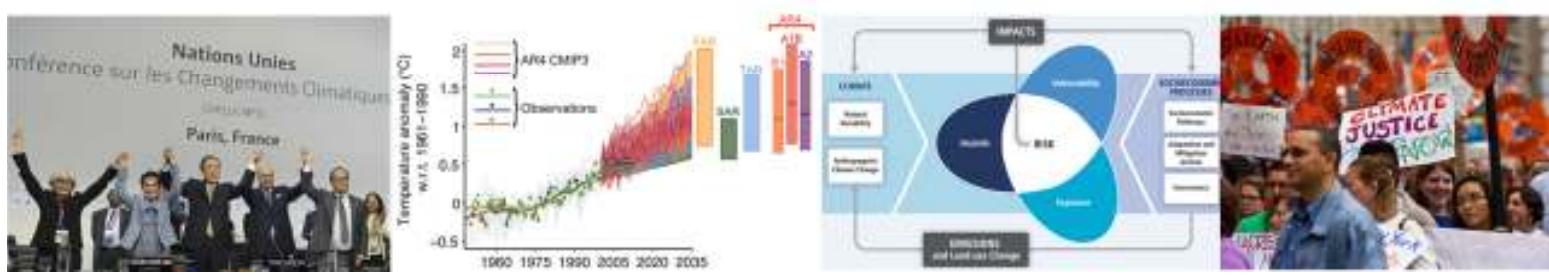




Energy Systems & Climate Change



Evaluating alternatives

MEEN 40090
Energy Systems & Climate Change

WJS Slide 5a.1

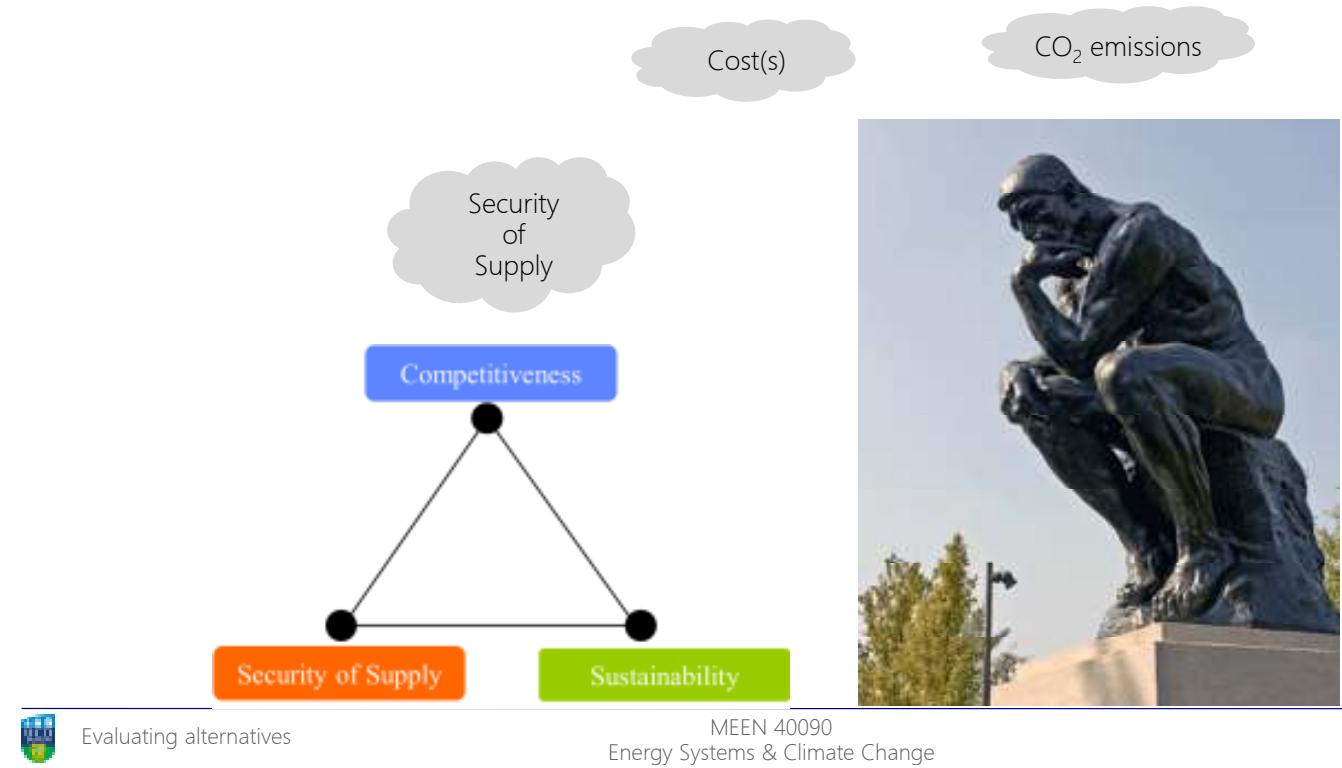


Evaluating alternatives

