Role of Subsidies in Promoting UK Green Generating Technologies

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Introduction

UK government to set in law world's most ambitious climate change target, cutting emissions by 78% by 2035 compared to 1990 levels

https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035

- ❑ Is this achievable?
- ❑ Question the role of subsidies in attaining this target

From:
Department for Business, Energy & Industrial Strategy, Prime Minister's Office, 10 Downing Street,
The Rt Hon Kwasi Kwarteng MP, The Rt Hon Sir Alok Sharma KCMG MP, and The Rt Hon Boris Johnson MP
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Focus: Green Technology

- ❑ Offshore wind
- ❑ Nuclear

Green Technologies

- ❑ Offshore wind
- ❑ Onshore wind
- ❑ Solar
- ❑ Bio-Energy with / without Carbon Capture Utilization & Storage (CCUS)
- ❑ Nuclear
- ❑ Combine Cycle Gas Turbine (CCGT) with CCUS
- ❑ Hydrogen with / without CCUS
- ❑ Energy storage (hydro-pump, battery)
- ❑ Demand management through digitalisation

Focus: Subsidy

UK Government's instrument of choice for subsidizing low-carbon electricity generation:

- ❑ Contract-for-Difference (CfD)
  - ❑ OPEX
- ❑ Regulated Asset Base (RAB)
  - ❑ DEVEX and CAPEX

Direct and Indirect Government Funding

- ❑ DEVEX: (Development Expenditure)
  - ❑ Seed-corn and grants for emerging technologies
- ❑ CAPEX: (Capital Expenditure)
  - ❑ Sweeteners, Loan guarantees, Tax breaks, Capital allowances, Public Private Partnership (PPP), Infrastructure and resourcing investments
- ❑ OPEX: (Operating Expenditure)
  - ❑ Feed-in-Tariffs (FiT's), Collars
- ❑ DECEX: (Decommissioning Expenditure)
  - ❑ Tax breaks
  - ❑ Government intervention

Should Governments Intervene?

Orthodox Economic Theory (Walras, …, Samuelson)

- ❑ Intervention is not a sensible strategy

Theory of Comparative Advantage (Ricardo)

- ❑ Strategy of entrenching past winners internationally is backward looking

Market Failure

- ❑ Market alone incapable of achieving an optimal allocation of economic resources

Should Governments Intervene?

Market Failure

- Public Goods
  - Clean air, Education: that private actors are not sufficiently incentivized to provide
- Imperfect Information
  - Inhibits economic actors to interact efficiently
- Moral Hazard
  - Actions of one that force others to bear the costs
- Market Power
  - Powerful actors abuse their position to limit competition
- Externalities
  - Actions of one benefit or harm others

Should Governments Intervene?

Climate Pollution is a Negative Externality

- ❑ Control the polluters
  - ❑ Make the polluters pay
- ❑ Carbon Price
  - ❑ Advocated by World Bank, IMF, OECD, leading academic economists
- ❑ Cap & Trade Permit System
  - ❑ EU ETS
- ❑ Regulation
  - ❑ Implied cost of compliance

Should Governments Intervene?

Three Intervention Policy Candidates

1. **Carbon Price**
2. **Cap & Trade**
3. **Regulation**

This contrasts with UK's intervention policy

- ❑ **CfD**

- ❑ **RAB**

Wind Generators

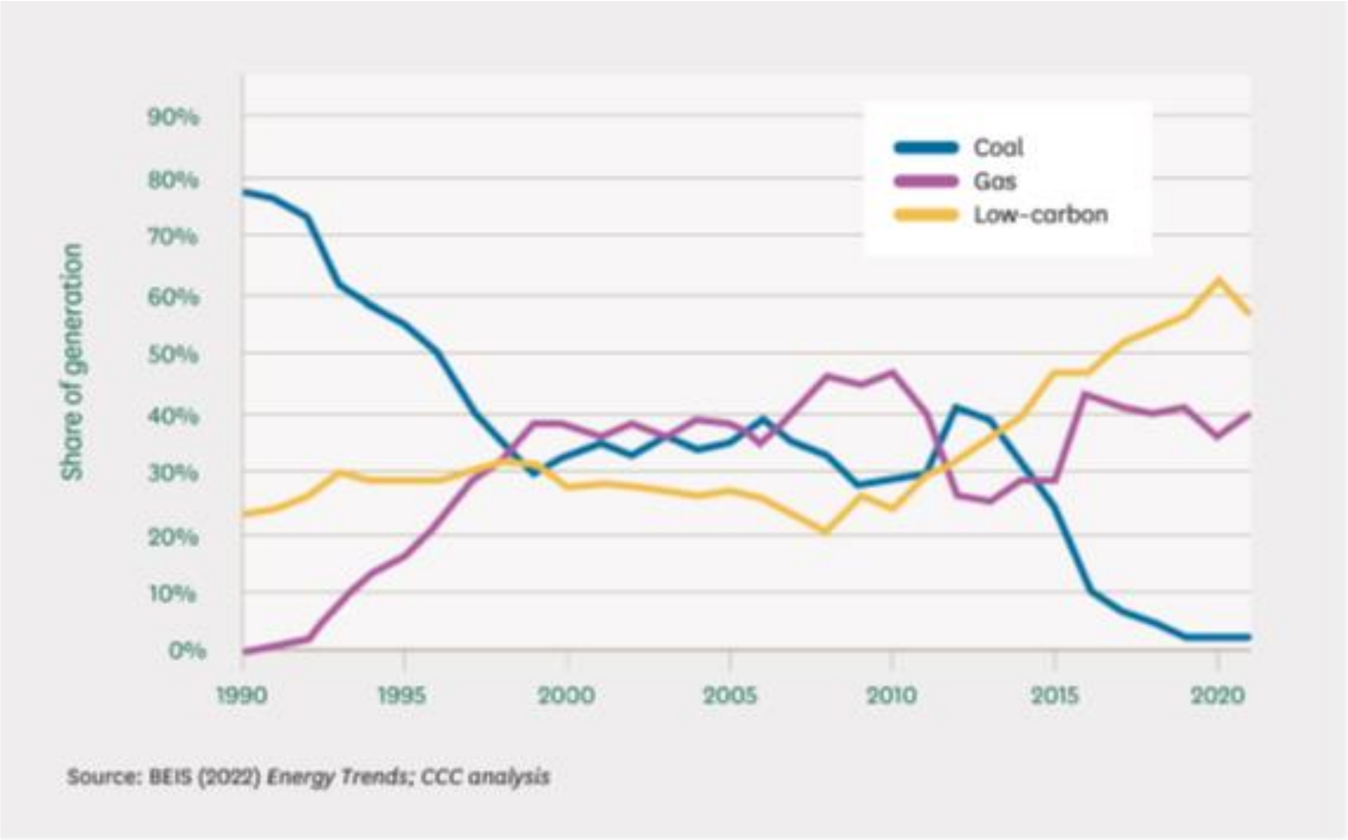
Britain is one of the largest off-shore wind generators
- By 2030, expected 30 GW
- Second only to PR China
- Geographical advantage: high winds and shallow seas

Natural appeal of off-shore wind
- Wind blows at night and in winter complementing solar
- Avoids NIMBYism

Advocates
- Subsidy regime (CfD) has raised volumes and lowered CAPEX and OPEX

Critics
- Subsidy is too generous and ineffective

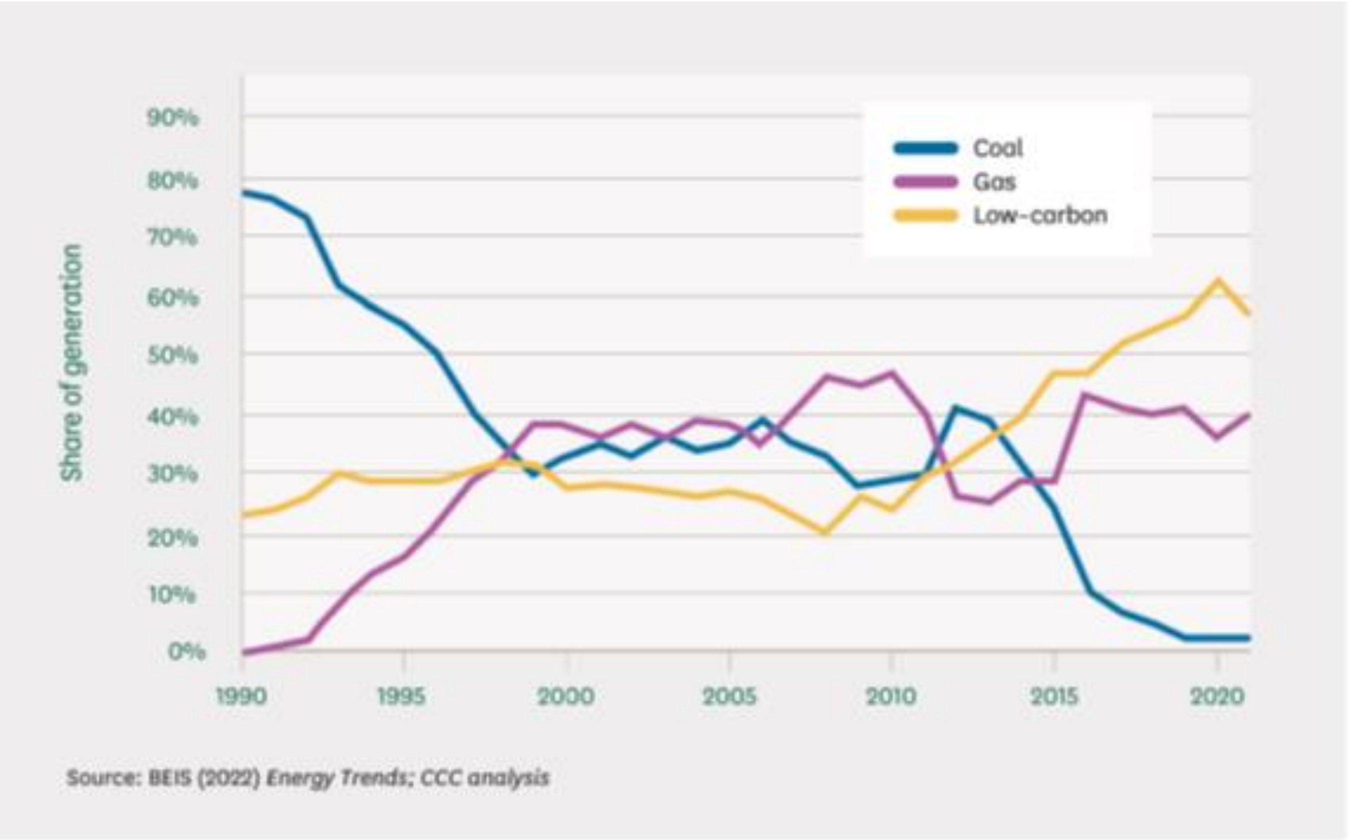
UK Generation Mix



2021:

