Introduction in Energy Economics

1st TETHYS summer school - Day 4

George Xydis

Funded by
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University of Cyprus

UNIVERSITÀ DEGLI STUDI FIRENZE

NEEST
NEW ENERGY & ENVIRONMENTAL SOLUTIONS AND TECHNOLOGIES

AARHUS BSS

Who AM I?

EngTech

Conducts research within technology and engineering.

CET

Focuses on the development of new and innovative energy systems for businesses and consumers.

- Wind Projects Development Coordinator at [Iberdrola Renewables](#)
- Wind Project Developer at **Vector Hellenic Windfarms S.A.**
- Researcher in the Center for Electric Power and Energy, at the **Technical University of Denmark**
- As a freelancer, had the chance to work with: the **Green Fund, GSF Capital, Volkswind GmbH**, and other institutes and SMEs
- Since 2017 @ Aarhus University, Dept. of Business Development and Technology (Assoc. Professor until 2022, Full Professor until 2024, & on leave after that)
- Since Nov. 2019, also a Lecturer at **Johns Hopkins University** at Energy Policy and Climate program teaching 425.624 Wind Energy: Science, Technology and Policy.
- Since Jan. 2024, also an Assoc. Professor at the dept. of Mechanical Engineering, University of Peloponnese

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CENTRE FOR ENERGY TECHNOLOGIES
DEPARTMENT OF BUSINESS DEVELOPMENT AND TECHNOLOGY
AARHUS UNIVERSITY

JOHNS HOPKINS UNIVERSITY

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΛΟΠΟΝΝΗΣΟΥ
University of the Peloponnese

IBERDROLA

Technical University of Denmark
Center for Electric Power and Energy
Department of Electrical Engineering

VECTOR

AGENDA

	Duration & Structure
Introduction in Energy Economics	09.00 - 10.00
Energy Policy & Carbon Pricing	10.00 - 11.00
Environmental & Regulatory Barriers	11.00 - 12.00
Oil & Gas Economics: Benchmarking for Renewable Energy Investments	12.00 - 12.45
Lunch Break	12.45 - 13.30
Offshore Wind Economics & Auctions	13.30 - 14.30
Energy Investment Metrics: NPV, IRR, LCOE & LCOH	14.30 - 15.30
Training Session	15.30 - 16.15

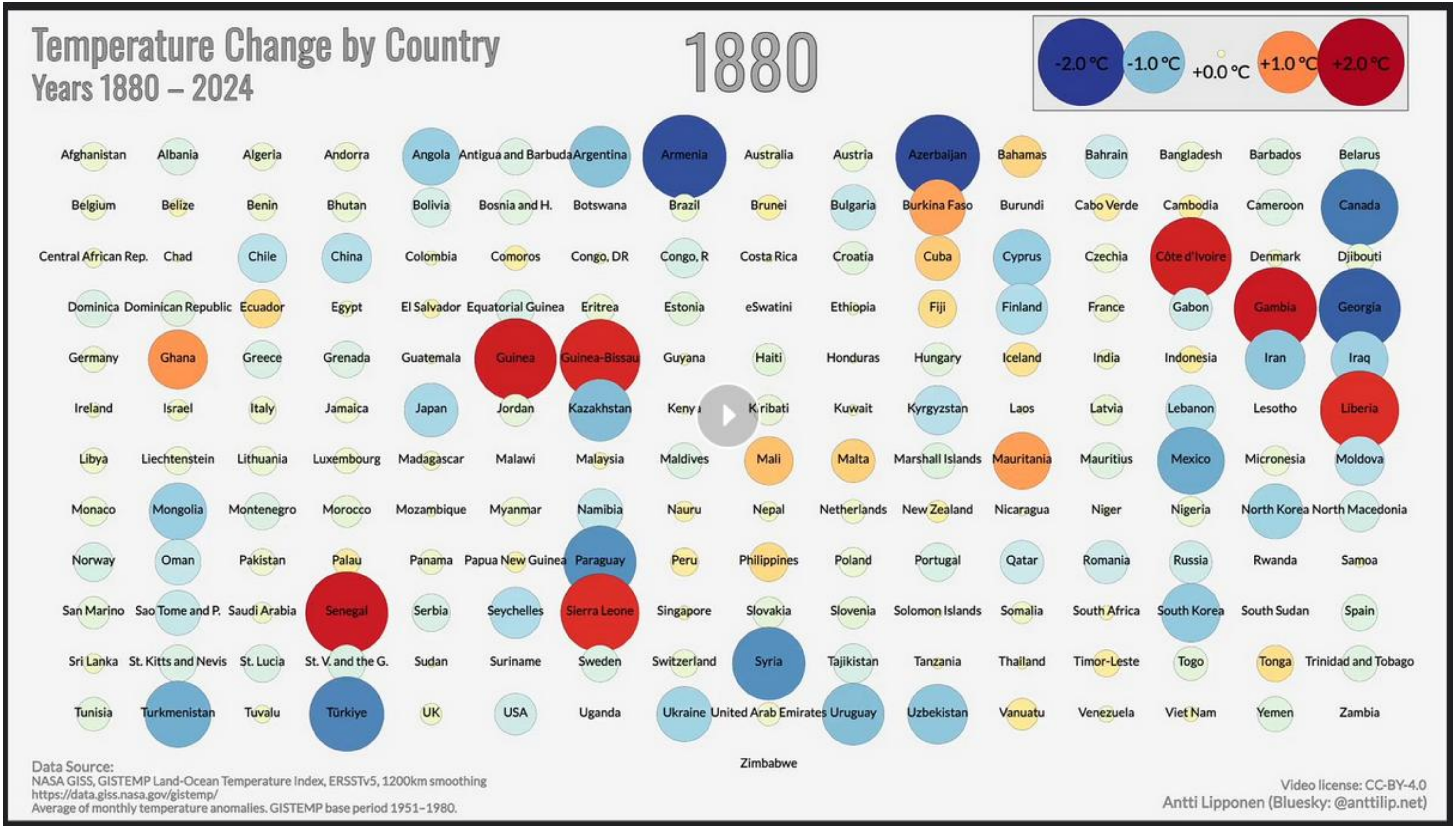
LATEST IPCC REPORT

Three things to know about the latest IPCC Report:

1. Climate emissions are still rising—current government plans aren't ambitious enough. The report details what's needed to address this.

2. It's no longer enough to just cut emissions—**we also need to remove some of the carbon** that's already in the atmosphere.

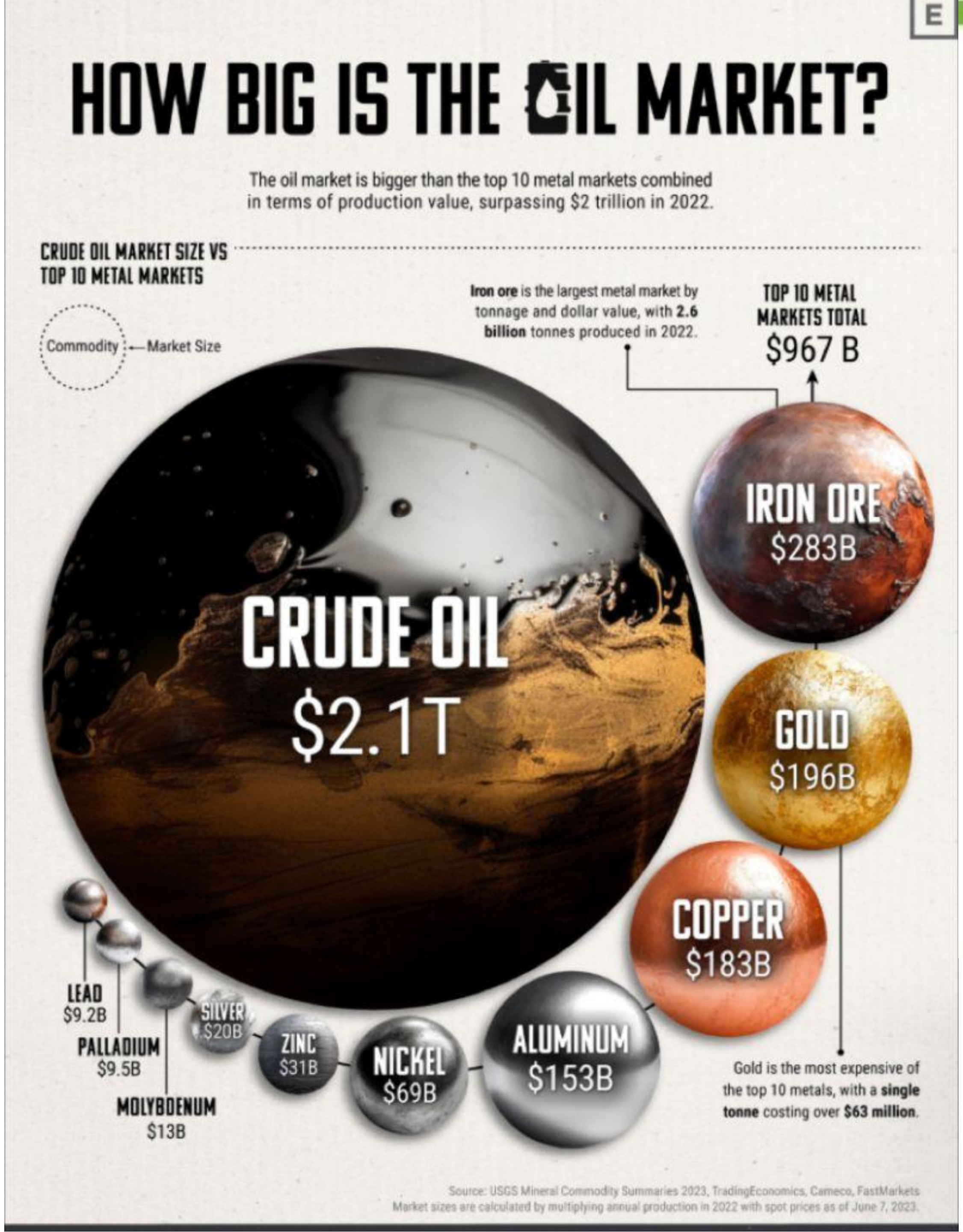
3. If we're going to do this, **we must leverage nature**. Investing in natural climate solutions could provide up to 1/3 of the emission reductions we need–one of our most powerful tools to tackle climate change that is available to us ***right now***.