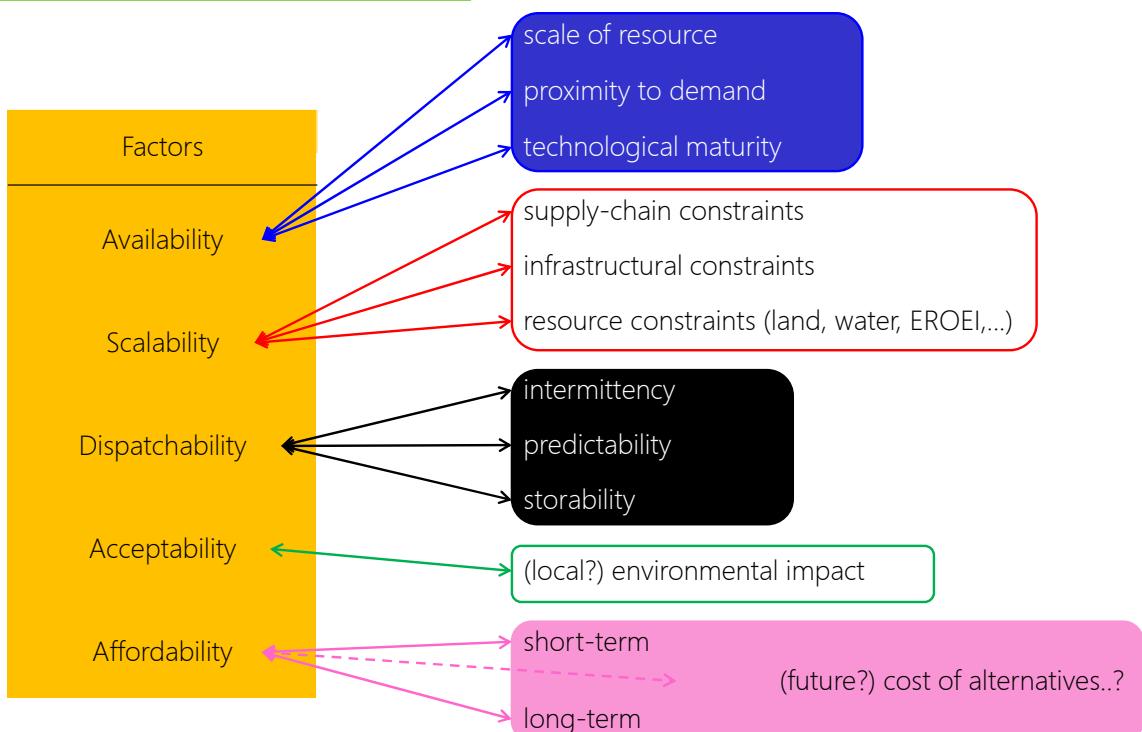
MEEN 40090
Energy Systems & Climate Change

WJS 5a.2

Evaluating alternatives



Evaluating alternatives



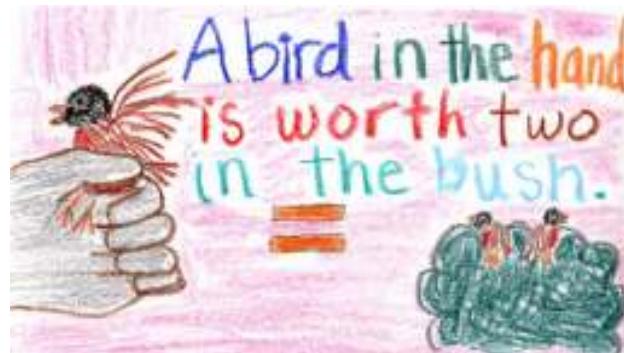
Time preference for money:



