services) • Industry (Waste heat recovery).

Low

Materiality of potential Carbon Trust investments

High

Diverse mid-century deep reduction scenarios are possible, require changes to system structure and advanced transmission and are more *capital intensive*

-60% futures	'Default'	'Deep Green'
Demand	540TWh	390TWh
Wind	12-15%	45-50%
PV	1%	3-5%
Biomass	10-15%	25%
Marine	3-5%	5-10%
CO2 capture	10-20GW	Only for hydrogen
Nuclear	5-10%	-
MicroGen	20%	20%

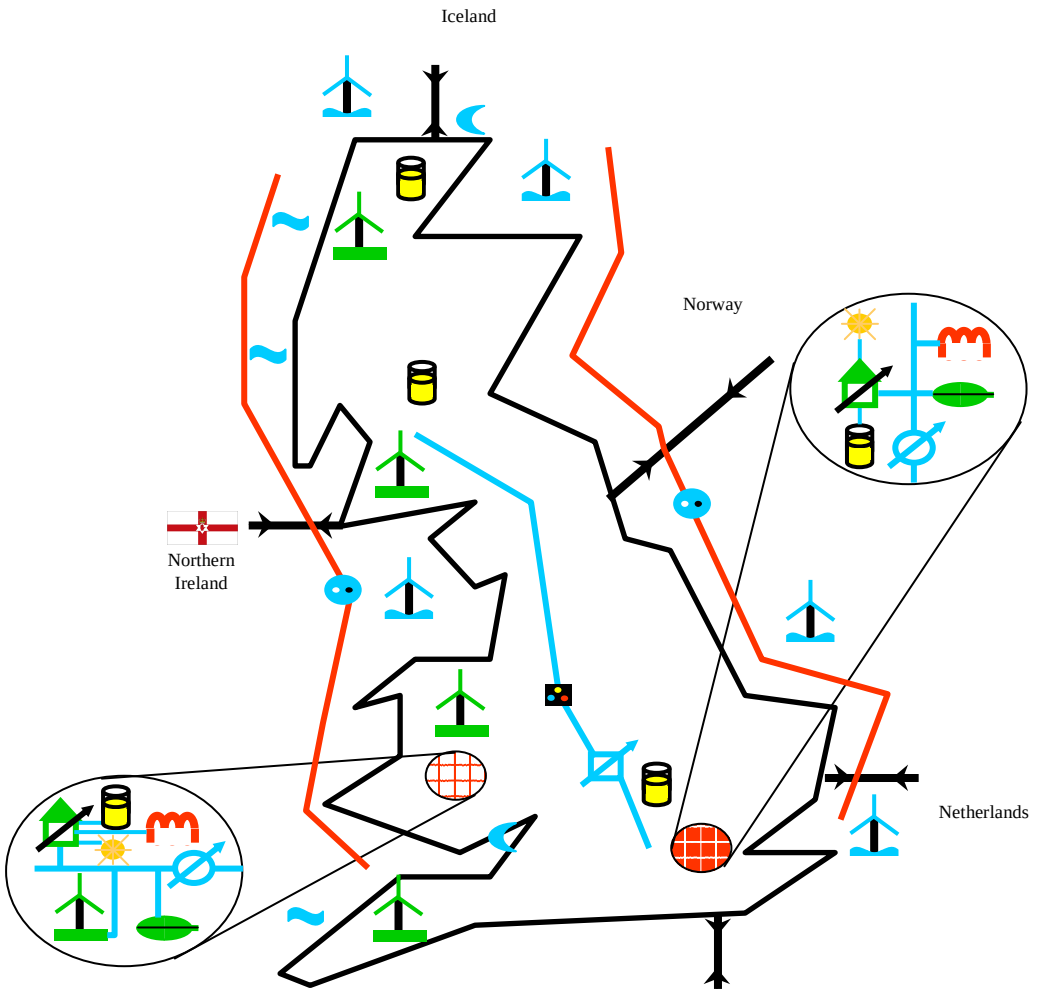
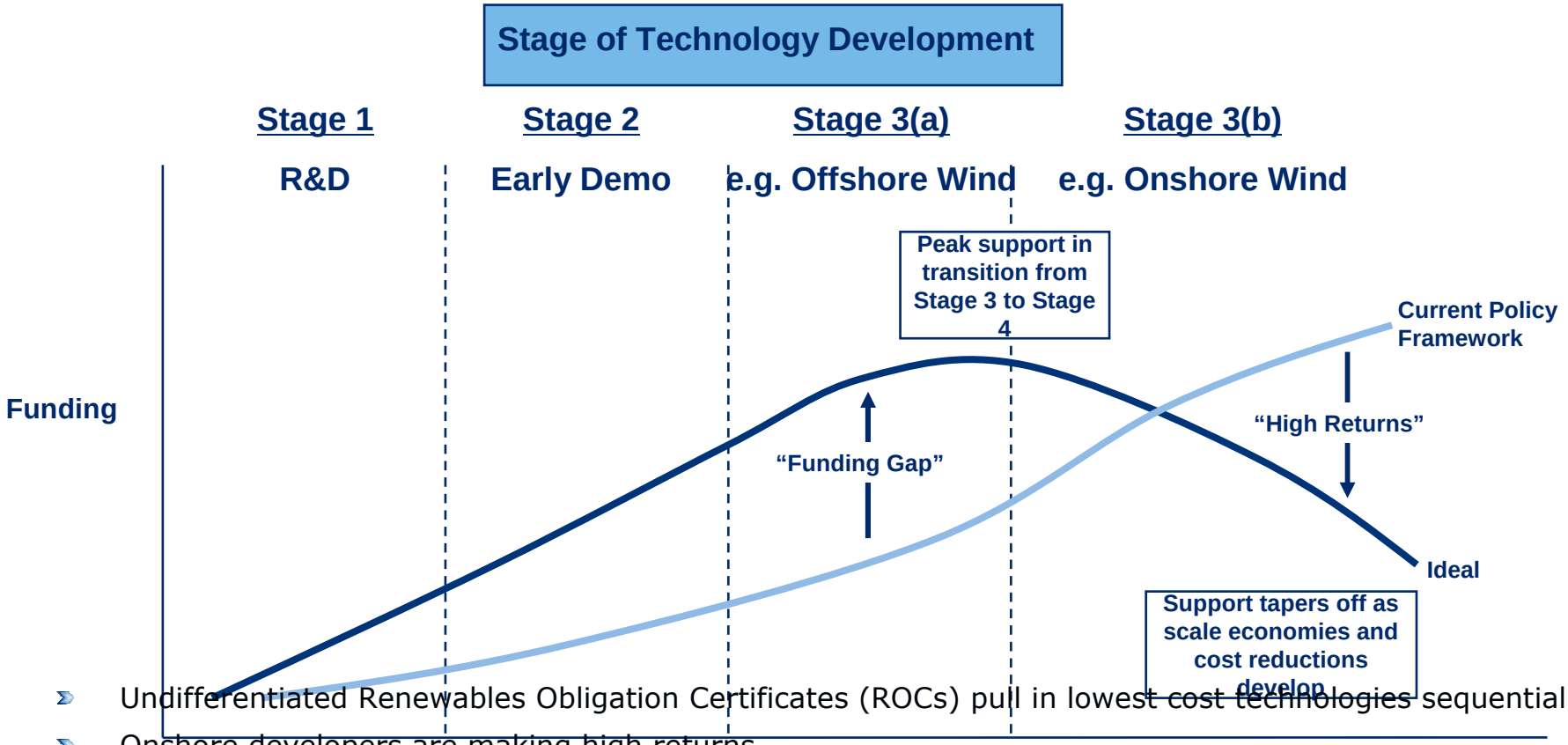