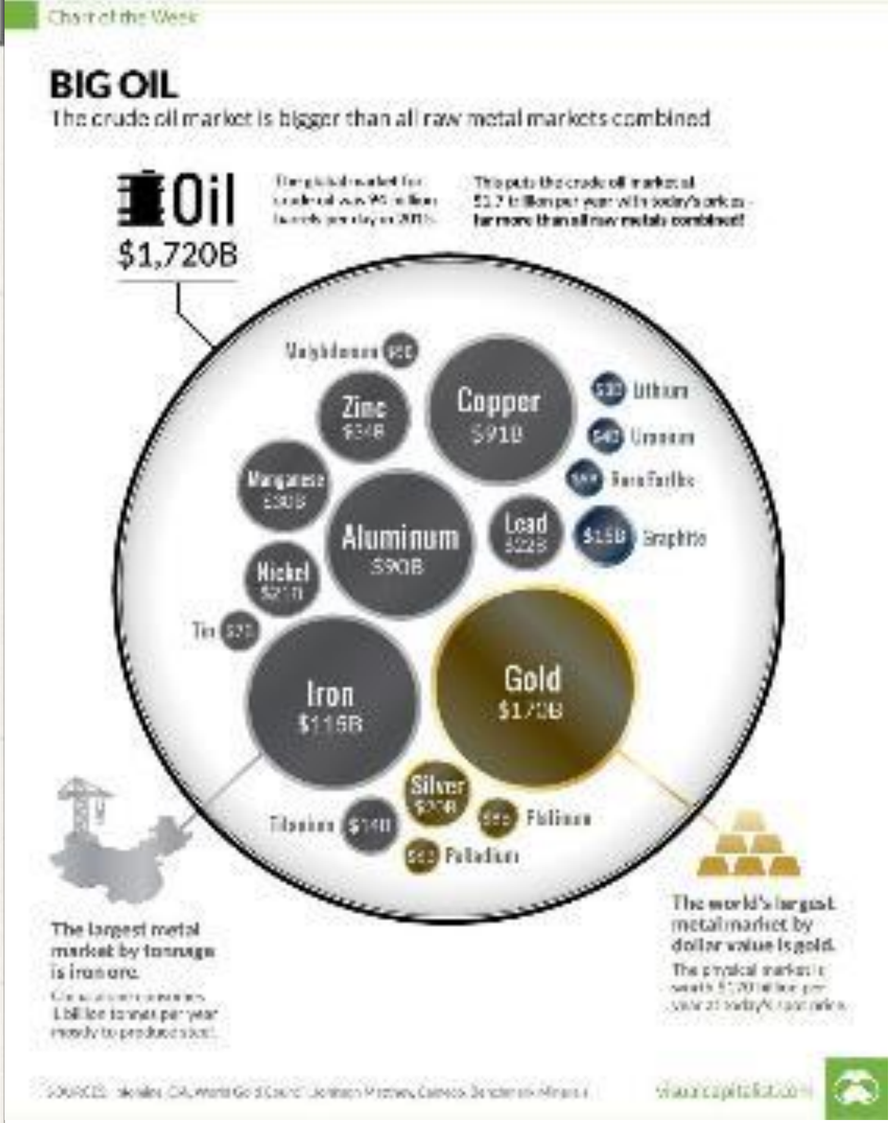


National Oceanic & Atmospheric Administration data by Antti Lipponen,
https://www.flickr.com/photos/150411108@N06/54352976970/

HOW ABOUT THE OIL INDUSTRY?

Too big to fail?





The Transformative Impact of Renewable Energy on Global

Exploring the role of sustainability in contemporary energy markets

Renewable Share

30%

By 2023, **renewables** accounted for over **30%** of global electricity generation, highlighting their growing significance.

Investment Surge

$2Trillion

Investment in **renewable energy** technologies surged to nearly **$2 trillion** globally, reflecting market confidence.

Policy Shift

5 Years

In the last **5 years**, policies favoring **sustainability** have accelerated the transition towards renewables.

Energy Transition

12 States

As of 2023, **12 states** have adopted aggressive renewable energy targets, influencing national market dynamics.

Future Projections

50%

By 2030, it is projected that **50%** of global electricity could come from renewable sources if current trends continue.

Job Creation

1Million

The shift towards **renewables** is expected to create over **1 million** jobs in the energy sector by 2025.

TETHYS

Analyzing Market Volatility in Energy Economics

A detailed overview of price changes and volatility indices

Year	Price per Barrel	Market Volatility Index
2020	$39.73	42.3
2021	$68.29	37.5
2022	$96.10	49.8

A VISUAL CAPITALIST NEWS EXPLAINER

IS IT EASY?

The COVID-19 Oil Crash

Why Prices Went Negative, and Getting Out of the Glut

IS IT EASY TO MOVE AWAY FROM FOSSIL FUELS?

This map shows the current position of tankers, mostly filled with oil. They are “stranded” around the world because there is no way to unload, since onshore warehouses are full, pipelines are full, and without flow, due to the low demand for oil.

Navigating Regulatory Challenges in Energy Markets

Exploring how regulations impact sustainable energy transitions and market structures

Regulatory Diversity

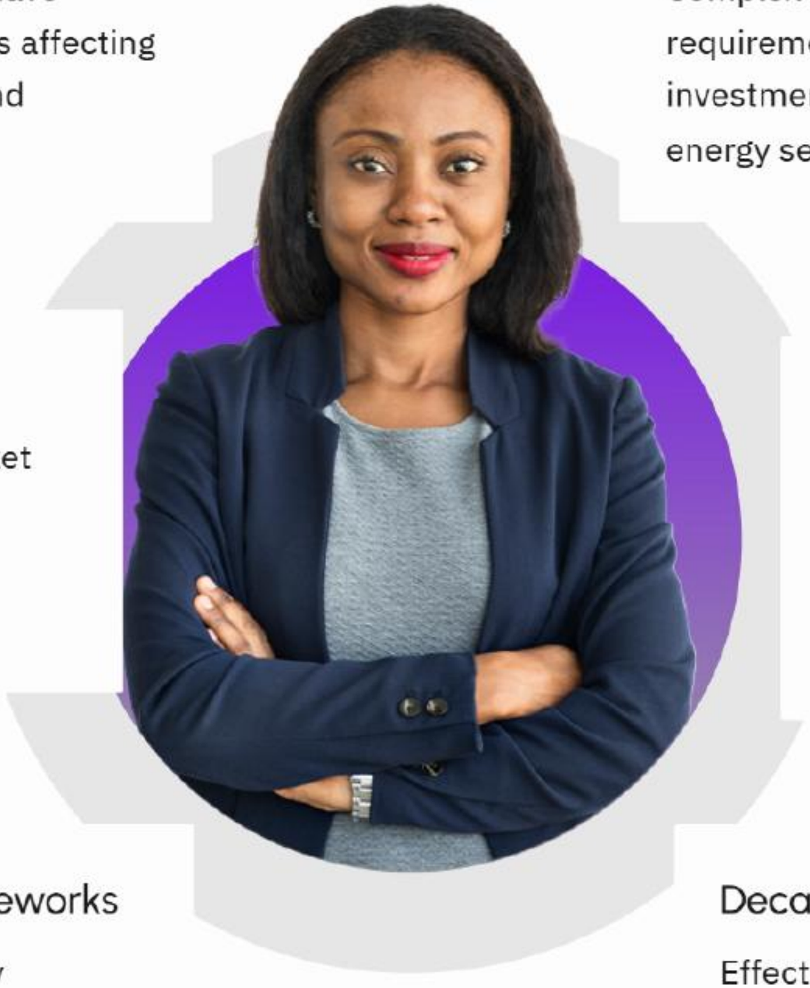
Different regions have varying regulations affecting energy markets and innovations.

Compliance Burdens

Complex compliance requirements can deter investment and innovation in energy sectors.

Market Structures

Regulations shape market structures, influencing competition and sustainability efforts.



Innovation Stifling

Restrictive regulations may hinder technological advancements in renewable energy.

Facilitating Frameworks

Adaptive regulatory frameworks can promote investment in sustainable energy technologies.

Decarbonization Goals

Effective regulations are essential for achieving decarbonization and sustainability targets.

The Critical Role of Government Policies in Energy Transition

An analysis of effective instruments like subsidies, tariffs, and carbon pricing

The European Green Deal Investment Plan aims to mobilize over €1 trillion in sustainable investments to achieve the EU's 2050 climate neutrality goal. Key financial tools include the Recovery and Resilience Facility (RRF), which requires 37% of its financing to support climate goals, and the Just Transition Fund, providing €19.3 billion to support regions heavily reliant on fossil fuels.

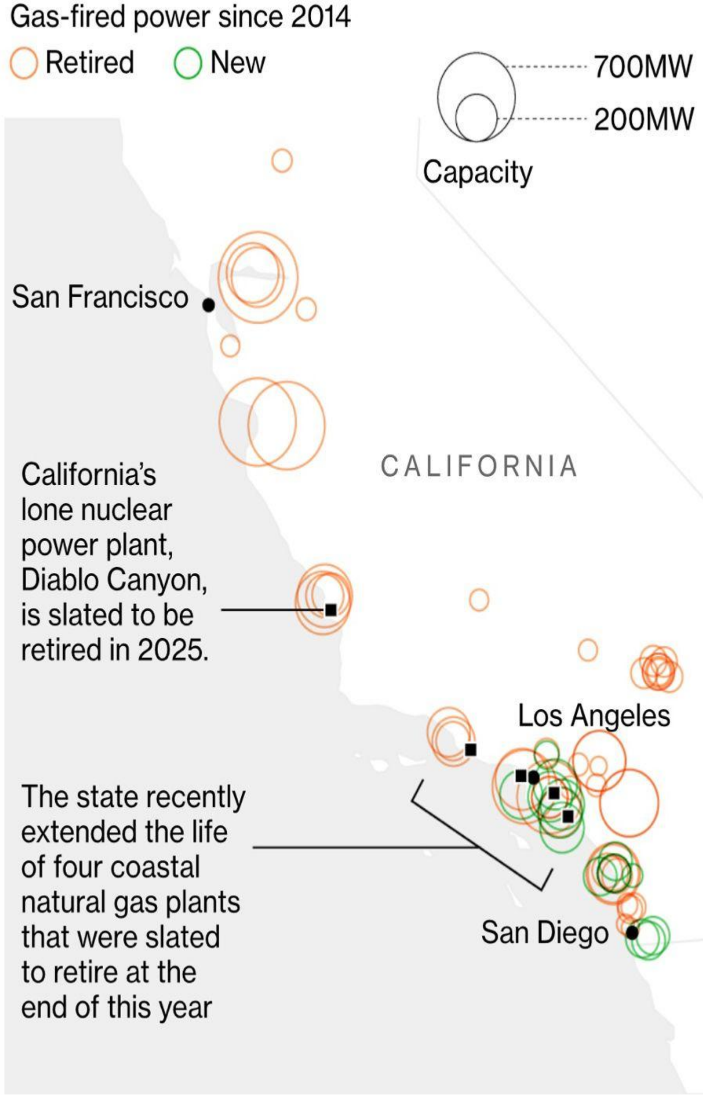
Government policies are crucial

Government policies significantly influence the pace of the transition to renewable energy, acting as catalysts for necessary changes in market dynamics and investments.