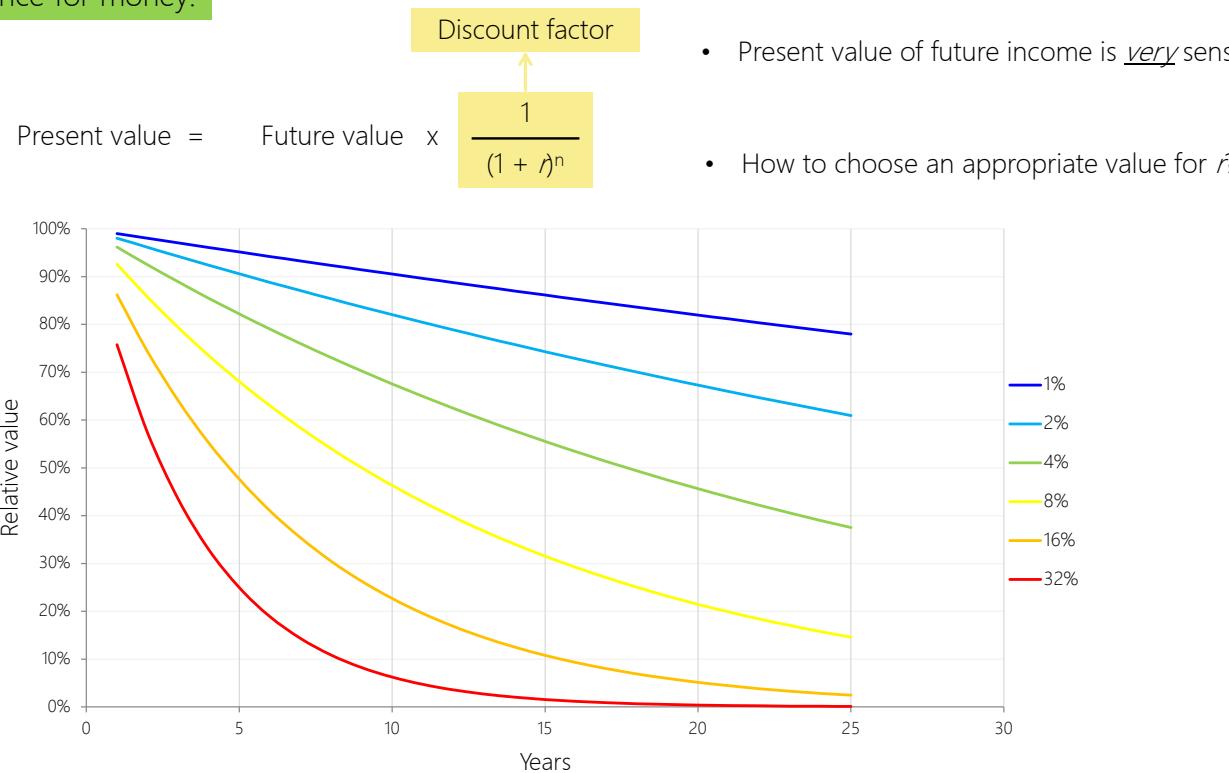
Time preference for money:

$$\text{Present value} = \text{Future value} \times \frac{1}{(1 + r)^n} \longrightarrow n = \text{number of years}$$

→ r = discount rate (per year)



Time preference for money:

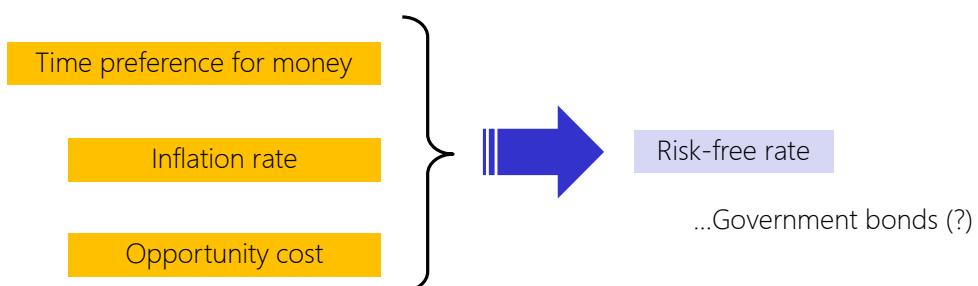


Time preference for money:

Opportunity cost:

- Value of the next-best alternative
- Spend €50 on a night out, or on a pair of jeans, or invest it...in the hope of getting more than €50 later
- Not all investors have the same opportunities

Hence: projects compete for investors; investors compete for projects



Time preference for money:

Risk premium:

- Shares versus deposits
- Wind versus marine
- Denmark versus Yemen
- Leads to WACC

Technology risk

Country risk

Firm risk

Market risk

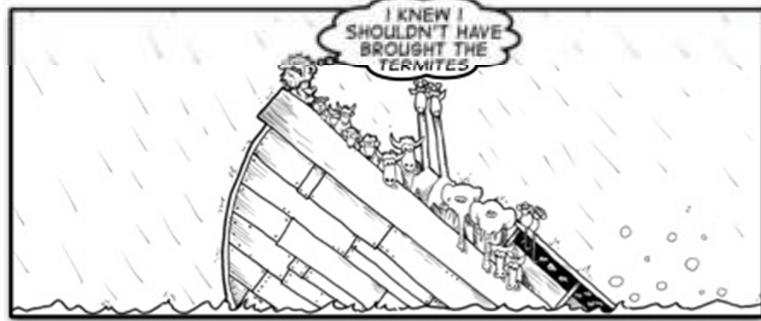
etc...