Figure 1.5 : "Green plus" Scenario: Electricity Network in 2050.
Source: SuperGen/CUP forthcoming May 2006

Where can the money come from?

1-size-fits-all supports generate large gains to first-past-the-post technologies leaving others languishing ..



- Undifferentiated Renewables Obligation Certificates (ROCs) pull in lowest cost technologies sequentially
- Onshore developers are making high returns
- White Paper has now moved to 'banded ROCs'

Source: Carbon Trust, Policy frameworks for renewables

For explicit ‘strategic deployment’ incentives, the jury has come in on the credits vs feed-in tariffs debate

- Banding removes much of the original justification
- Some subsidy leaks to suppliers
- Planning, grid constraints etc create further friction, driving up ROC prices higher
- Price volatility (of both ROCs, and underlying electricity) raises the cost of capital
- If the aim is to secure innovative investment at lowest cost, feed-in is more efficient and still creates competition in the manufacturing chain

The BIG BUTs

EU ETS Phase I confirmed that carbon controls generate a lot of money for *someone* – *tentative* link emerging between these rents and technology investment?

- Power sector profits from EU ETS €5bn+ during 2005
- Likely aggregate Phase II profits €5-10bn/yr @ €20/tCO2
- International and sectoral investment linkages emerging through the CDM & JI

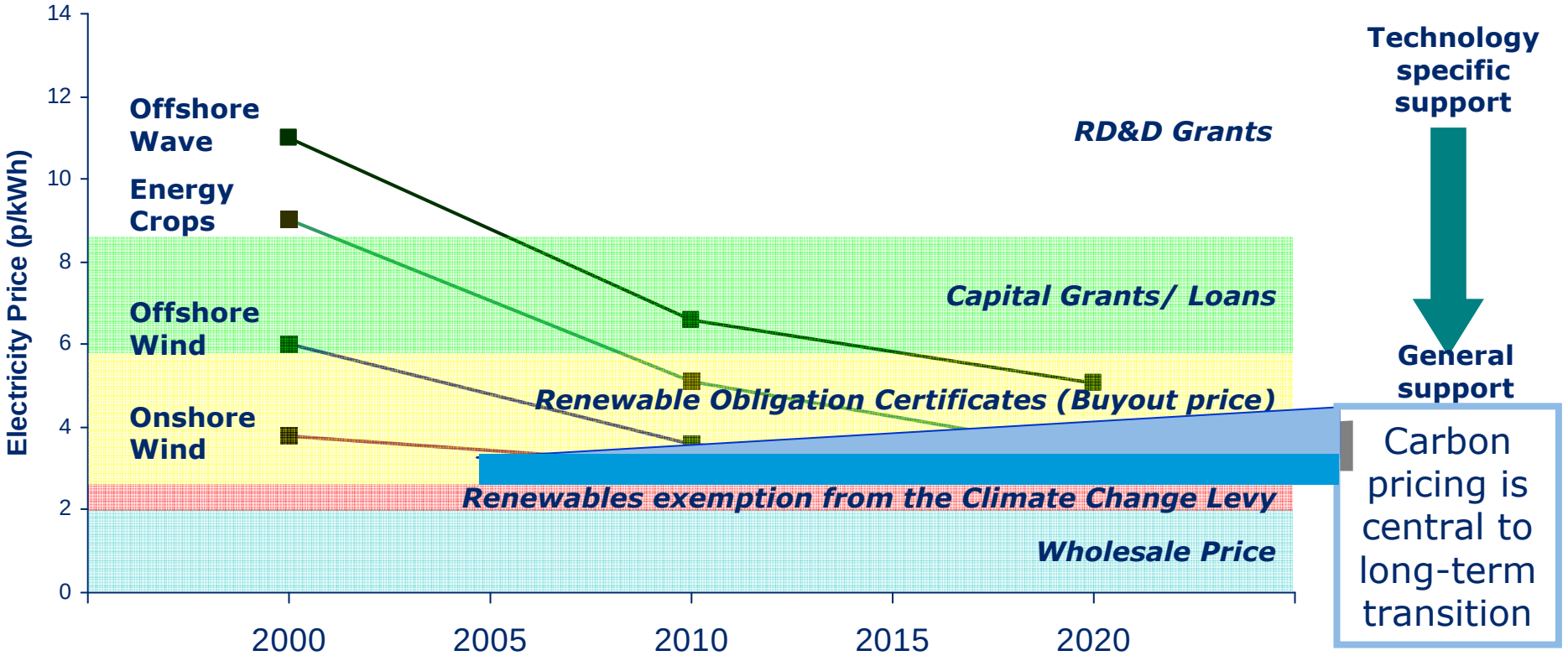
Also funding technology:

- E.On announce €100m R&D Centre
- UK Environmental Transformation Fund announced 'co-incident' with Auctioning decision
- UK £1bn National Institute for Energy Technologies (NIET) announced to be 50:50 co-funded with private sector, initial sponsors E.On, EdF, Shell, BP.

Generating revenues is *intrinsic* to the crcaping carbon - and can replace the poliitcal *problem of finding money for technology y the*political need *to be seen doing something useful with the revenues*

.. market pull is crucial to harness interest and governments want to see a strategy of 'convergence' through different instruments …

Appropriate economic support for technologies will vary as costs decline and industries grow