EASY? THE EXAMPLE OF CA

Nukes, Gas Fading Fast in California

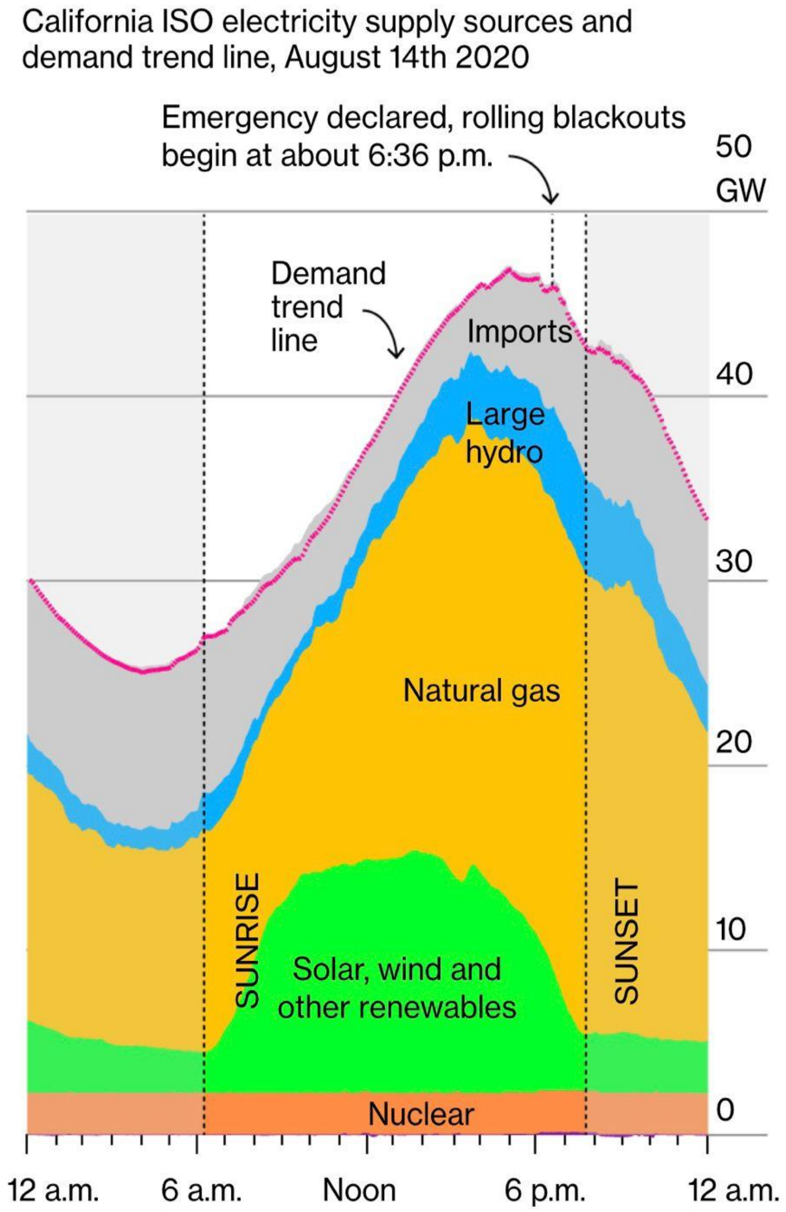
Since 2013, natural-gas generator capacity has dropped about 20% from a peak of 49 GW. The state's last nuclear plant may close in 2025.



Sources: California Energy Commission, Energy

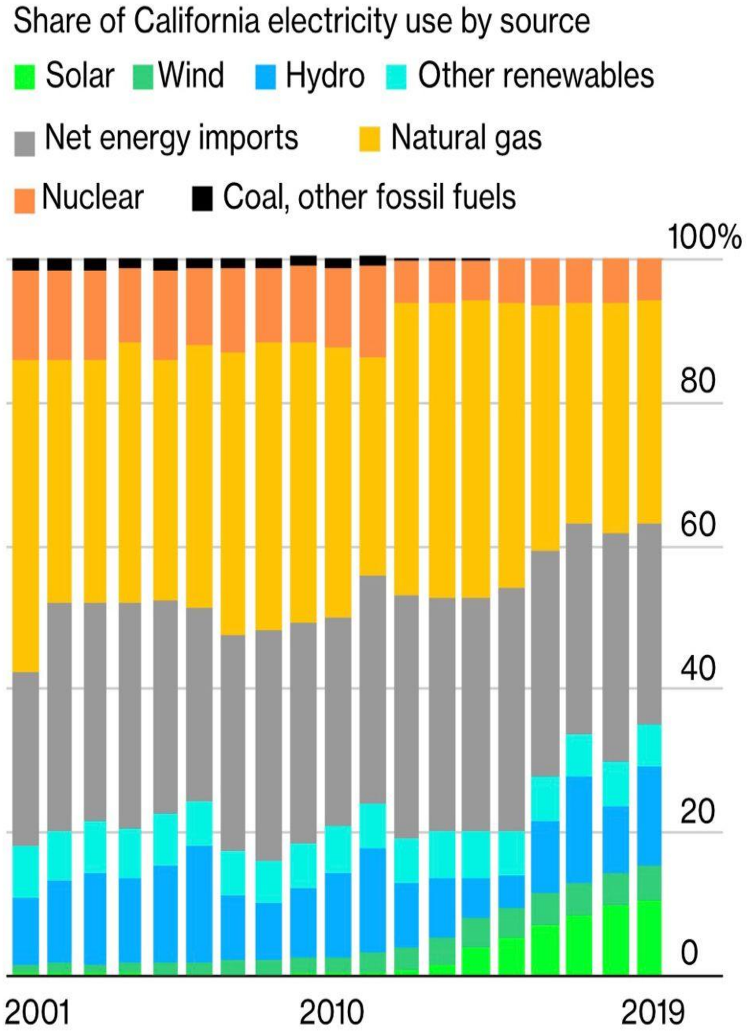
Twilight Emergency

As solar output ebbed at sundown, California fell short on power Aug. 14



Wanted: Big Batteries

California needs storage systems as it turns more to wind, solar



Source: California Energy Commission

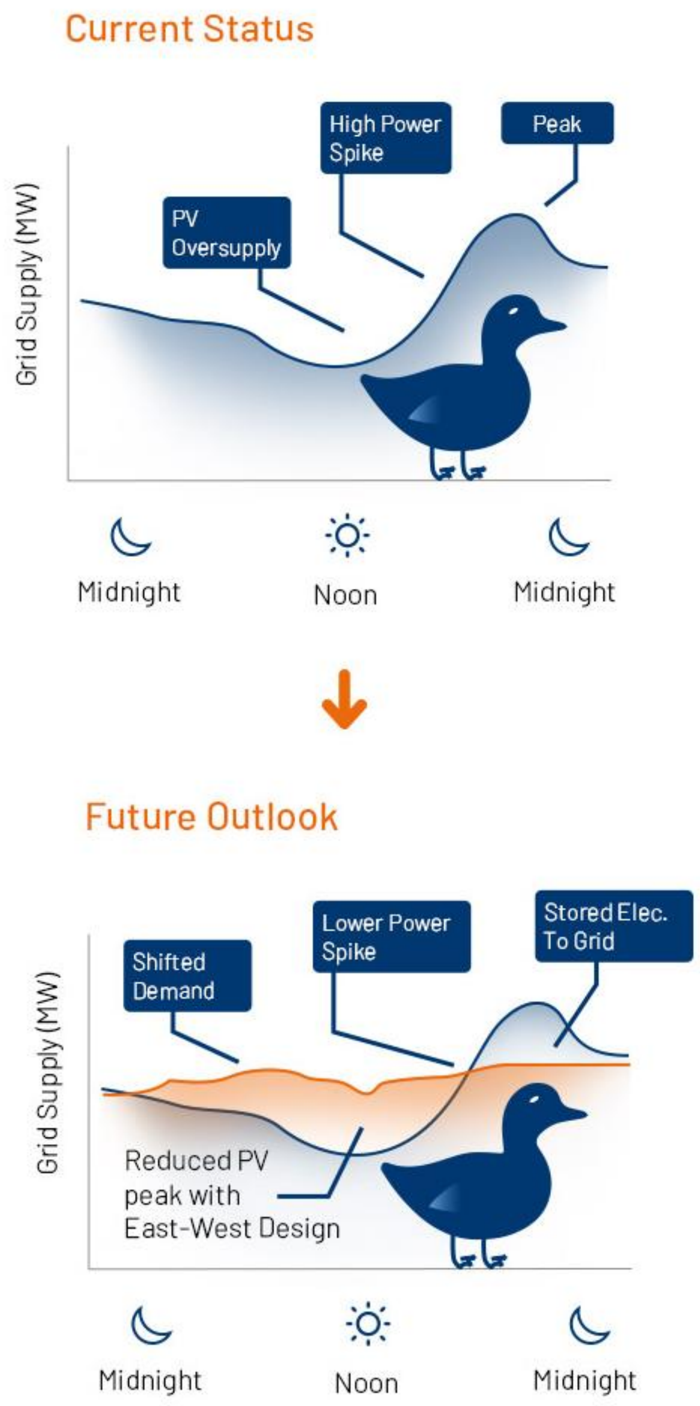
Note: Other renewables: biomass, geothermal. Other fossils: waste heat, petroleum coke, oil

DUCK TALES

Myth:6

The duck curve, which shows a late afternoon load spike as large amounts of solar energy go offline coincidentally during the evening peak electricity demand, will be very difficult and expensive to solve

Increased demand side management coupled with short-term balancing and electrical storage (possibly making use of electric vehicles adjusting their charging practices) can solve this problem without causing instability in the grid.