- ❑ 40% - Renewables
- ❑ 15% - Nuclear
- ❑ 40% - Gas

UK Generation Mix

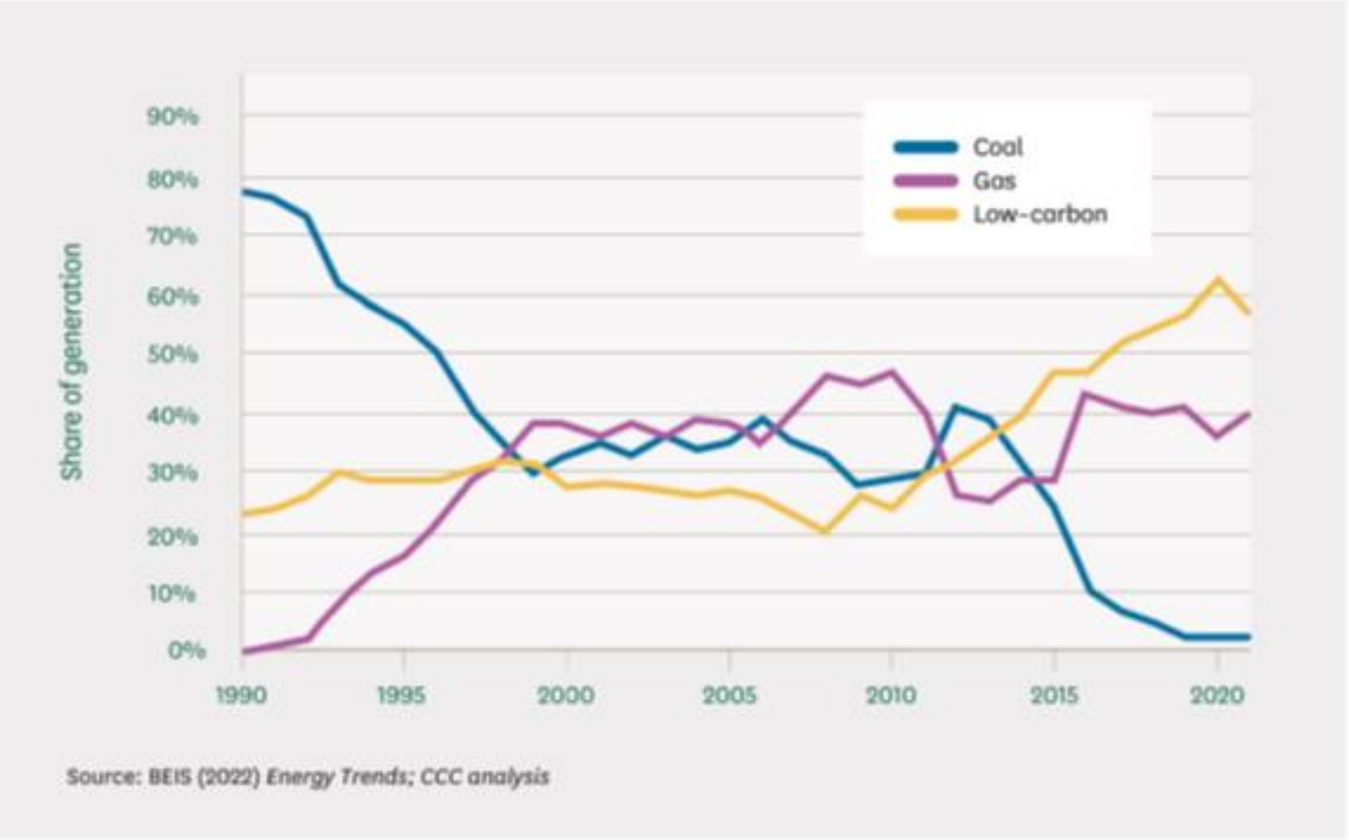


Demise of COAL

1990 - 2022
COAL replaced by CCGT
Carbon Tax and Cap & Trade

2010 – 2022
Investment in Renewables
Subsidies (CfD's)

UK Generation Mix



- ❑ Second-by-second demand-supply balance
- ❑ System to operate securely and safely
- ❑ Different technologies perform different roles

Generation Mix

Total UK Generation Capacity Mix:

- ❑ Renewables – inherently variable and intermittent
- ❑ Dispatchables – constant and instantaneous

2023: 100 GW

40% renewables (on- and off-shore wind and solar)
60% dispatchables (unabated gas, bio, nuclear)

2035: 200 GW

70-90% renewables (on- and off-shore wind and solar)
10-30% dispatchables (hydrogen, nuclear, CCUS gas, CCUS bio) and storage (battery, pumped hydro)
+ demand management through digitisation

Subsidy Race

To retain investment in low-carbon energy and to support growth and jobs

Subsidy competition for low-carbon technologies

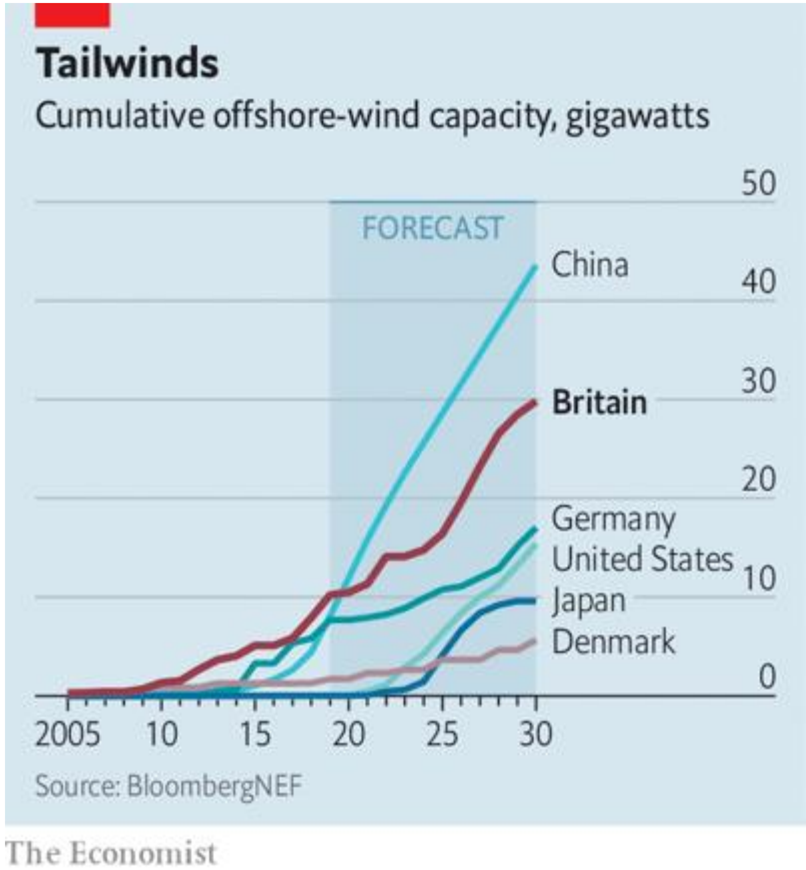
- ❑ PR China subsidy programme

- ❑ US Inflation Reduction Act (IRA) [and Chips & Science Act]
  - ❑ $370 bn of subsidies and tax credits for clean energy technologies

- ❑ EU Green Deal Industrial Plan
  - ❑ Subsidise production of solar panels, batteries, wind turbines, electrolysers and heat pumps