Risk-free rate

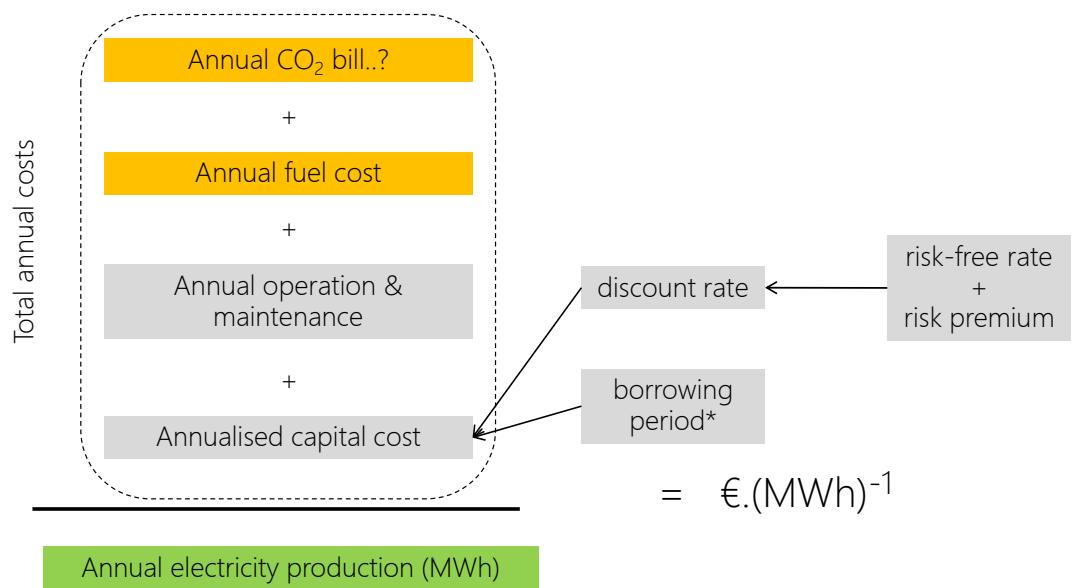
+ Risk premium

= Discount rate



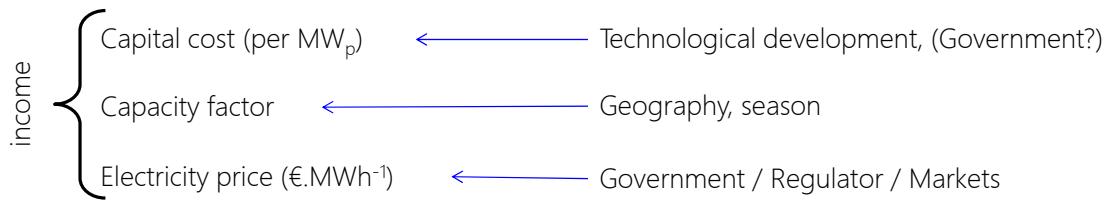
Levelised cost of electricity (lcoe):

LCOE estimates the average cost of producing electricity over the lifetime of a plant.

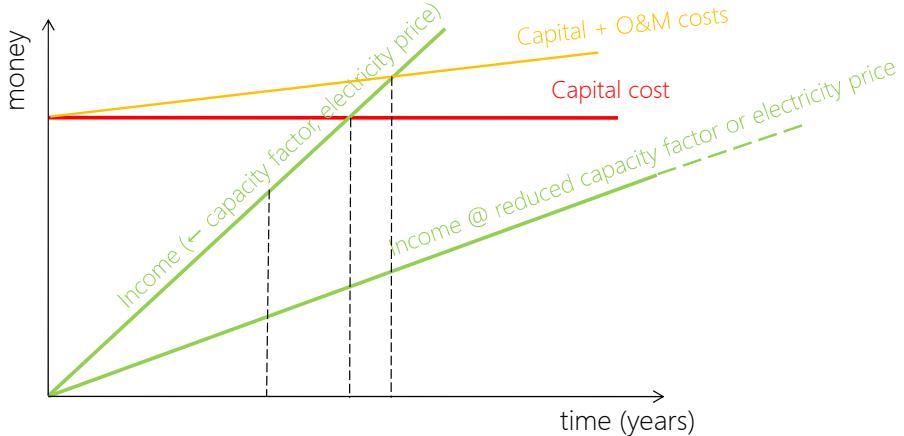


Levelised cost of electricity (lcoe):