EASY? THE EXAMPLE OF CA

Mark Jacobson · Following
Stanford U Professor-Civil & Environ Eng, Director-Atmos/Energy Progr...
1w ·

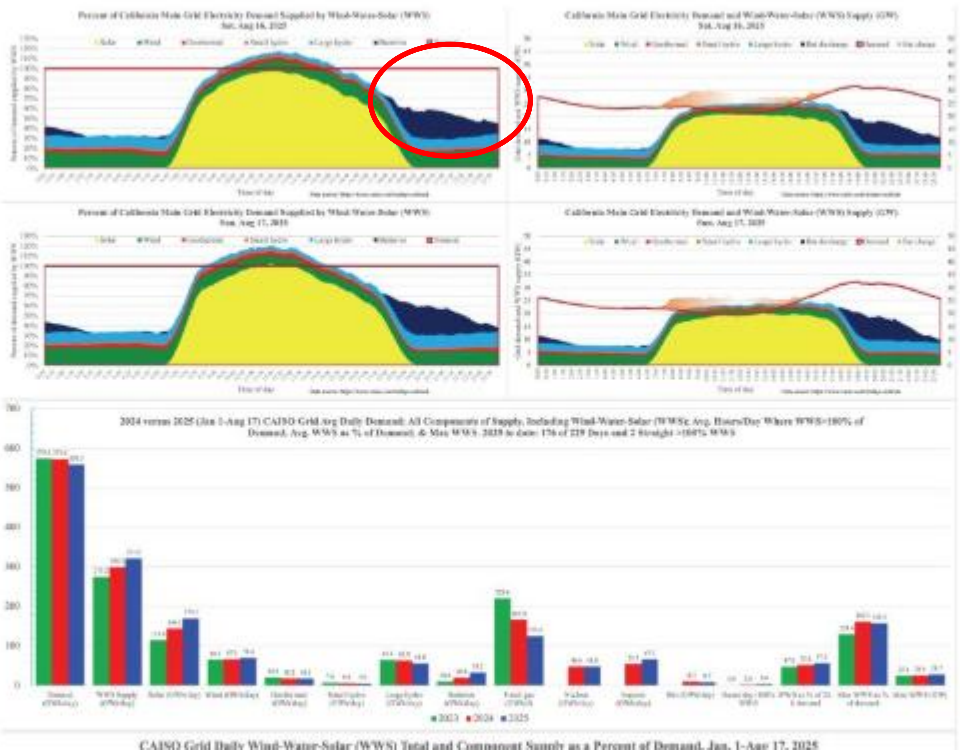
California on pace to become 100% WindWaterSolar 24/7/365 by 2033

57.5% of all demand in 2025 met by WWS, vs 52.4% in 2024.

2 more >100% WWS days for 176 of 229 (76.9%) in 2025

Gas down 25% v '24 & 43% v '23

Demand down 2.4% v '24 & 2.6% v '23 despite more EVs, heat pumps, AI



Electricity Price Determination in Market Systems

The "Merit Order“?

Lowest cost bids first: Renewable energy (wind, solar, which have near-zero marginal cost) and nuclear.

Middle bids: Coal plants.

Highest bids: Natural gas "peaker" plants (used only when demand is very high).

California's Renewable Energy Initiatives and Economic Impact

Exploring policies, investments, and job creation in California's clean energy sector

Clean Energy Goal

100%

California aims to achieve **100%** clean energy by **2045**, setting a benchmark for other states.

Jobs Created

1.5M

The renewable energy sector is projected to create **1.5 million** jobs by **2030**, enhancing economic growth.

Investment Growth

$100B

Investment in renewable energy initiatives is expected to exceed **$100 billion** by **2030**.

Renewables Share

40%

Currently, **40%** of California's energy comes from renewable sources, showcasing significant progress.

Emission Reduction

20%

Policies aim for a **20%** reduction in greenhouse gas emissions by **2030**, promoting sustainability.

Average Wage

$25/hr

Jobs in the renewable energy sector offer an average wage of **$25/hour**, competitive with other industries.

DIVE BRIEF

Renewables make up 91% of the 15 GW of generation the US added in first 5 months of 2025: FERC

"Solar continues to deliver new power to the grid faster and cheaper than any other source of electricity," said Stephanie Bosh, senior vice president of communications for SEIA.

Published Aug. 27, 2025

- The United States added more than 15 GW of new electricity generation resources between January and May this year, led by 11.5 GW of solar, followed by 2.3 GW of wind and 1.3 GW of gas, according to the Federal Energy Regulatory Commission's monthly infrastructure report.

- Gas still constitutes 43% of the country's total generating capacity, according to the report. Coal is just shy of 15%; solar is a little over 11%; wind is 11.8%; and nuclear is 7.7%.

TETHYS

The Critical Role of Government Policies in Energy Transition

An analysis of effective instruments like subsidies, tariffs, and carbon pricing

REMINDER

Government policies are crucial

Government policies significantly influence the pace of the transition to renewable energy, acting as catalysts for necessary changes in market dynamics and investments.

Germany's Energiewende: Successes and Challenges

Exploring the impact of Germany's Energiewende on renewable energy and emissions reduction

45%

Renewable energy share in 2020

As of 2020, Germany achieved a **45%** share of renewable energy in its total electricity consumption, showcasing significant progress in its energy transition.

40%

Emissions reduction since 1990

Since the inception of the Energiewende, Germany has reduced its greenhouse gas emissions by **40%** compared to 1990 levels, highlighting effective climate policy.

1.5million

Jobs created in renewables

The Energiewende has led to the creation of over **1.5 million** jobs in the renewable energy sector, contributing to economic growth and sustainability.

€5billion

Annual investments in renewables

Germany invests approximately **€5 billion** annually in renewable energy technologies, driving innovation and infrastructure development.

2,022

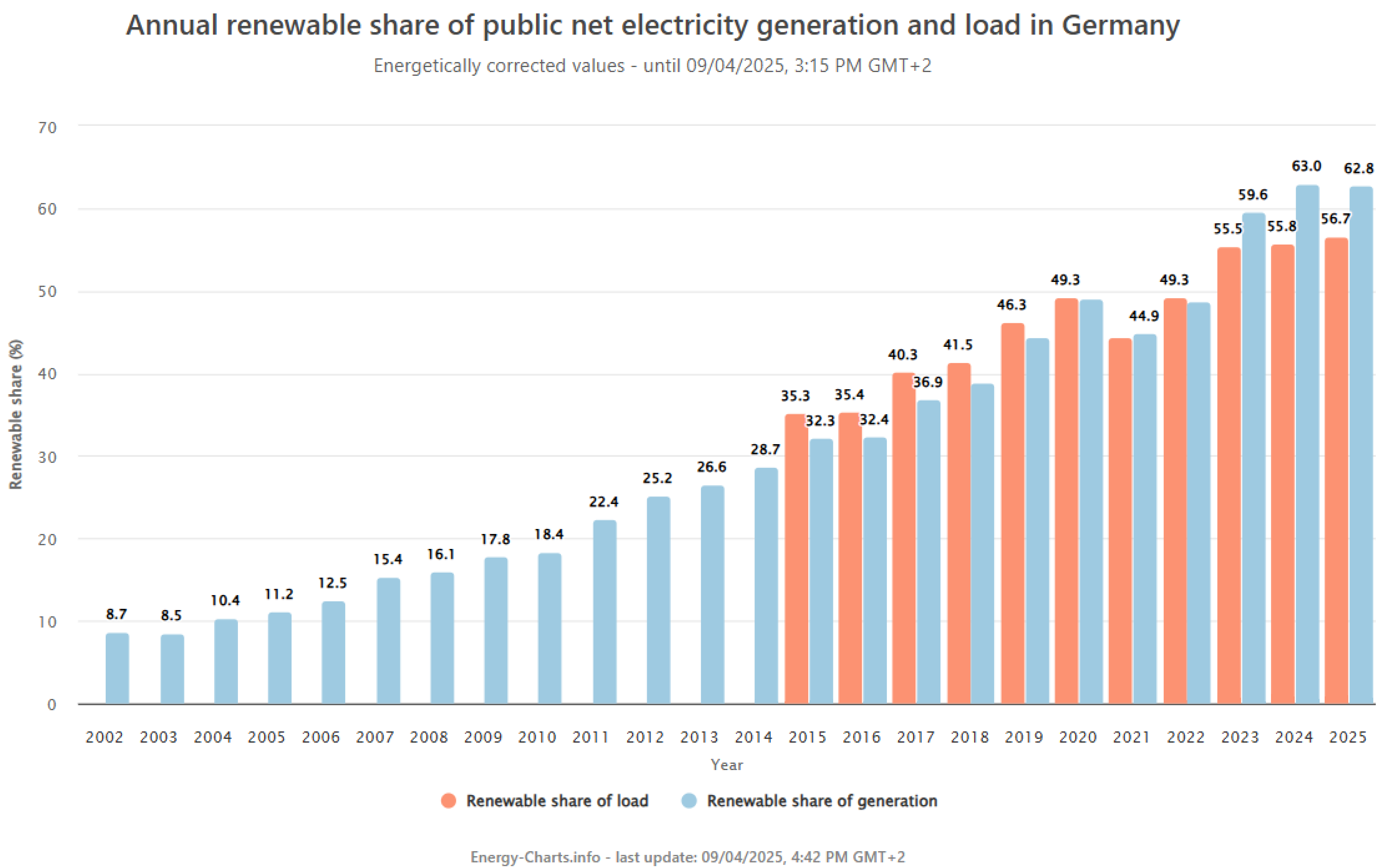
Target year for 65% renewables

Germany aims to achieve a **65%** share of renewables in electricity generation by **2022**, reflecting ambitious goals for energy transition.