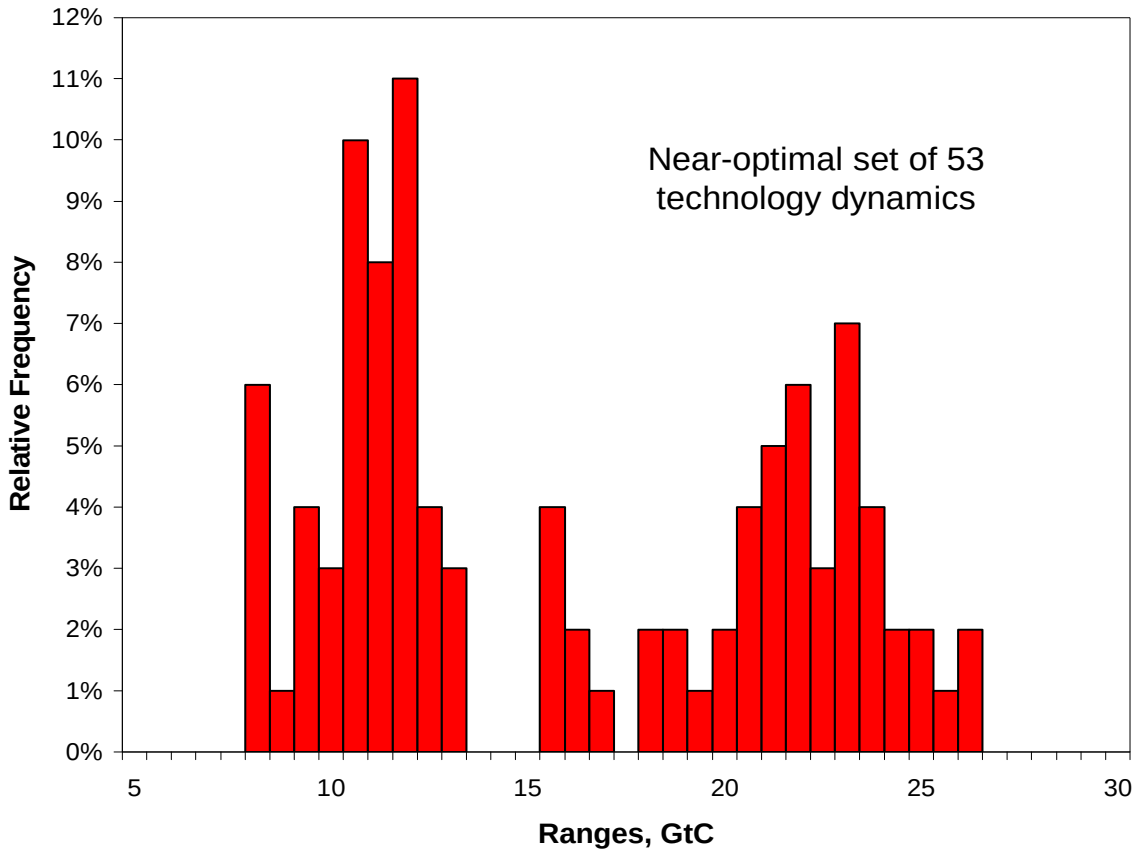


Note: Renewable Obligation Certificates exclude recycling; Capital grant on max of 40% of typical cap costs
Source: PIU Working Papers (OXERA II Base case cost decline)

The Big Picture - all energy futures involve huge investment & learning, in diverse sets of interrelated technologies: the big challenge is *redirection* not *optimality* – & aligning investment

Probability density distribution of least-cost carbon emissions in 2100

- Uncertainty in key inputs
- very wide range of energy technologies and resources
- learning-by-doing
- learning spillover effects in technology clusters



Source: Gritzevski & Nakicenovic, in *Energy Policy, 1999*

.. And those are just some of the BIG Questions

- - Is there anything better than feed-in tariffs?
- - How "Differentiated" should "differentiated supports" be?
- - What are plausible convergence points from dedicated support to carbon price basis?
- - Use of auction revenues
- - How can future carbon controls be made more ‘bankable’?
- - Kyoto & AP6: competitors or cousins?
- - Can electricity and end-use companies behave more like oil companies?
- - How to align costs of capital - or find other ways (Carbon contracts, etc)
- And finally ….

.. And so the role of carbon markets is ..

- Generating substantial revenues that can support low carbon innovation expenditures both by companies (rents from free allocation) and governments (auction revenues)
- *Scaring investment away from carbon-intensive paths*, that will then look for other (lower carbon) options (and also thereby avoid lock-in):
  - Amplifying the risks around carbon-intensive investment
  - Reducing risks around low carbon-intensive investment
- Creating the *strategic conviction* at Board level in major multinationals that governments have the guts to regulate carbon and will drive the world along a "lower carbon path" – including helping low carbon technologies traverse the innovation chain
- Providing a policy prospect for *market convergence / exit strategy* for technology support policies
- Generating a classic price-base incentive