Three main factors dominate the economic viability of renewable electricity plant:



Consider (very) simplified analysis:



Levelised cost of electricity (lcoe):

Sensitivity of lcoe to external variables, for each technology type

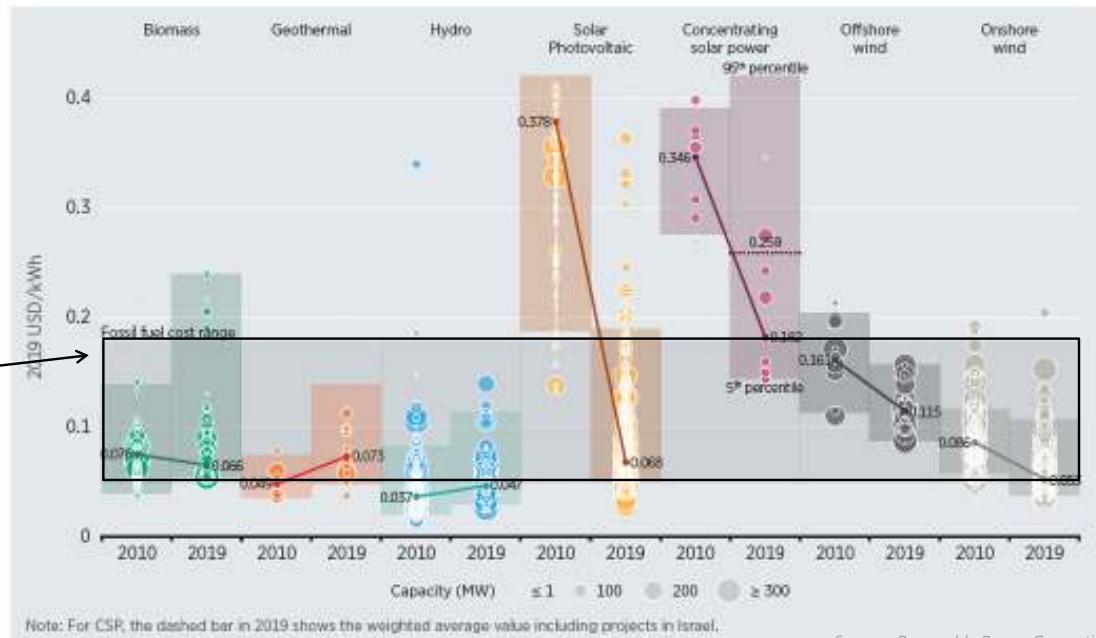
| | coal | gas | nuclear | renewables |
|----------------------|----------|----------|----------|------------|
| Capital cost | high | moderate | high | very high |
| Discount rate (WACC) | high | moderate | high | very high |
| Fuel cost | moderate | high | very low | zero |
| CO ₂ cost | high | moderate | zero | zero |
| Capacity factor | high | moderate | high | very high |

...so estimates of future lcoe for each technology are sensitive to the specific values assumed for these parameters



Levelised cost of electricity (lcoe):

Figure 1.2 Global LCOEs from newly commissioned utility-scale renewable power generation technologies, 2010–2019



Note: For CSP, the dashed bar in 2019 shows the weighted average value including projects in Israel.

Source: Renewable Power Generation Costs in 2019. IRENA (2020)