10%

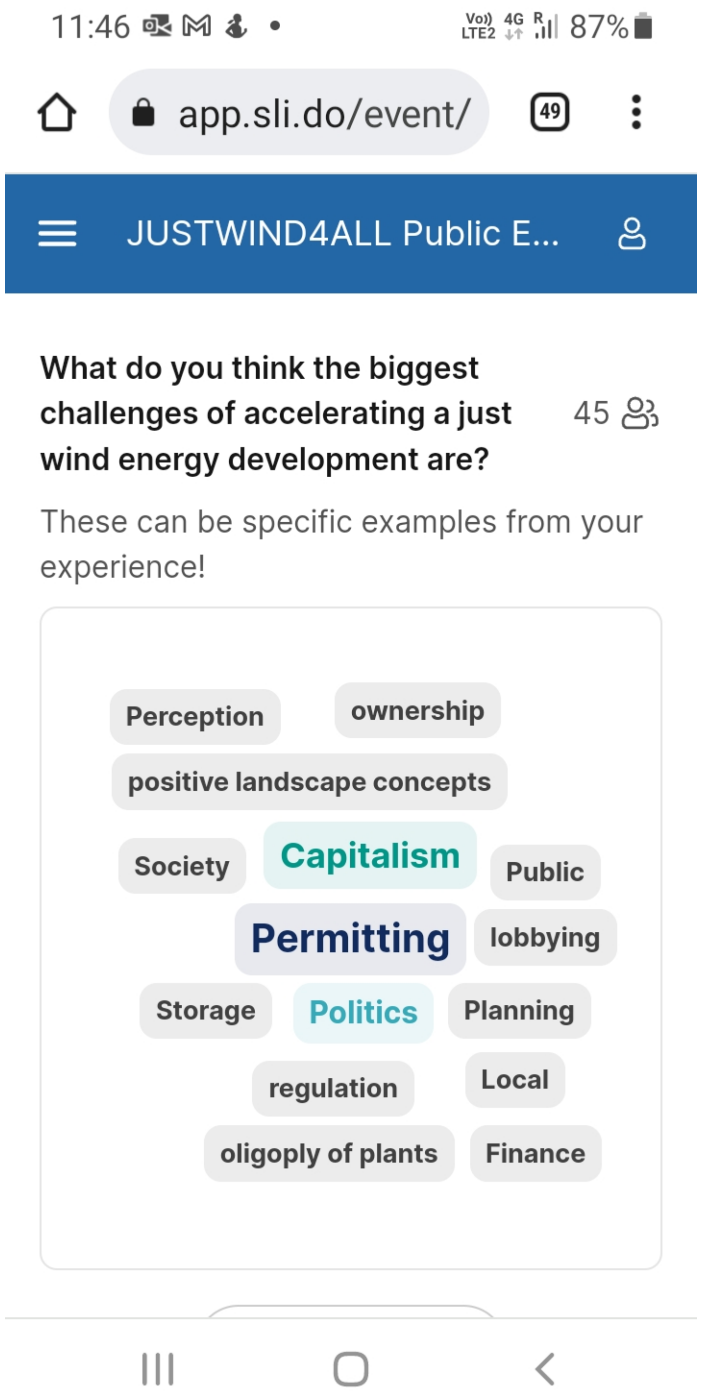
Energy savings from efficiency

Through energy efficiency measures, Germany has achieved **10%** in energy savings, underscoring the importance of integrated energy policies.



Annual renewable share of public net electricity generation and load in Germany
Energetically corrected values - until 09/04/2025, 3:15 PM GMT+2
Renewable share (%)
70
60
50
40
30
20
10
0
8.7
8.5
10.4
11.2
12.5
15.4
16.1
17.8
18.4
22.4
25.2
26.6
28.7
35.3
32.3
35.4
32.4
40.3
36.9
41.5
46.3
49.3
44.9
49.3
55.5
59.6
55.8
63.0
56.7
62.8
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025
Year
Renewable share of load
Renewable share of generation
Energy-Charts.info - last update: 09/04/2025, 4:42 PM GMT+2

IS IT EASY?


11:46
87%
app.sli.do/event/
JUSTWIND4ALL Public E...
What do you think the biggest challenges of accelerating a just wind energy development are?
45
These can be specific examples from your experience!
Perception
ownership
positive landscape concepts
Society
Capitalism
Public
Permitting
lobbying
Storage
Politics
Planning
regulation
Local
oligoply of plants
Finance


Energiequelle GmbH
1,291 followers
4d • Edited •
✓ Following
Unbelievable! 75 folders were necessary for the BimschG application in our German repowering project Moorhusen (East Frisia). Here, 10 wind turbines of the type GE 5.5 with a rotor diameter of 158 m are to be built in the 1st construction phase.
Dear energy policy: this is not the way to solve the climate crisis. Permits must be made easier!
#klimakrise #energytransition #windenergie #windpower #windkraft #erneuerbareenergien
87 · 4 comments

CASE OFFSHORE WIND ELECTRICITY GRID GREEN HYDROGEN +8

Energy island – the Baltic sea's nodal point for intelligent energy

11. OCTOBER 2022

Solution provider

ENERGINET

Energinet is an independent public enterprise owned by the Danish Ministry of Climate, Energy and Utilities. We own, operate and develop the transmission systems for electricity and natural gas in Denmark.

MORE FROM ENERGINET

Want to see this solution first hand?

Add the case to your visit request and let us know that you are interested in visiting Denmark

REQUEST VISIT

Denmark's $34BN Energy Islands Could Solve Europe's Power Problem

The Brussels Times

Denmark delays construction of North Sea energy island by three years

Denmark delays construction of North Sea energy island by three years ... Denmark has postponed its North Sea energy island project by at least...

Aug 24, 2024

EU Energy
10,661 followers
3h •

+ Follow ···

Commissioner Dan Jørgensen represented the European Commission today in the signature ceremony for a €645.2 million grant agreement on the Bornholm Energy Island hybrid offshore project. ...more

25 5 comments · 6 reposts

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TETHYS

ENERGY POLICY OR ENERGY POLITICS?

energynews.pro

Swedish Defense Blocks Offshore Wind Farms in the Baltic Sea

Offshore wind farm projects in the Baltic Sea are deemed incompatible with Sweden's national defense due to the disruptions they would cause to critical...

Nov 28, 2024

Review Energy

Sweden halts 13 offshore wind farms in the Baltic Sea due to national security concerns

OffshoreWIND.biz

Denmark Unveils Plan for Up to 3.8 GW Bornholm Energy Island

The Danish Energy Agency (DEA) has revealed its Plan for Program Bornholm Energy Island, outlining the framework for the future energy...

May 14, 2024

We've started BUILDING EVERYwhere, with no CONTROL

Himanshu Tewari • 2nd
TESLA (Energy Storage Management Team)
1w •

+ Follow

This is the result incase the Monoline trackers fails to align in the stow (horizontal flat) position during strong winds. #riskmanagement #rootcauseanalysis #solarfarm

Tanja Matko
August 12 at 5:05 PM ·

Spodaj na fotografiji je litijevo polje v Čilu. Če ptica pristane na enem od teh bazenov, umre že zaradi stika, saj je litij nevrotoksin.

Čile, ki je drugi naj... **See more**

> Below in the photo is a lithium field in Chile. If a bird lands on one of these pools, it dies from contact, because lithium is a neurotoxin.
>
> Chile, which is the second-largest lithium producer in the world, is struggling with water supply problems (ie.e. they don't have drinking water), because the water is used to produce lithium batteries for electric cars and mobile devices. 2000 tons of water are used to obtain one ton of lithium.
> In addition to lithium, batteries for electric cars also contain cadmium, mercury and lead (and many other substances).

Energy Efficiency

Harnessing Energy Efficiency Across Sectors

Exploring cost-effective strategies for reducing greenhouse gas emissions through efficiency practices

Potential Emission Cuts

30%

Implementing energy efficiency measures can lead to **30%** reduction in greenhouse gas emissions across various sectors, highlighting the importance of adopting these practices.

Cost Savings Potential

$500billion

Enhancing energy efficiency could save businesses and households over **$500 billion** annually, demonstrating the financial benefits of adopting sustainable practices.

Residential Savings

25%

Residential energy efficiency improvements can yield savings of up to **25%** on energy bills, making it a critical area for investment and policy focus.

Industrial Efficiency Gains

20%

The industrial sector can achieve efficiency gains of **20%**, significantly reducing operational costs and contributing to lower emissions.