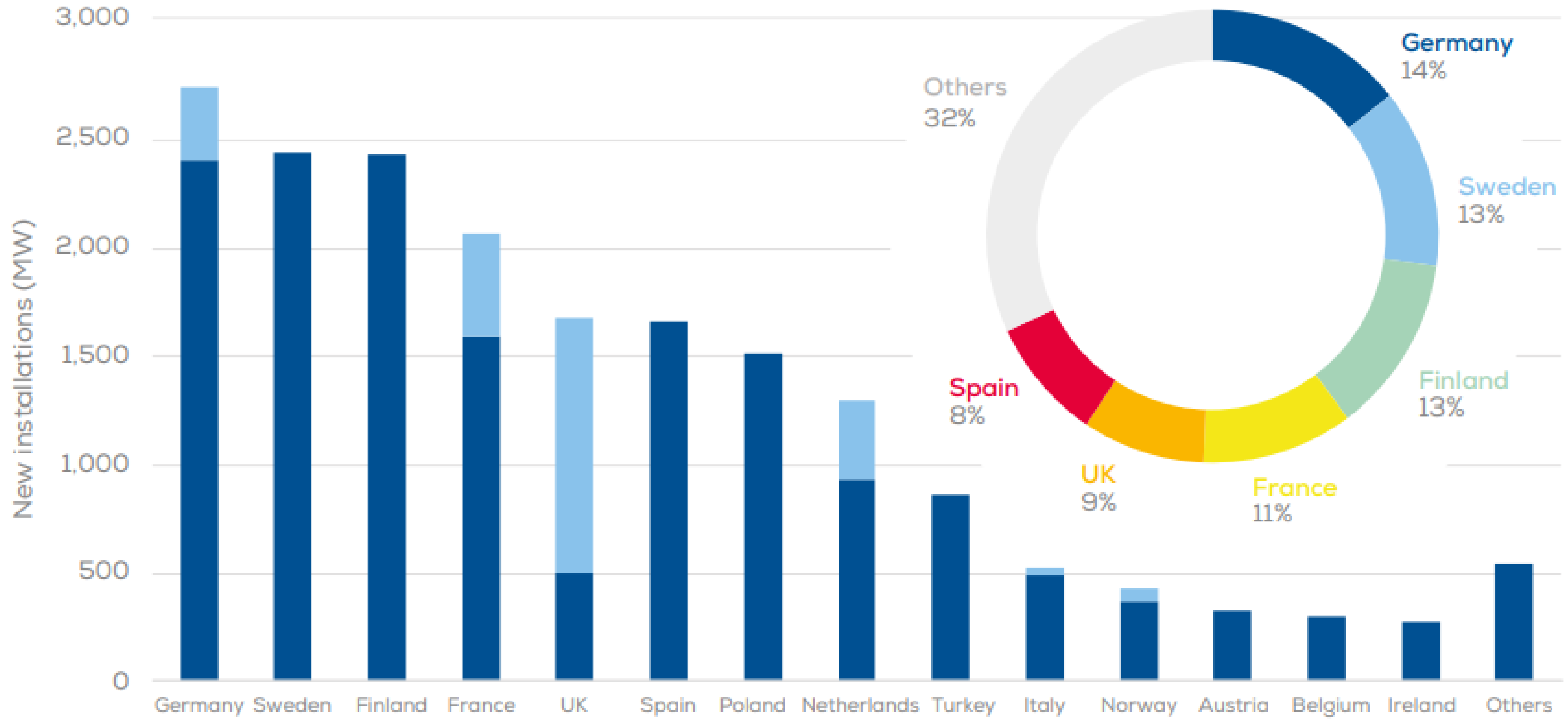
BUT, subsidies
- ❑ Confer unfair advantages and distorts trade
- ❑ Redirect capital and expertise
- ❑ Create overcapacity and inefficiencies

UK Position in Offshore Wind Generation



UK has created a leading position in offshore wind generation

New wind installations in Europe per country in 2022



	Germany	Sweden	Finland	France	UK	Spain	Poland	Netherlands	Turkey	Italy	Norway	Austria	Belgium	Ireland	Others
Onshore	2,403	2,441	2,430	1,590	502	1,659	1,517	933	867	496	372	328	303	280	546
Offshore	342	0	0	480	1,179	0	0	369	0	30	60	0	0	0	0

Source: WindEurope

Wind Generation in Europe

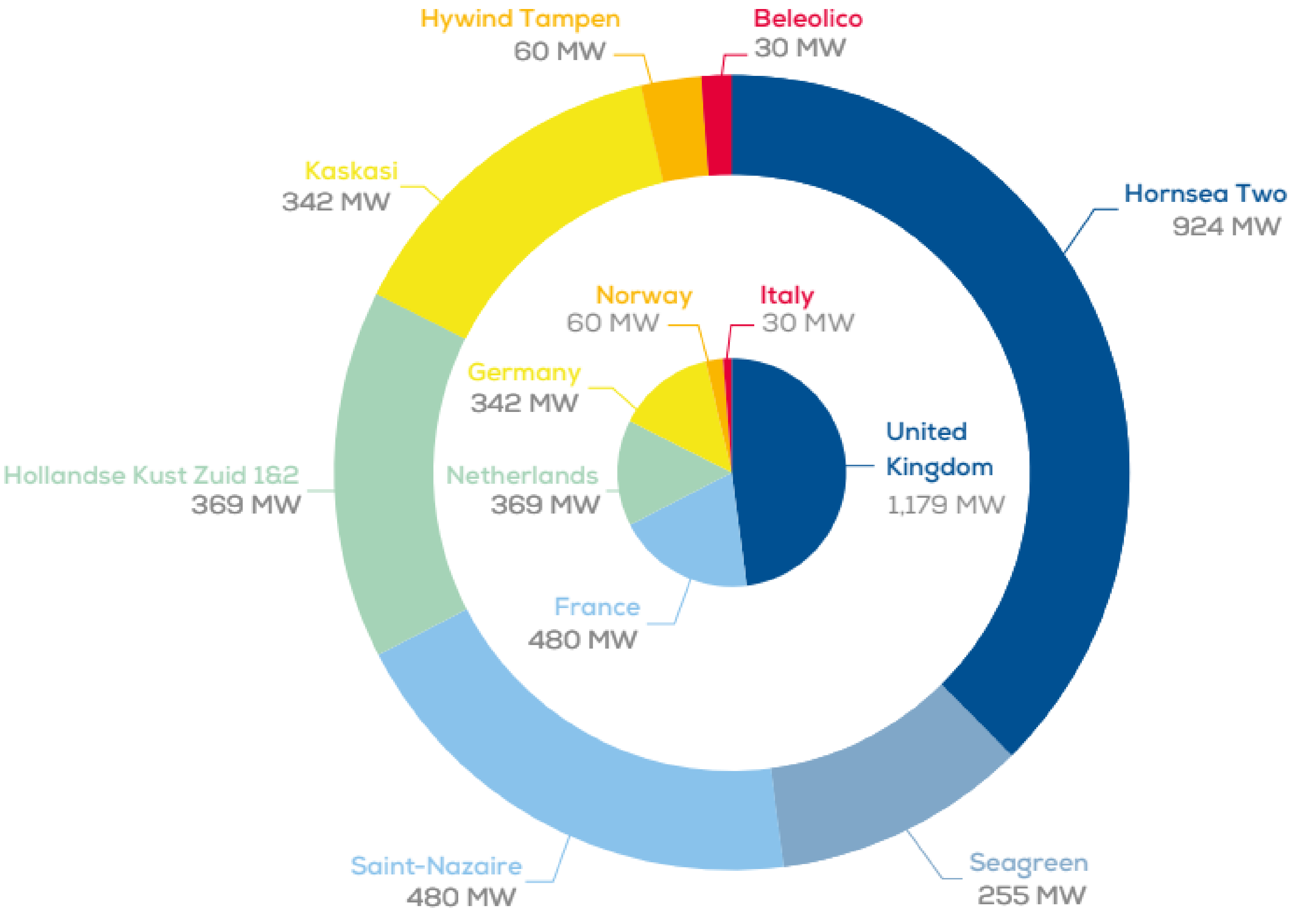
New additions, total wind capacity and the share of wind in the electricity demand in 2022

- Ordered by wind share in power mix

	New Installations 2022 (MW)			Cumulative Capacity (MW)			Wind Share in Power Mix 2022		
	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total
Denmark	131		131	4974	2308	7282	31%	25%	55%
Ireland	280		280	4612	25	4637	34%		34%
UK	502	1179	1681	14575	13918	28493	12%	15%	28%
Germany	2403	342	2745	58267	8055	66322	21%	5%	26%
Portugal	28		28	5671	25	5696	26%		26%
Spain	1659		1659	29793	5	29798	25%		25%
Sweden	2441		2441	14393	192	14585	25%		25%
Netherlands	933	369	1302	6223	2829	9052	12%	7%	19%

Source: WindEurope

New offshore wind farms in Europe in 2022



Source: WindEurope

CfD

CfD is a long-term constant pricing agreement between low-carbon developer and publicly-owned Low Carbon Contracts Company (LCCC)

The contract guarantees developers an inflation adjusted fixed price (£/MWh) for their electricity generated over fixed term

- ❑ Fixed price is termed the **strike price (SP)**
- ❑ It protects the developer from volatile electricity market prices
- ❑ Revenue certainty reduces project risk and so decreases the cost of project financing

Levelised Cost of Electricity (LCOE)

LCOE is the discounted lifetime cost of building and operating an electricity generation asset:

- Expressed as a cost per unit of electricity generated (£/MWh).

$$NPV\left(Total\,Cost\right)=\sum_{n}\frac{TotalCapex_n+TotalOpex_n}{\left(1+r\right)^n}$$

$$NPV\left(ElectricityGeneration\right)=\sum_{n}\frac{ElectricityGeneration_n}{\left(1+r\right)^n}$$

$$LevelisedElecticity\,Cost=\frac{NPV\left(Total\,Cost\right)}{NPV\left(ElectricityGeneration\right)}$$

LCOE is a consistent way for comparing the costs of different generating technologies

Administrative Strike Prices (ASPs)

LCOE is adjusted to form the ASP by including specific operating, locational and policy factors

- Revenue assumptions
- Other costs such as transmission losses, routing costs, and technology-specific factors (scrappage costs)
- CfD terms (contract length, risk allocation)
- Technology and industry developments
- Wider policy considerations

An illustration – Dogger Bank projects (NS):

- Being significantly larger, they benefit from scale economies
- Being situated far from shore, they benefit from good wind resource and relatively shallow water depth
  - This yields significantly higher load factors than average at same construction costs as the reference plant