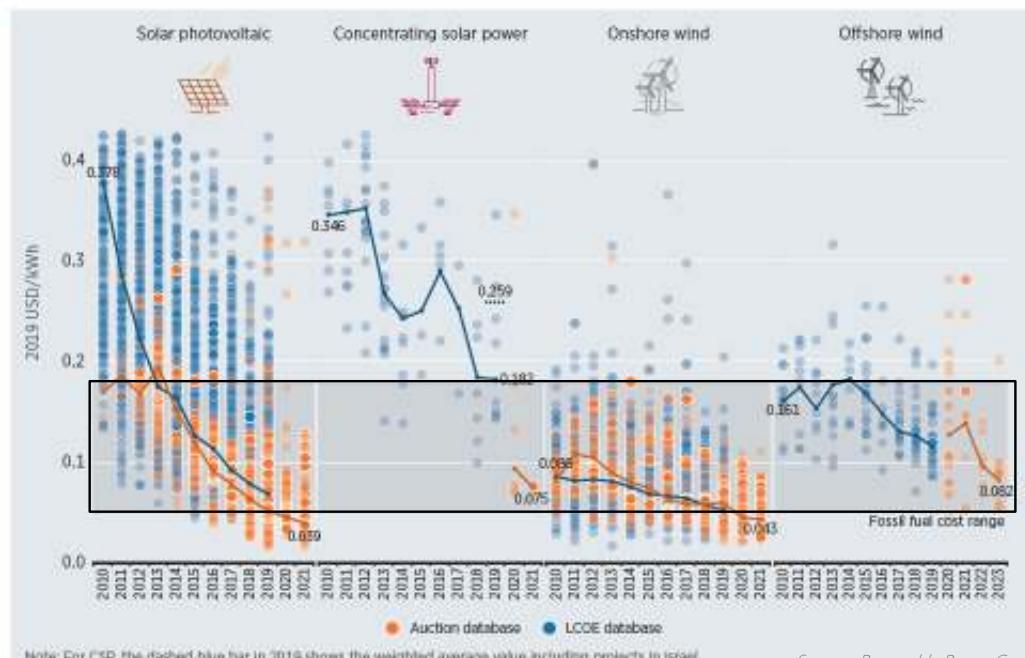
Evaluating alternatives

MEEN 40090
Energy Systems & Climate Change

WJS 5a.13

Levelised cost of electricity (lcoe):

Figure 1.3 The LCOE and PPA/Auction prices by project for solar PV, onshore wind, offshore wind and CSP, 2010–2023



Note: For CSP, the dashed blue bar in 2019 shows the weighted average value including projects in Israel.

Source: Renewable Power Generation Costs in 2019. IRENA (2020)