Transportation Impact

15%

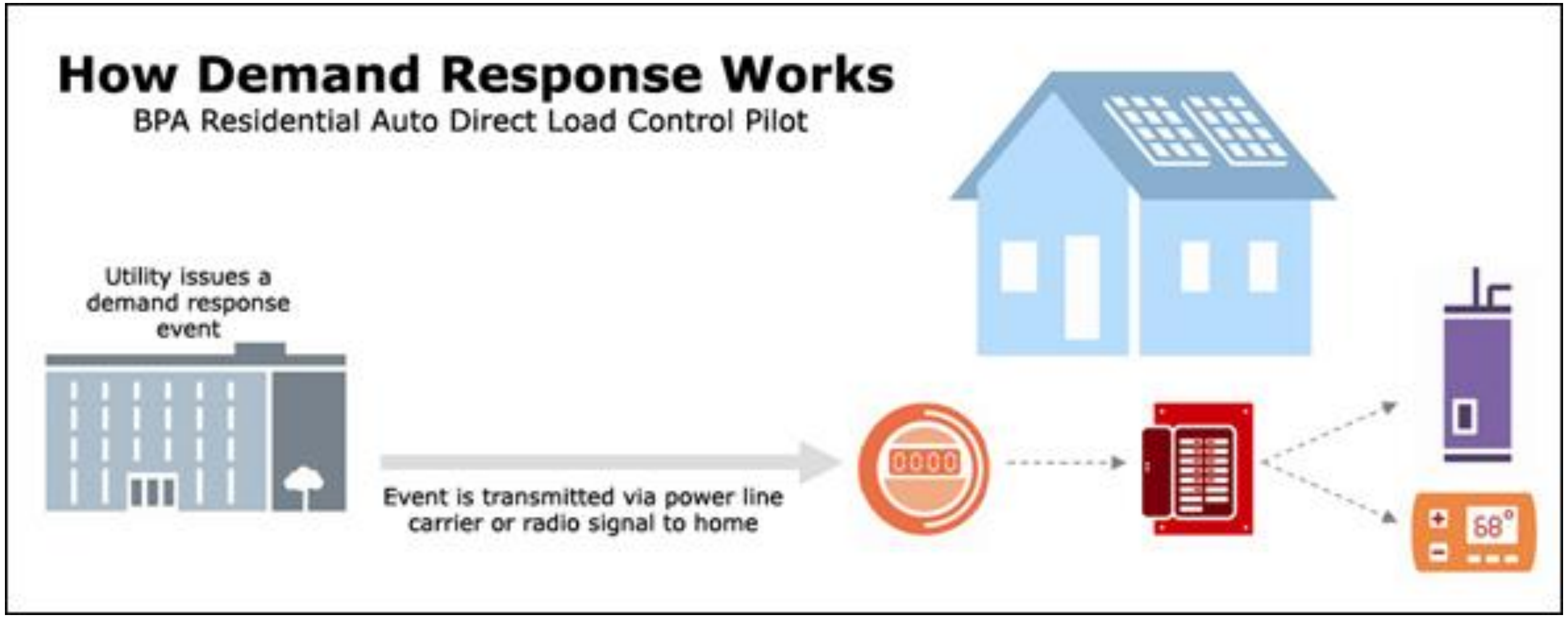
Transportation energy efficiency measures can reduce fuel consumption by **15%**, underscoring the need for innovations in this area.

Global Potential

40%

Globally, energy efficiency has the potential to cut energy demand by **40%** by 2030, showcasing its role in sustainable development.

Demand Side Management & Demand Response



Flex your power

In California ISO, there is the program ‘flex your power’ , Participants, **receive a monthly bill credit of $7 per kW** for agreeing to reduce demand by a pre-determined amount - 15% or 100 kW, whichever is higher — during emergency situations (“Flex Alert” programme)

Most people sign-up to receive Flex Alert notifications via email and on mobile phone and soon after the call they:

turn off all unnecessary lights, computers and appliances

2) postpone using major appliances until after 7 p.m.

3) turn air conditioning thermostat to 25.5° C or higher (California ISO, 2011).

The Critical Role of Government Policies in Energy Transition

An analysis of effective instruments like subsidies, tariffs, and carbon pricing

REMINDER

Government policies are crucial

Government policies significantly influence the pace of the transition to renewable energy, acting as catalysts for necessary changes in market dynamics and investments.

Economic Implications of Smart Grids

Exploring cost savings, efficiency, and investment trends in energy distribution

$100billion

Projected investment by 2025

Significant growth in smart grid technologies expected.

15%

Reduction in operational costs

Cost efficiency through optimized energy distribution.

30%

Increase in renewable integration

Enhanced ability to incorporate renewable energy sources.

20%

Improvement in reliability

Greater resilience against outages.

$5.5trillion

Global market potential

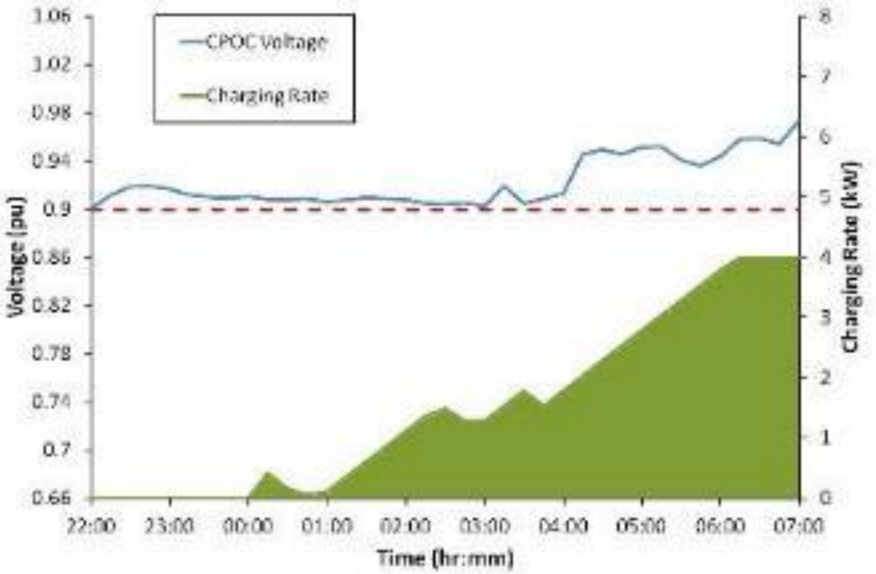
Expansive future for smart grid investments.

80%

Consumer engagement increase

Higher participation in energy management programs.