CfD

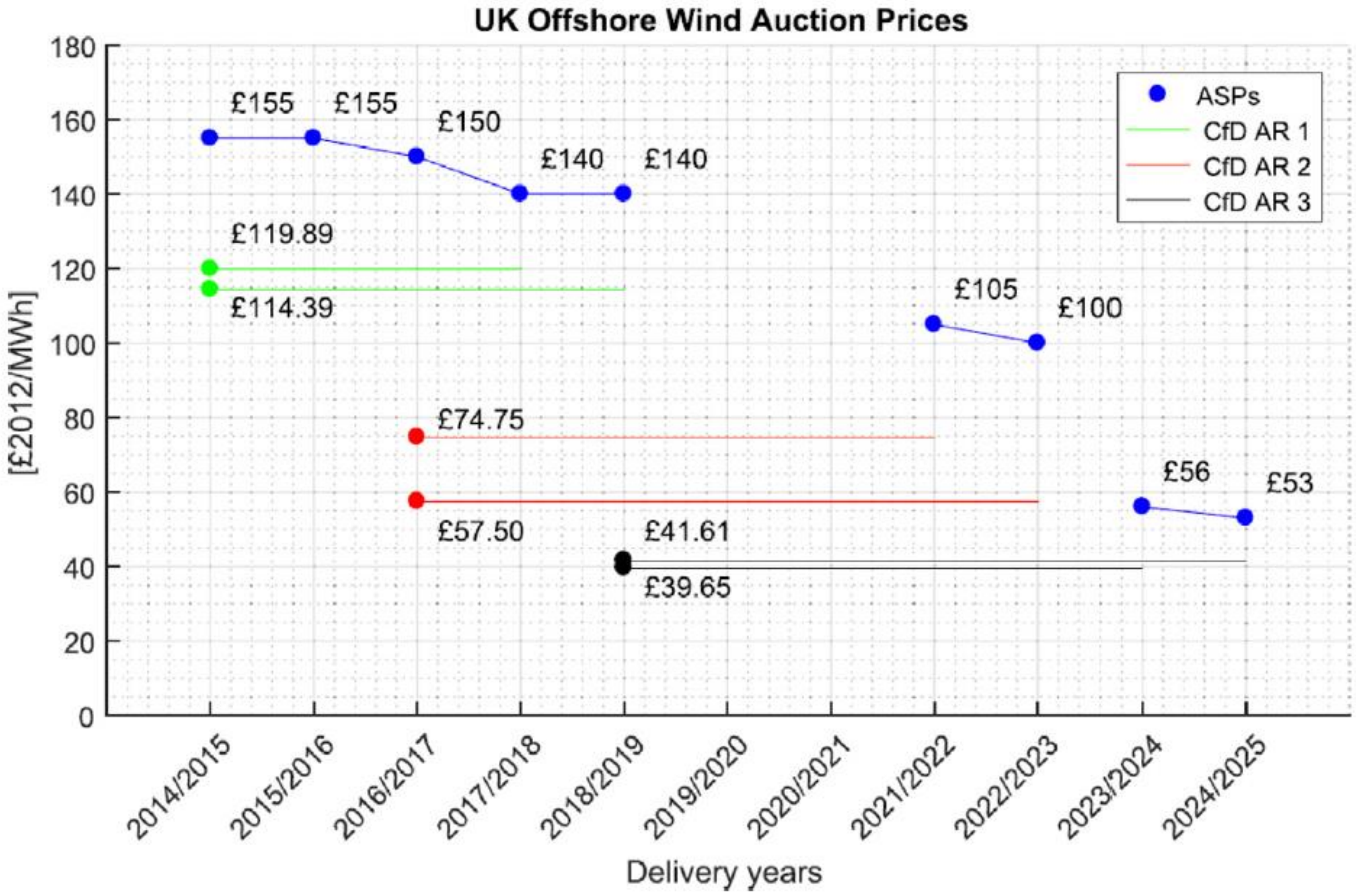
CfD is derived from a reverse auction with a limited subsidy budget:
- To maintain competition
- To ensure value for money for electricity

Submitted bids include:
- Technology type (on- and offshore wind, solar, etc)
- Electricity selling price
- Capacity
- Delivery year

Outcomes of the auction process:
- Strike price (SP)
- Assigned generation capacity

Obtaining a CfD contract was generally considered to be the most viable route to market

Strike Prices (SPs) (at 2012 prices)



Decline is ASPs

Decline is CfD's SP

Decline in ASP and SP

Advocates: This reflects

- Significant cost reductions especially in CAPEX induced by CfD
- Learning by Government and Developers

Critics: This reflects

- Over-generous Government leading to exorbitant energy consumer liability
- Mispricing due to Government inexperience

Offshore Wind

Generating capacity to attain targets

2022:	13 GW
2030	50 GW
2050	65-125 GW

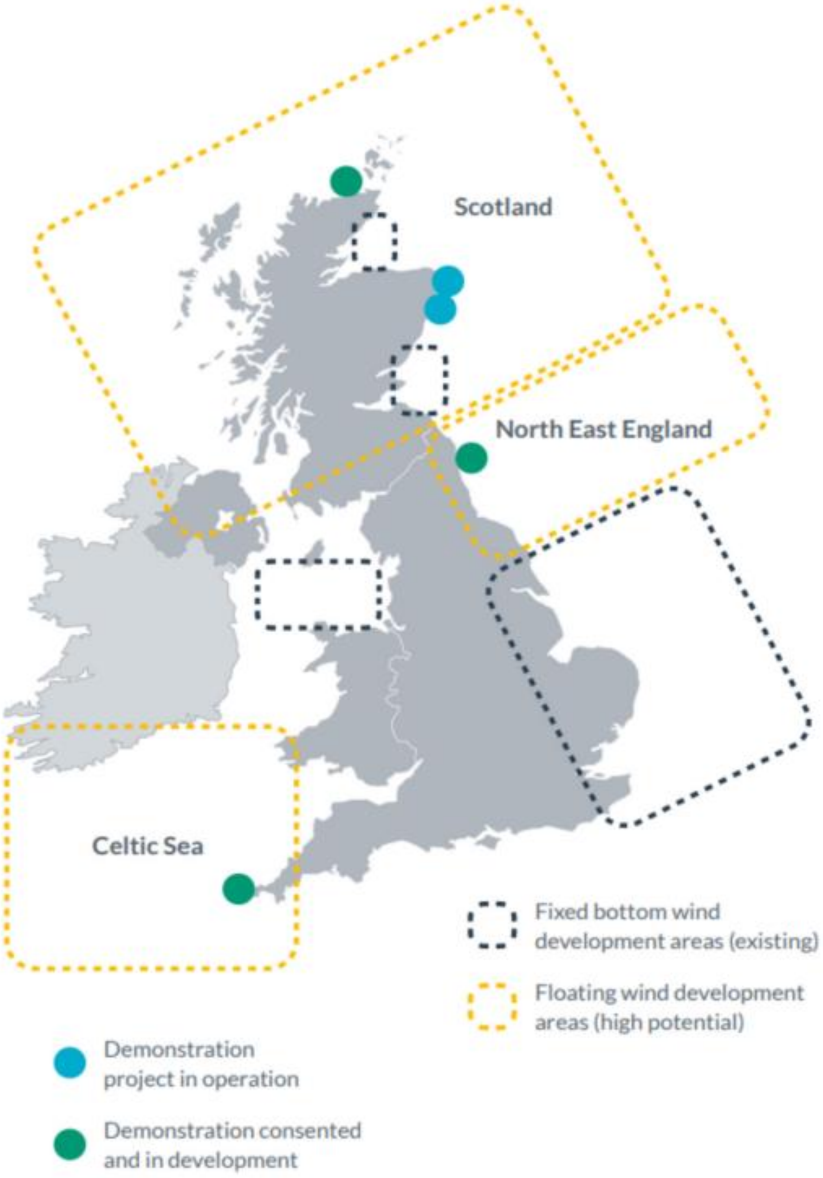
Target: 27 GW over next 8 years?

Bottlenecks:

- ❑ Government procedures and regulations
- ❑ Ineffective and disproportionate subsidy system
- ❑ Inadequate infrastructure system and supply chain handicaps

House of Commons: Business, Energy and Industrial Strategy Committee

Floating Offshore Wind



Potential to expand and diversify the UK's portfolio of wind generation assets

Nascent technology

Wind turbines installed on floating platforms anchored to the seabed by flexible anchors

Deployed in deeper waters where wind speeds are more consistent

Significant at scale new investment in UK ports, infrastructure and supply chains
- ❑ To incentivize disadvantage communities
- ❑ To generate green economy

Onshore Wind

Generating capacity:

2022:	14 GW	3 GW England 11 GW Scotland
2030	23 GW	3 GW England 20 GW Scotland

Retirement of onshore wind assets

- ❑ By 2024, 40 projects
- ❑ By 2027, 70 projects
- ❑ By 2030, 1.4 GW

Repowering

- ❑ Replacing old turbines with newer technology having greater efficiencies
- ❑ Risks

Repowering Risks

Government:

- Decommissioning obsolete turbines results in reduced low-carbon electricity and the need to incentivize new projects

Developer:

- Replacement of infrastructure to accommodate enhanced efficiency
- Price cannibalization
  - Wind-farm outputs tend to be highly correlated
  - Prices driven down to marginal cost when total demand met by wind-farms
  - Close-to-zero marginal cost insufficient to payback CAPEX

Nuclear

Generating capacity:

1999:	13 GW	
2023	6.0 GW	Produces 15% of UK power supply
2030	4.4 GW	Hinckley Point C on stream