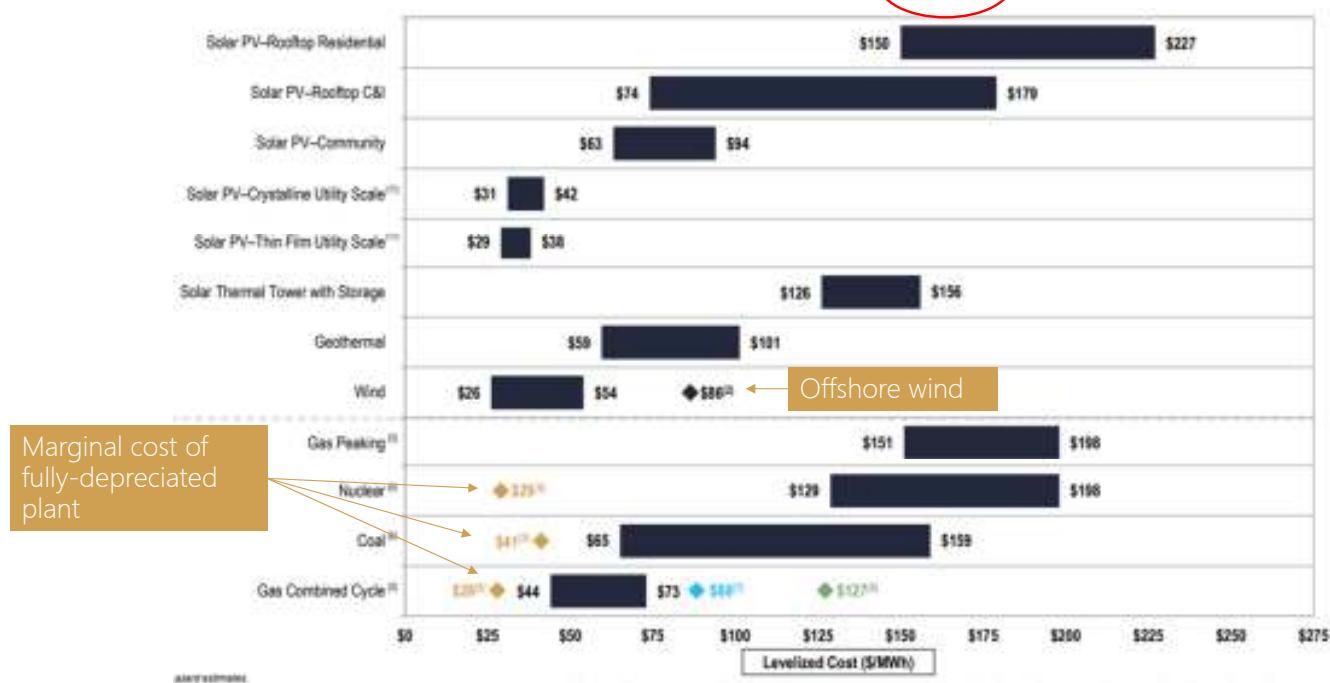
Evaluating alternatives

MEEN 40090
Energy Systems & Climate Change

WJS 5a.14

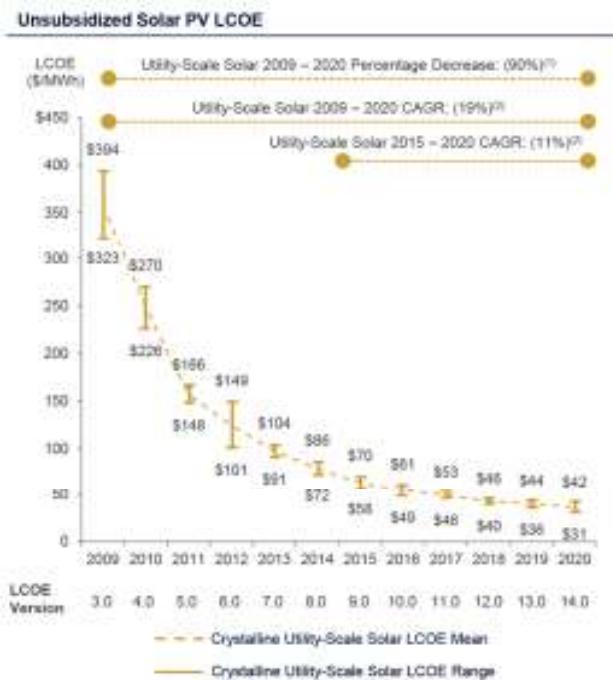
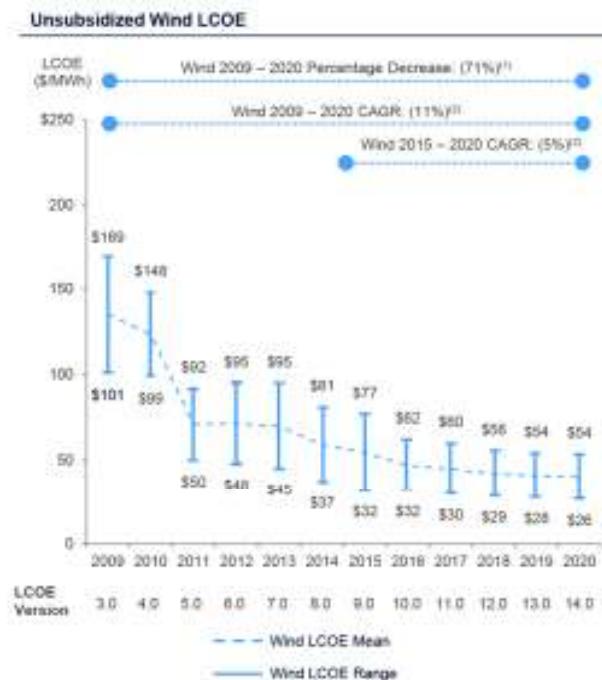
Levelised cost of electricity (lcoe):

Lazard data for USA



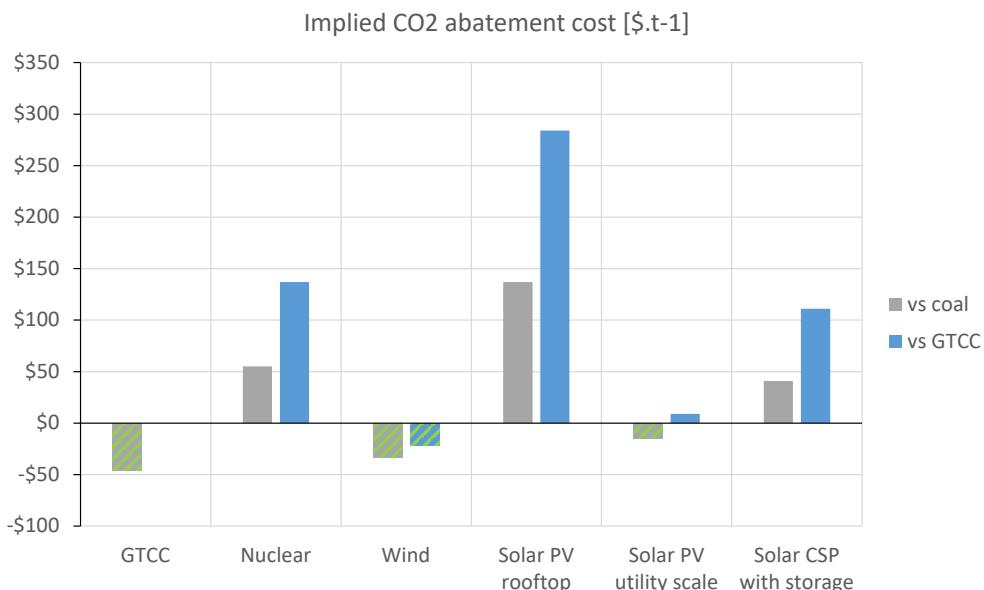
Levelised cost of electricity (lcoe):