Electromobility, ELECTRICITY MARKETS, & Demand Response



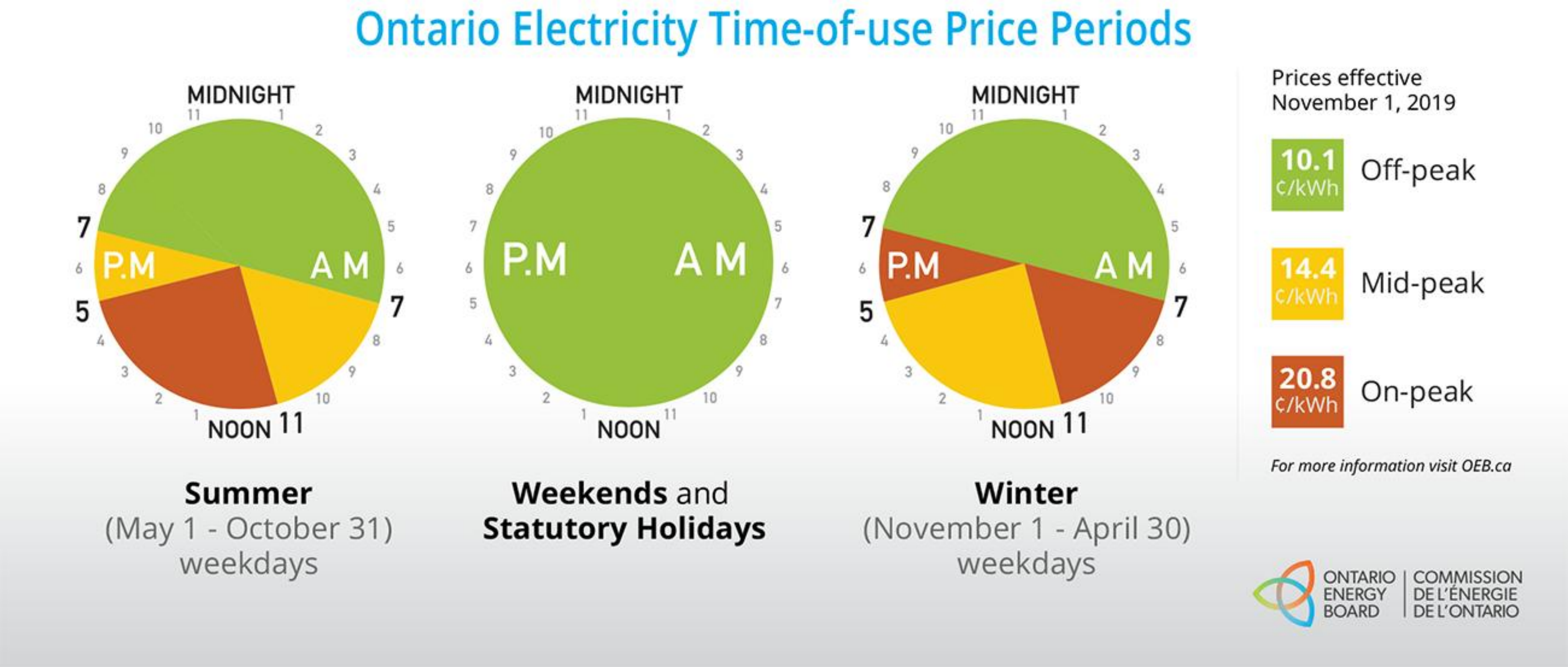
For the User

- Energy Cost Management
- Motivation for participation
- Net metering

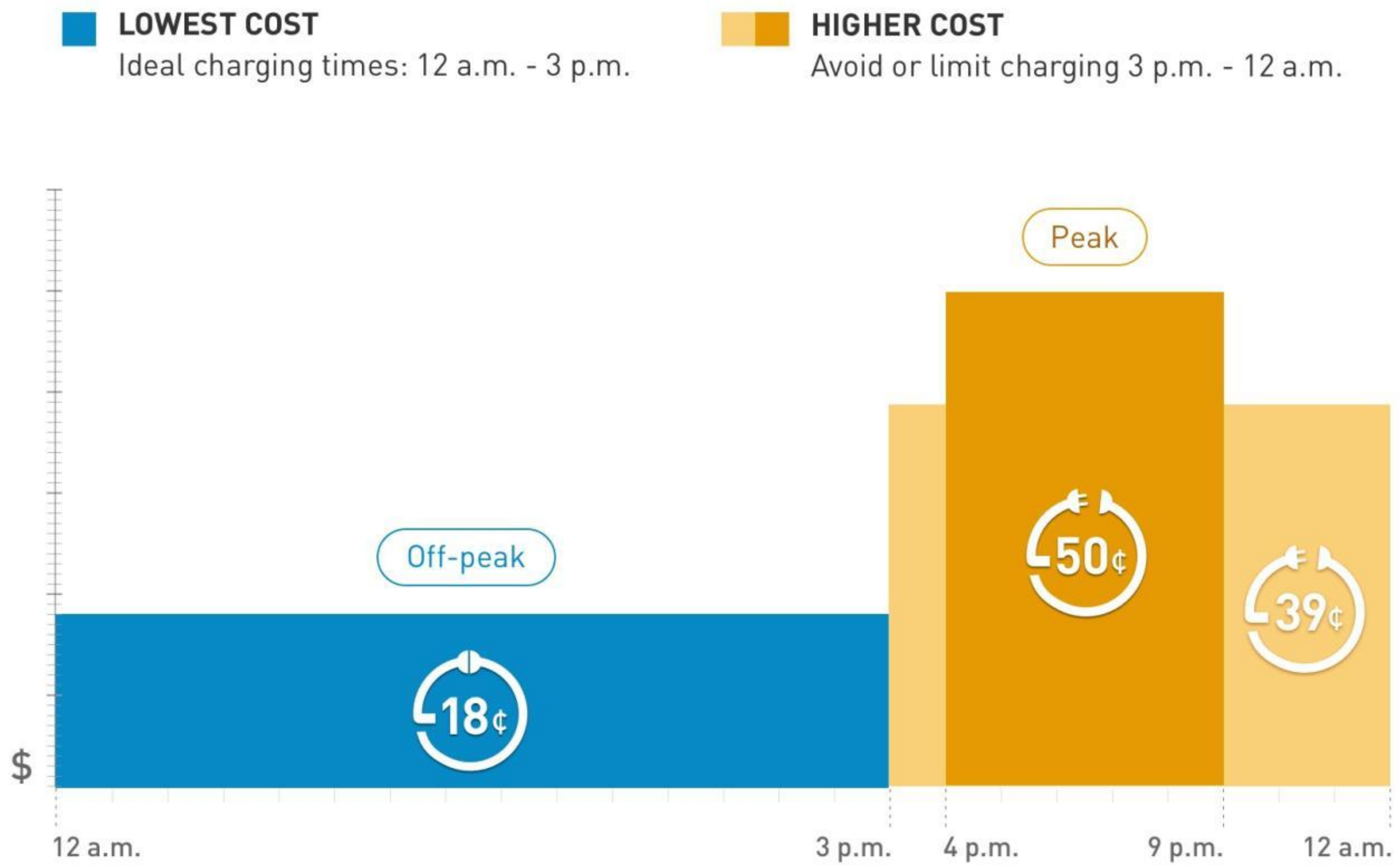
For the Grid

- RES Storage
- Load shifting, Ancilliary Services
- RES Integration

Time-OF-USE


Ontario Electricity Time-of-use Price Periods
MIDNIGHT
P.M
A M
7
5
NOON 11
Summer
(May 1 - October 31)
weekdays
MIDNIGHT
P.M
A M
NOON
Weekends and
Statutory Holidays
MIDNIGHT
P.M
A M
7
5
NOON 11
Winter
(November 1 - April 30)
weekdays
Prices effective
November 1, 2019
10.1 ¢/kWh
Off-peak
14.4 ¢/kWh
Mid-peak
20.8 ¢/kWh
On-peak
For more information visit OEB.ca
ONTARIO ENERGY BOARD
COMMISSION DE L'ÉNERGIE DE L'ONTARIO

Time-OF-USE: Can they be better?



Essential Skills for Future Energy Economists

Key competencies for energy economists in a changing landscape

Data Analysis Expertise

Energy economists must possess strong **data analysis** skills to interpret complex datasets effectively.

Policy Evaluation Abilities

Evaluating energy policies requires critical thinking and an understanding of **economic impacts**.

Technological Literacy is Crucial

Familiarity with emerging technologies is essential for adapting to new energy solutions and frameworks.

Embrace **Adaptability**

Energy economists must be flexible to adjust to evolving market conditions and **regulatory changes**.

Commitment to **Continuous Learning**

A mindset of ongoing education is vital to keep pace with rapid advancements in energy economics.

Yesterday's customer is today's prosumer and tomorrow's prosumager

LAST BIT?

ENGAGING COMMUNITIES FOR SUSTAINABLE DEVELOPMENT

The Role of Stakeholders in Wind Project Success

01

UNDERSTANDING THE REGULATORY LANDSCAPE

A comprehensive grasp of regulations is essential for successful deployment.

- **FOSTERING LOCAL SUPPORT**
  Involving local communities from the start nurtures trust and support for floating wind projects.
- **EDUCATIONAL OUTREACH**
  Providing education on benefits and impacts ensures informed community participation.
- **TRANSPARENT COMMUNICATION**
  Open discussions and information sharing help mitigate concerns and build relationships.
- **ECONOMIC BENEFITS**
  Supporting local economies through job creation enhances project acceptance and social responsibility.
- **SOCIAL RESPONSIBILITY INITIATIVES**
  Implementing initiatives that prioritize local needs strengthens community ties and project viability.


THE ENERGY WORLD IS BECOMING SMARTER THAN YOU.
CAN YOU HANDLE THIS?

THANK YOU

QUESTIONS?

Energy Policy & Carbon Pricing

1st TETHYS summer school - Day 4

George Xydis

Funded by
the European Union

University of Cyprus

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AARHUS BSS

Understanding Energy Policy and Carbon Pricing Mechanisms

This presentation will delve into the intersections of energy policy and carbon pricing, examining their roles in environmental outcomes and economic frameworks, while analyzing effective mechanisms, successful case studies, and future trends essential for advanced PhD students.

Global Energy Demand in 2016:

In 2016, global primary energy demand was approximately **13,800 million tonnes of oil equivalent (Mtoe).** Fossil fuels (oil, coal, and natural gas) dominated the energy mix, accounting for nearly 80% of the total demand.

Global Energy Demand in 2023:

By 2023, global energy demand had risen to around **15,000-15,500 Mtoe**, reflecting a steady increase of about 1-2% per year. The demand growth in 2023 was driven largely by emerging economies, particularly in Asia, Africa, and Latin America. There has been a significant increase in the contribution of renewable energy sources (wind, solar, hydro) to the energy mix, alongside greater emphasis on energy efficiency and decarbonization efforts. However, **fossil fuels still account for about 75-80%** of the energy demand, though their share is slowly declining.

Understanding Energy Policy and Carbon Pricing

Exploring the impact of carbon pricing on sustainability and energy consumption.

Market-based approach

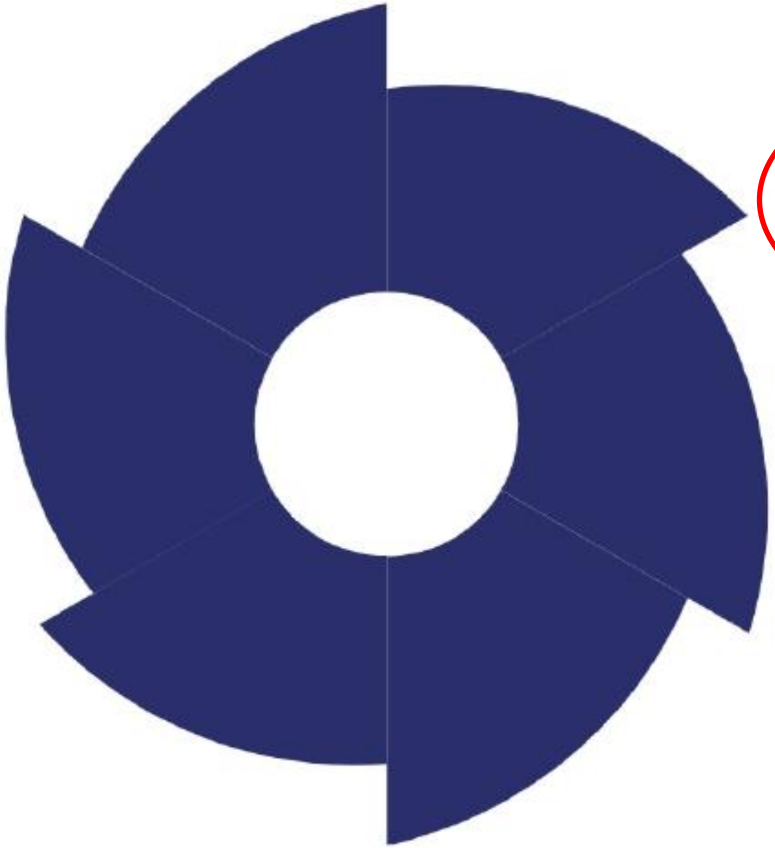
Carbon pricing assigns a cost to **emitting carbon dioxide**, encouraging reduced emissions.

Advantages and challenges

Each system has distinct **benefits** and **challenges** in effective **implementation** and acceptance.

Carbon taxes

These taxes directly charge emitters, incentivizing **lower carbon** outputs and investment in clean energy.



Influences industry behavior

It directly affects how **industries** and **consumers** engage with energy **consumption**.

Historical context

Understanding past **debates** helps contextualize current **energy policies** and their evolution.

Cap-and-trade systems

A key component of carbon pricing, offering **flexibility** for emissions reduction across sectors.

INTERNATIONAL JOURNAL OF SUSTAINABLE TRANSPORTATION
2023, VOL. 17, NO. 2, 118–127
https://doi.org/10.1080/15568318.2021.1992688

Taylor & Francis
Taylor & Francis Group

A behavioral change study in Denmark engaging car drivers in reducing fuel consumption: The key is in the message

Anders Hoffmann, Evanthia Nanaki, Peter Enevoldsen, and George Xydis

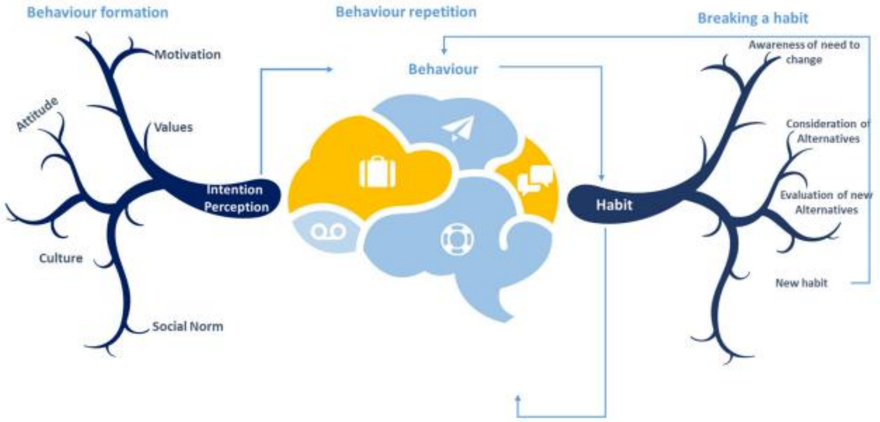
Department of Business Development and Technology, Aarhus University, Herning, Denmark