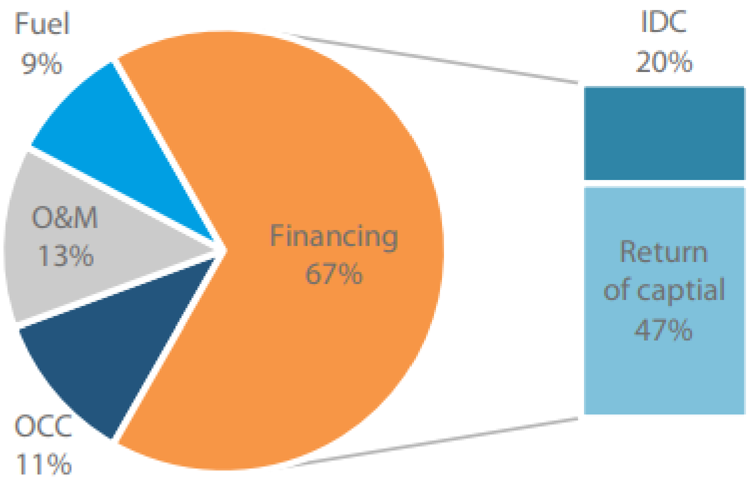
Hinckley Point C (HP-C): (in development)

- Capacity 3.2 GW
- Subject to delays and cost escalation
- CfD with strike price £89.50 /MWh (2012 prices)
    - CfD with strike price about £150.00 /MWh (2029 prices)

Sizewell C (S-C): (to be developed)

- Capacity 3.2 GW
- S-C and HP-C share same technology and supply chain, implementation more efficient
- RAB and CfD financing

Financing of Nuclear

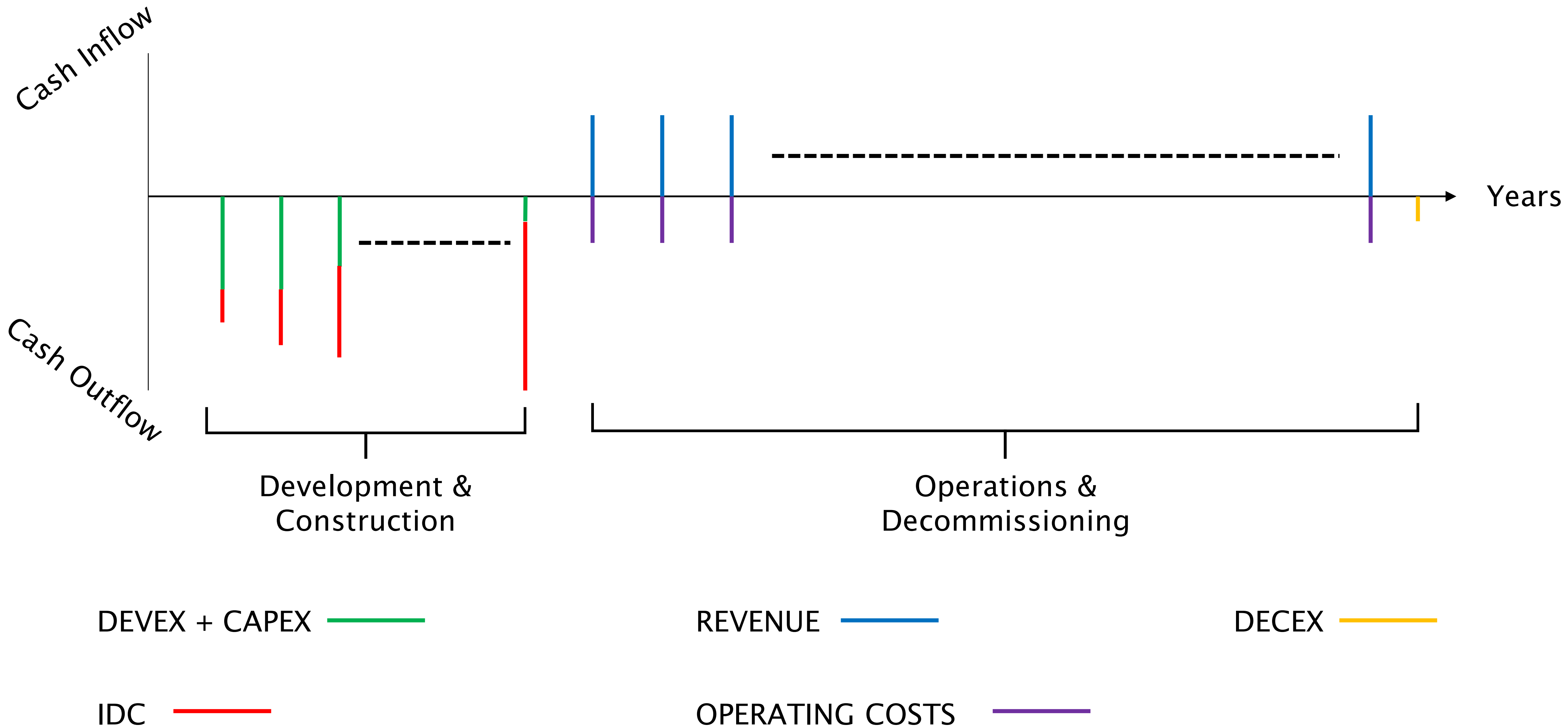


Mechanism for reducing the financing cost

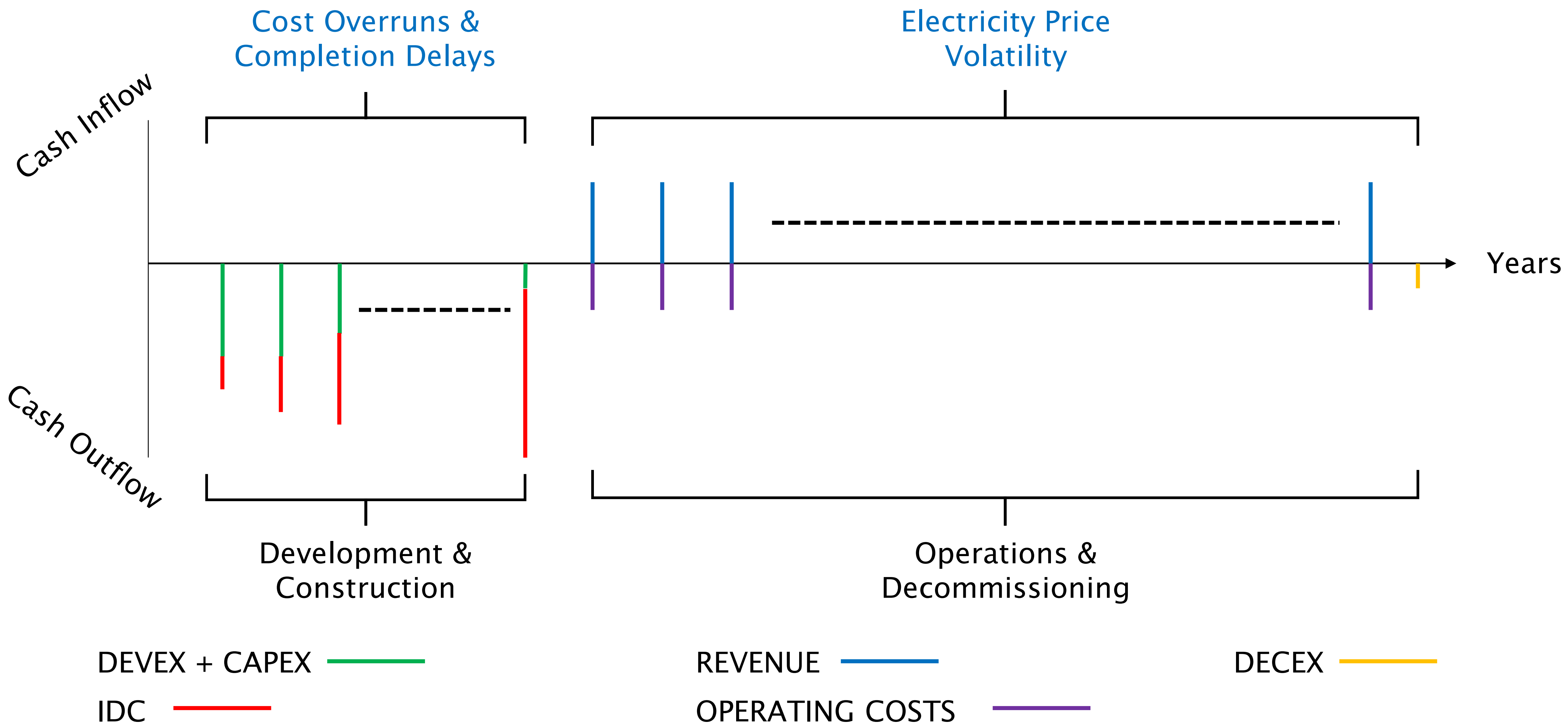
Note: Calculations based on OCC of USD 4 500 per kilowatt of electrical capacity (/kW$_e$), a load factor of 85%, 60-year lifetime and 7-year construction time at a real discount rate of 9%.