Lazard data for USA



Cost of CO₂ abatement:

Lazard data for USA



Raw data: Lazard's cost of energy analysis – version 11.0 (2017). www.lazard.com



Evaluating alternatives

MEEN 40090
Energy Systems & Climate Change

WJS 5a.17

Levelised cost of electricity (lcoe):

Dubai's 900 MW solar tender sees lowest bid of \$0.0169/kWh

The offer was apparently submitted by Saudi energy giant ACWA Power, which refused to confirm the bid when asked by pv magazine. The second lowest bid – \$0.0175/kWh – was reportedly submitted by a consortium formed by Emirati developer Masdar, French utility EDF and Chinese PV panel maker Jinko Power.

OCTOBER 18, 2019 [IRELAND BELLIEVE](#)

[TOPICS](#) [SUBSCRIPTIONS](#) [STAY CONNECTED](#) [ABOUT US](#) [CONTACT](#)



Average solar power price in Brazilian A-6 auction reaches \$20.52/MWh

Only 100 MW of the 2.97 GW of renewable energy generation capacity generated in the previous auction made it to today's auction. Last auction was successful and their final electricity price was the lowest those offered by competing technologies.

[REVIEW](#) [TOPICS](#) [SUBSCRIPTIONS](#) [STAY CONNECTED](#) [ABOUT US](#) [CONTACT](#)



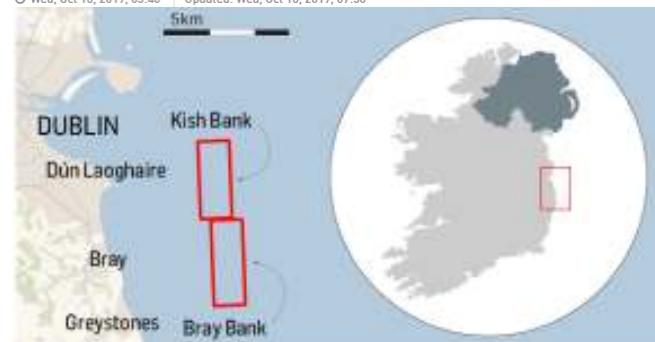
Offshore Wind Costs Fall Below New Nuclear Plants in U.K.

By [Matthew Steeples](#) | [Business](#) | [Markets](#) | [Tech](#) | [Politics](#) | [Finance](#) | [Energy](#) | [Opinion](#) | [International](#) | [Technology](#) | [Innovation](#) | [Finance](#) | [Markets](#) | [Tech](#) | [Politics](#) | [Finance](#) | [Energy](#) | [Opinion](#) | [International](#) | [Technology](#) | [Innovation](#)

Joint venture to build €1.5bn wind farm off Dublin coast

Companies plan to build offshore wind farm 10km off east coast and close to the capital

© Wed, Oct 16, 2019, 05:40 | Updated: Wed, Oct 16, 2019, 07:36



INTERNATIONAL • OFFSHORE WIND

The World's Biggest Turbines and No Subsidies: How Offshore Wind Is Entering a New Era

By [Catherine Smith](#) | October 7, 2018



Evaluating alternatives

MEEN 40090
Energy Systems & Climate Change

WJS 5a.18

Levelised cost of electricity (lcoe):

Other costs, not captured by lcoe

| Non-renewables | Renewables |
|--|---------------------------------------|
| <i>Pollution</i> | <i>Grid costs</i> |
| <i>Water use</i> | <i>Impacts on non-renewable plant</i> |
| <i>Upstream impacts - e.g. mining.</i> | <i>Backup costs</i> |
| <i>"Soft" (social) costs</i> | <i>Visual impact (social costs)</i> |
| | <i>"Hard" (financial) costs</i> |



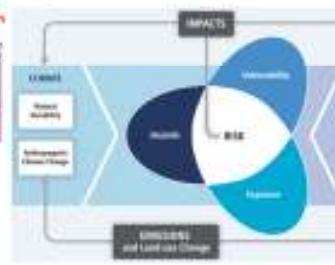
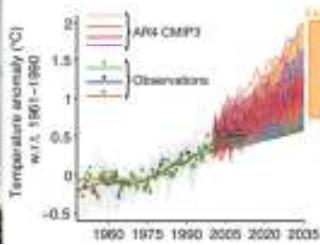
Evaluating alternatives

MEEN 40090
Energy Systems & Climate Change

WJS 5a.19



Energy Systems & Climate Change



Evaluating alternatives

MEEN 40090
Energy Systems & Climate Change

WJS 5a.20