OCC (Overnight construction costs): includes the materials, components, manpower and cost of capital required to design, construct and commission the plant
O&M (Operations and maintenance costs): all costs related to staffing, consumables and recurring maintenance activities
Fuel cycle cost: cost of the fuel used to produce electricity
IDC (Interest during construction)

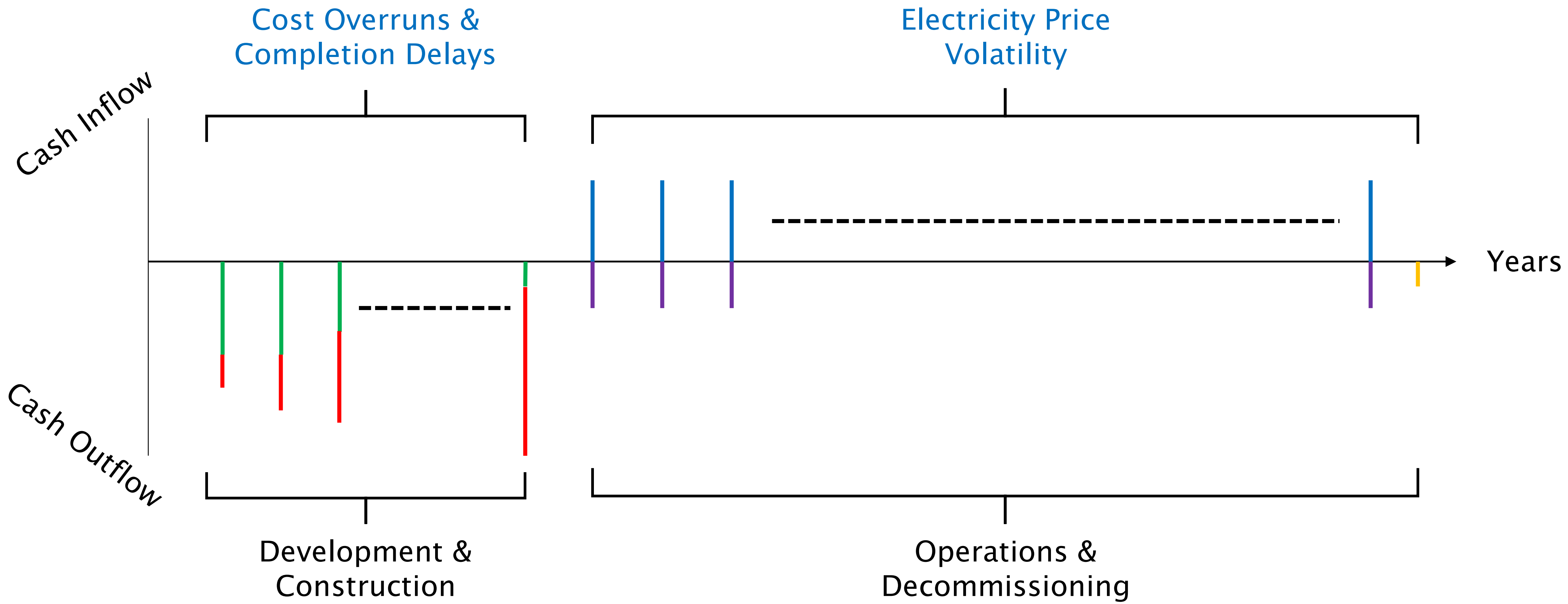
Financing of Nuclear



Financing of Nuclear – What are the Risks?



Financing of Nuclear – What are the Risks?



DEVEX + CAPEX
REVENUE
Subject to uncertainty

Financing of Nuclear – What are the Risks?

Mechanism for Managing the Risks

- To reduce cost overruns and completion delays
    - Without disqualifying the project

- To eliminate price volatility
    - Without deterring investor participation

Financing of Nuclear – What are the Risks?

No Single Mechanism for Managing the Risks

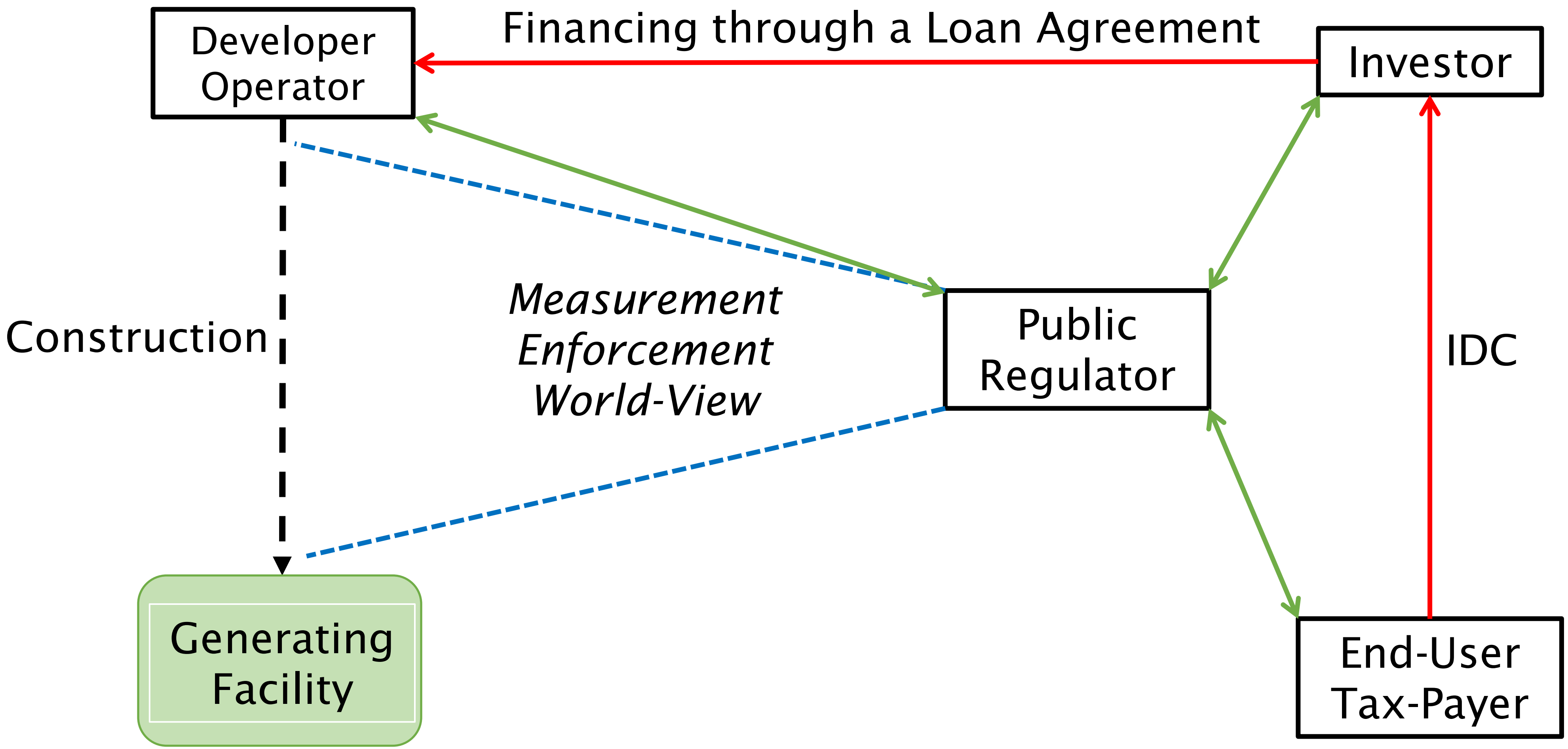
- ❑ To reduce cost overruns and completion delays
  - ❑ Without disqualifying the project

Regulated Asset Base

- ❑ To eliminate price volatility
  - ❑ Without deterring investor participation

Contract for Difference

RAB


Developer Operator
Financing through a Loan Agreement
Investor
Construction
Measurement
Enforcement
World-View
Public Regulator
IDC
Generating Facility
End-User Tax-Payer

RAB

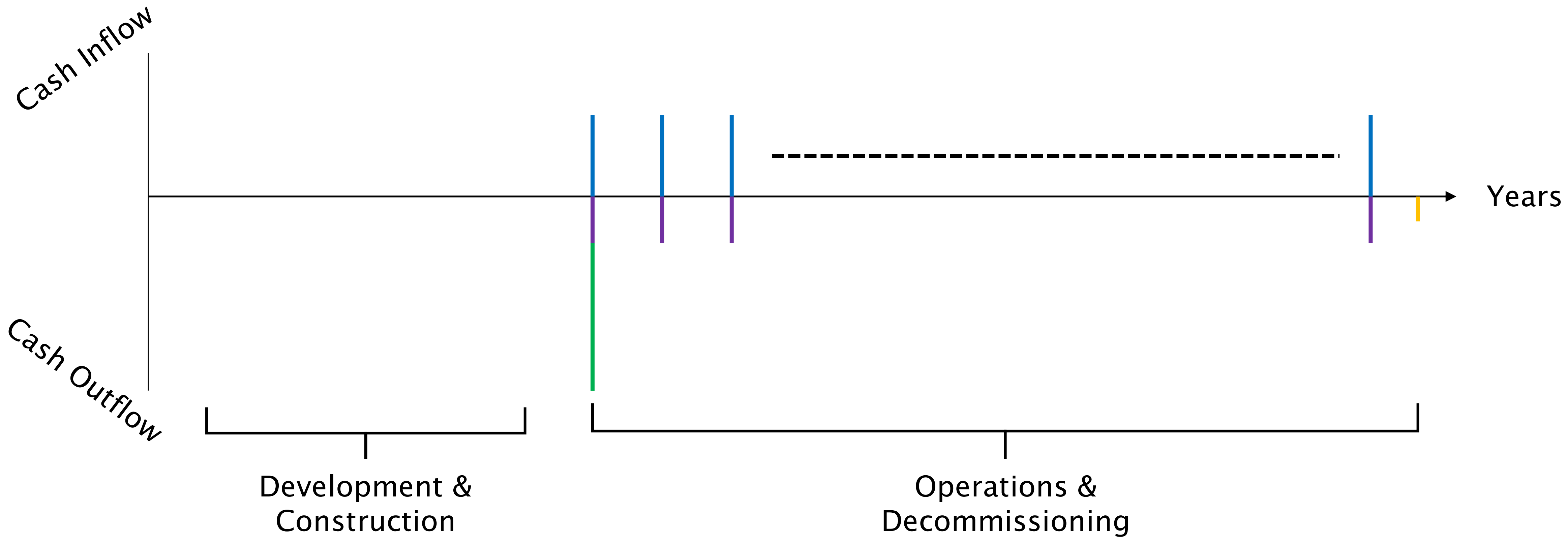
Contract exists between Developer-Operator on one hand,
and the Investor and the End-User Tax-Payer on the other hand

- ❑ Contract is subject to asymmetric information
- ❑ Construction may suffer legitimate cost and time over-runs
- ❑ But these are financed at zero cost to the Developer by the End-User Tax-Payer

Role of the Public Regulator

- ❑ To scrutinize all escalations
- ❑ To guarantee all escalations are genuine and legitimate
- ❑ The world-view of the Public Regulator is critical

During Operations

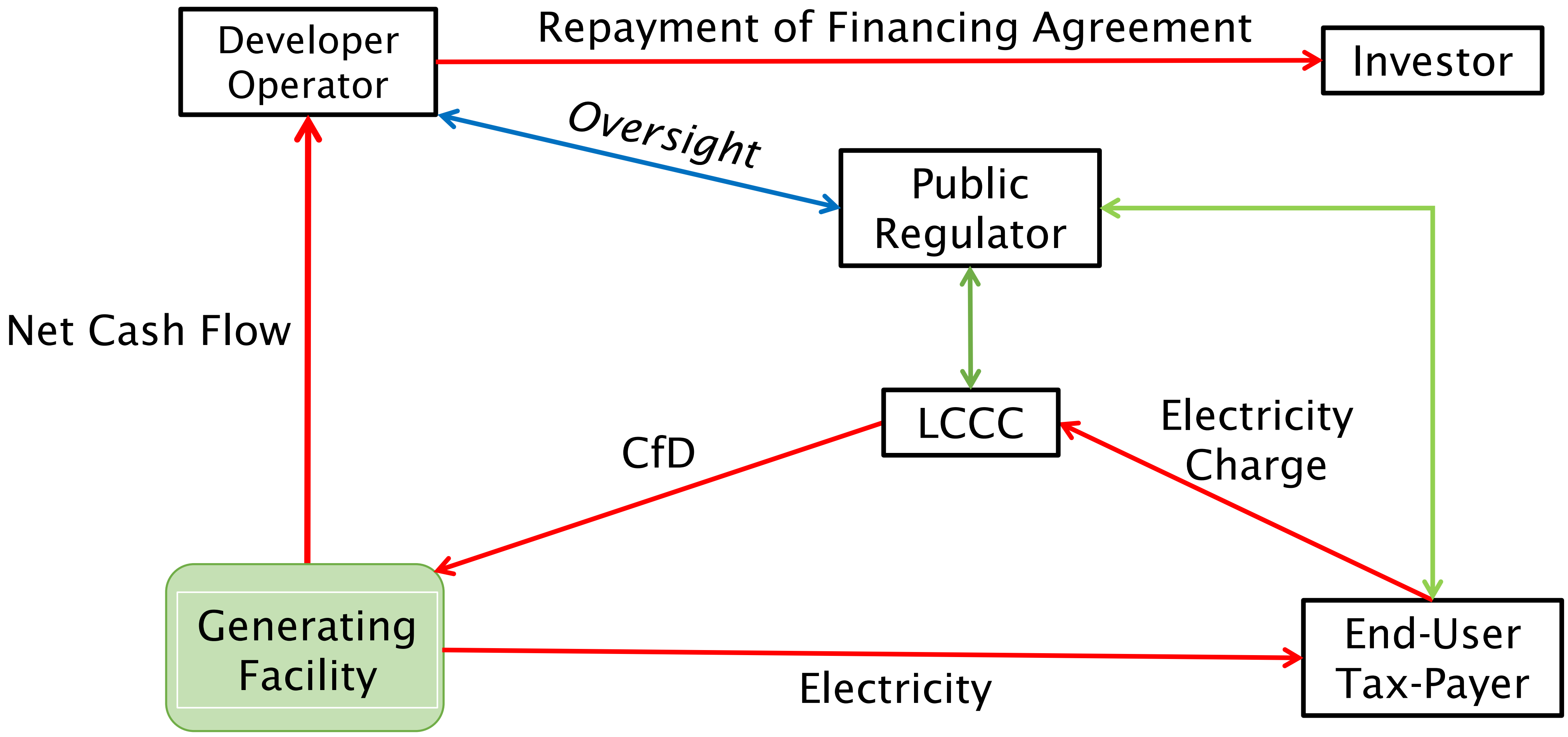


DEVEX + CAPEX

REVENUE

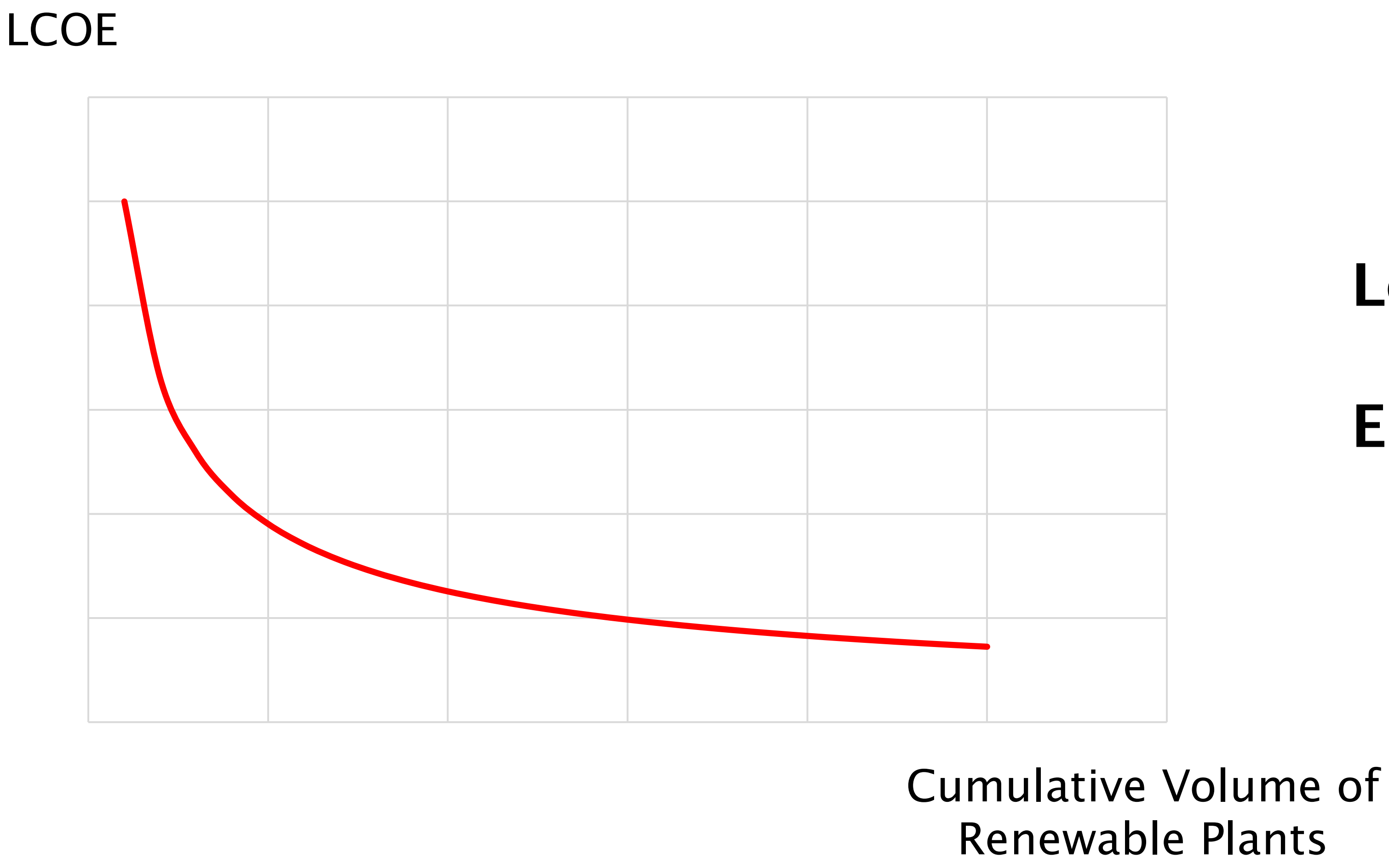
Subject to uncertainty

During Operations



CfD versus Carbon Price

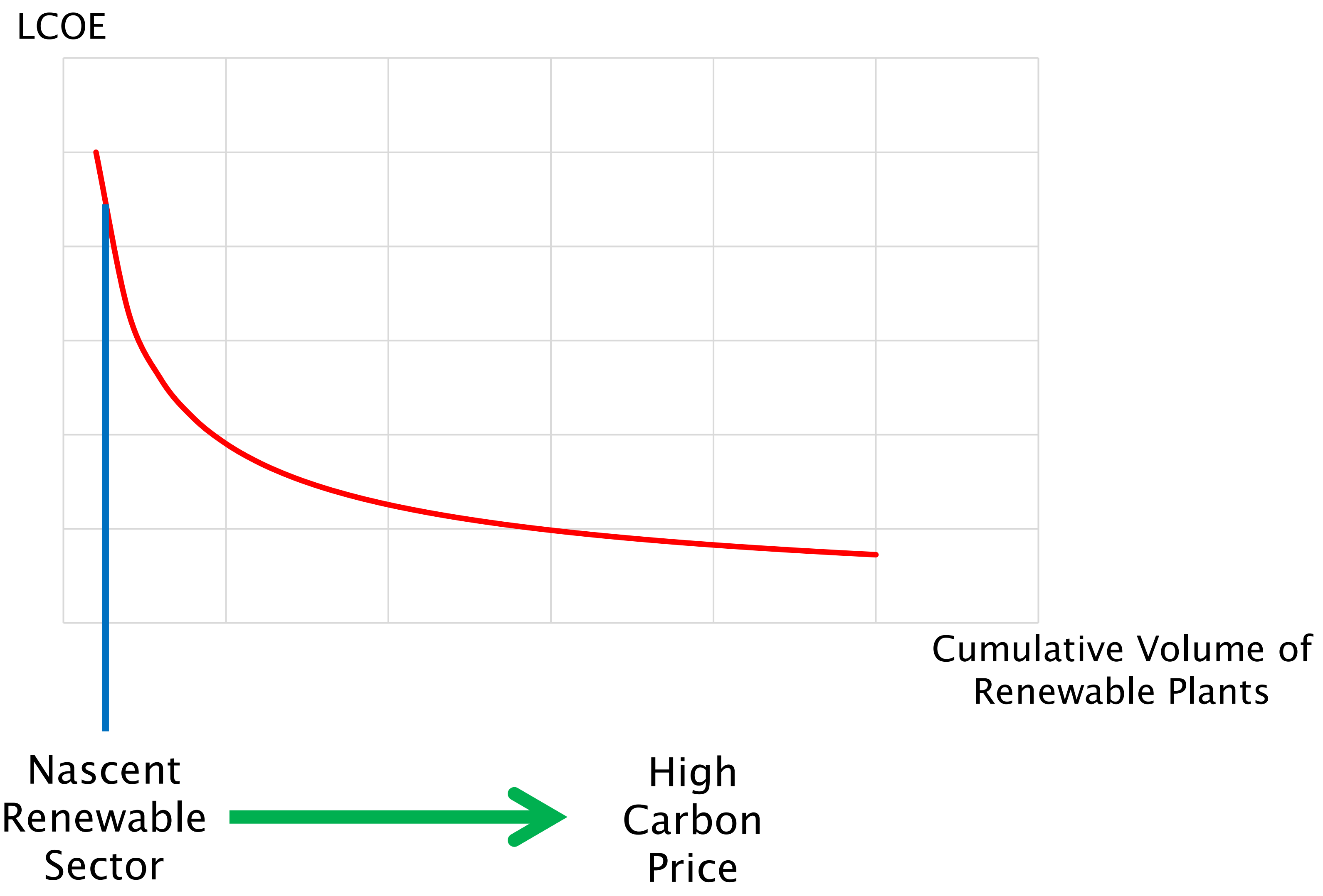
Levelised Cost Of Electricity declines with Cumulative Volume of Renewable Plants produced



Learning Economies

Economies of Scale

CfD versus Carbon Price



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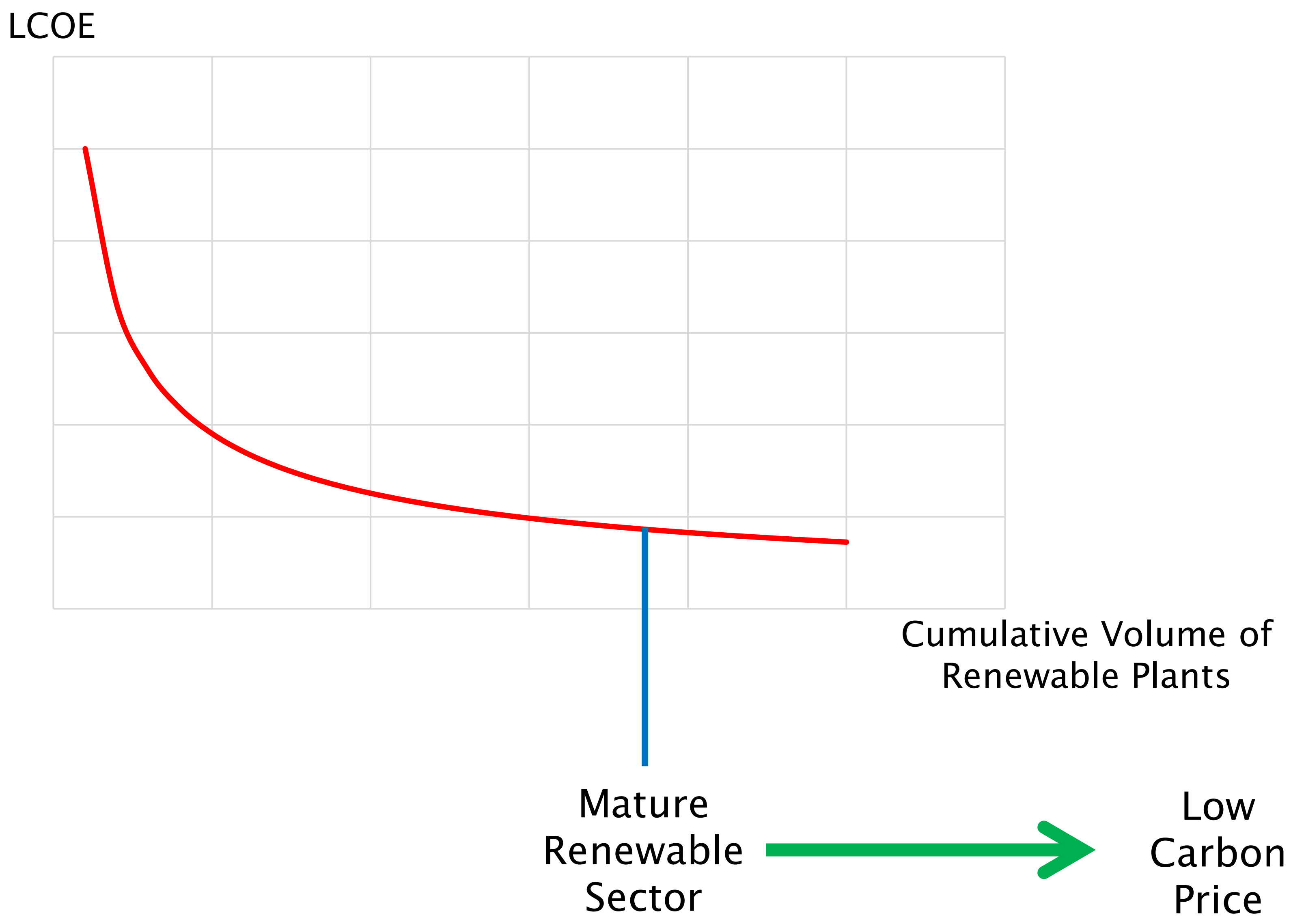


CfD versus Carbon Price

Nascent Renewable Sector → High Carbon Price

Mature Renewable Sector → Low Carbon Price

Historical evolution of carbon price: low to high

An initial high carbon price

- ❑ Force CCGT (dispatchable) to exit
  - ❑ Minimal proportion of dispatchables
- ❑ Induce CCGT to CCUS retrofits
  - ❑ Inhibit transition to renewables

Stiglitz (2019) advocates a high to low carbon price trajectory

But recognizes the adversarial political economy consequences

Potential for Global Advantages in Renewables

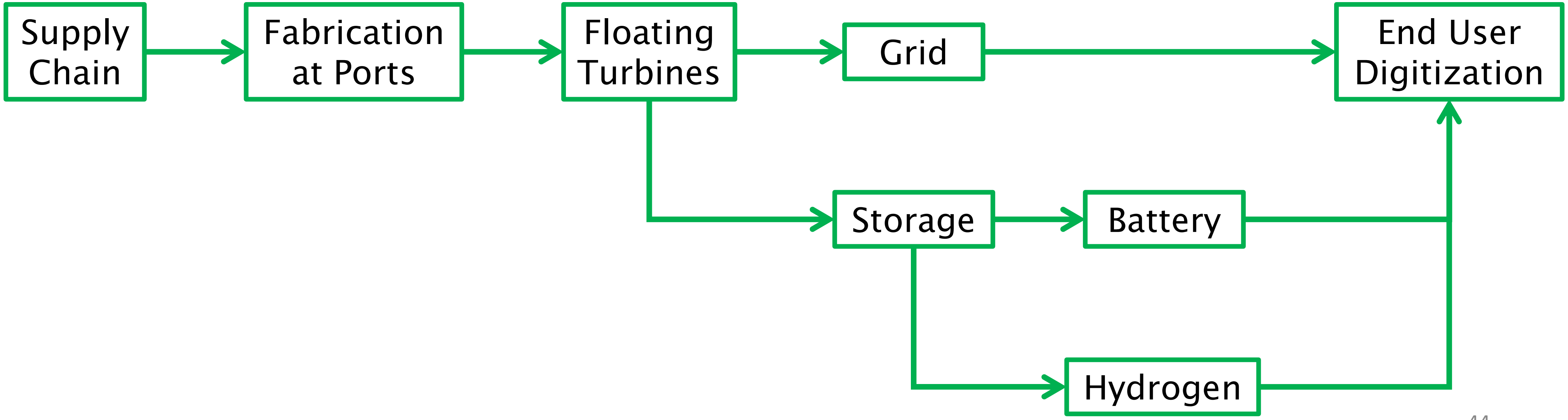
Locational Advantages

- ❑ Geography, Climate, NS Oil, Universities

Specific Advantages

- ❑ Fixed offshore wind turbine sector

But for the emerging floating offshore turbine sector?



Financing

Floating Offshore Turbine Value Chain

Financing Mix

- Government
- End User
- Debt Investors (low risk)
- Equity Investors (high risk)

Regulator: RAB and CfD

- ❑ World-view
- ❑ Contracting
- ❑ Enforcement

End

Thank you

Any questions?

References

House of Commons: Business, Energy and Industrial Strategy Committee
Decarbonisation of the Power Sector
April 25 2023