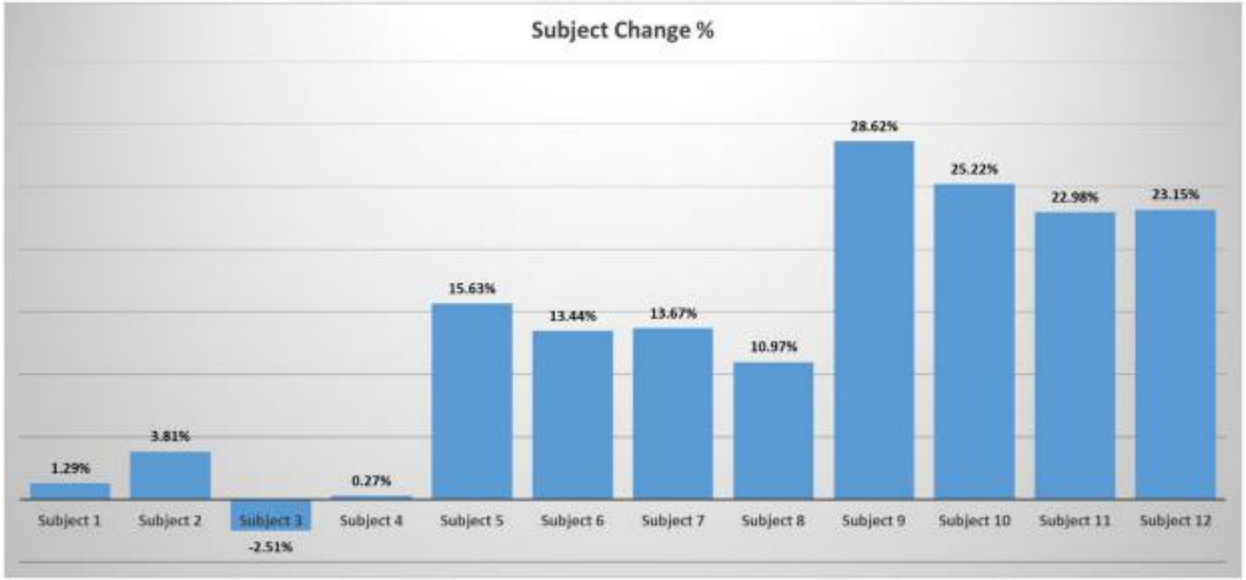
ABSTRACT

Regarding resource scarcity and overpopulation, there is already a large number of sustainable solutions and frameworks available that could help propel the world into a better future. Yet, many of these issues are still left unsettled, which would indicate issues with the implementation of these solutions. Following research on behavioral analysis, a conceptual integrated framework was developed aiming to reveal how and why we can motivate individual consumers to engage in sustainable fuel consumption activities. The framework was tested in Denmark in a 30 days experiment involving 12 voluntary participants, testing their response to energy savings strategies. The results indicate that attitude shifts combined with the promotion of sustainable initiatives can result in a significant decrease in fuel consumption ranging from 13.4% to 25%. Following the experiment, the role of a modern society building on habits that propel its citizens toward their goals while trying to understand why certain habits are holding them back from achieving the desired outcome is elaborated.

ARTICLE HISTORY
Received 27 May 2020
Revised 16 September 2021
Accepted 1 October 2021

KEYWORDS
Behavioral change; energy consumption; energy scarcity; habitual practices; sustainability





. Percentage of each subject's change.

Let's imagine companies operating in a region that has just implemented a carbon price of $50 per tonne of CO_2.

Company A: Coal-Fired Power Plant

Company C: Wind Energy Company

Company B: Natural Gas Power Plant

The carbon price doesn't pick a winner. Instead, it changes the entire playing field. It makes the social cost of pollution a private cost for the emitter. This simple price signal triggers a cascade of decisions across the industry, from daily operations to multi-billion-dollar investment strategies, systematically shifting the entire economy towards a lower-carbon future.

Old Business Model?

Impact of Carbon Price?

Behavioural Changes? Short term and Long term?

Comparing Carbon Pricing Mechanisms: Tax vs. Cap-and-Trade

Exploring key differences between carbon taxes and cap-and-trade systems for effective emissions reduction

Carbon Tax

- Imposes a **direct fee** on emissions.
- Provides **predictable costs** for emitters.
- Encourages **immediate emission reductions**.
- Simplicity in implementation and compliance.
- Revenue can be used for **clean energy projects**.

Cap-and-Trade System

- Creates a **market for emission allowances**.
- Sets a **cap** on total emissions allowed.
- Promotes **flexibility** in emissions reductions.
- Can drive innovation through **market mechanisms**.
- Potential for revenue generation through **allowance auctions**.


TRADING ECONOMICS
Calendar
News
Markets
Indicators
EU Carbon Permits
Summary
Stats
Forecast
Alerts
Export
Search...
1D
Export
API
EU Carbon Permits (EUR) 72.990 +1.270 (+1.77%)
85
80
75
72.990
70
65
60
Dec
2025
Feb
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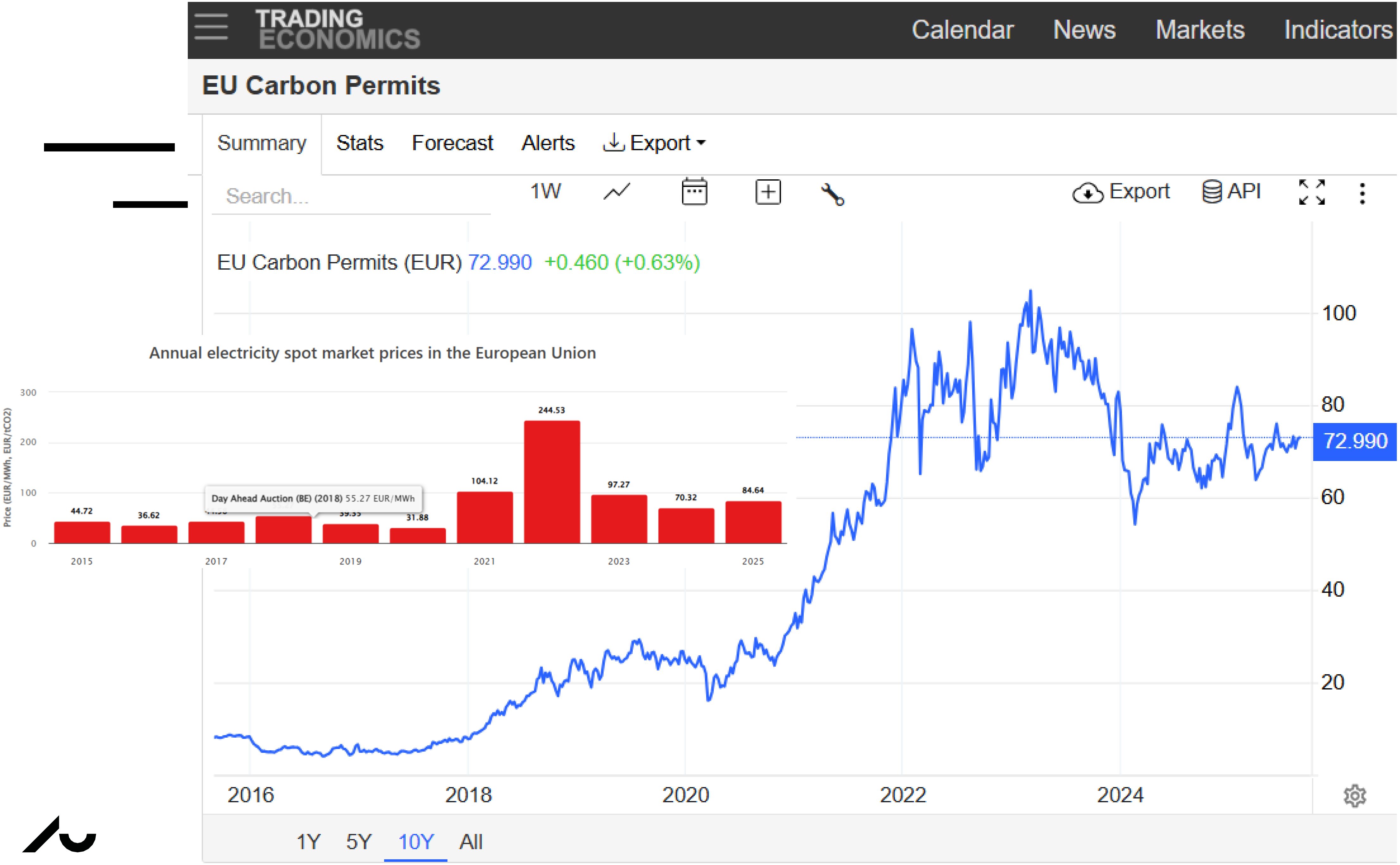
1Y
5Y
10Y
All



TRADING ECONOMICS
Calendar
News
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Indicators
EU Carbon Permits
Summary
Stats
Forecast
Alerts
Export
Search...
1W
Export
API
EU Carbon Permits (EUR) 72.990 +0.460 (+0.63%)
100
80
72.990
60
40
20
2016
2018
2020
2022
2024
1Y
5Y
10Y
All
Annual electricity spot market prices in the European Union
Price (EUR/MWh, EUR/tCO2)
300
200
100
0
44.72
36.62
31.88
104.12
244.53
97.27
70.32
84.64
Day Ahead Auction (BE) (2018) 55.27 EUR/MWh
2015
2017
2019
2021
2023
2025

Exploring the Economic Justification for Carbon Pricing

Understanding how carbon pricing aligns market prices with social costs of emissions

- **Internalizing external costs of emissions**

  Carbon pricing mechanisms aim to **internalize** the **external costs** associated with carbon emissions, thus ensuring that market prices reflect the true **social costs** of environmental degradation.

- **Impact of Pigovian taxes**

  The implementation of **Pigovian taxes** is designed to correct the market failure caused by carbon emissions, encouraging consumers and industries to reduce their **carbon footprint** effectively.

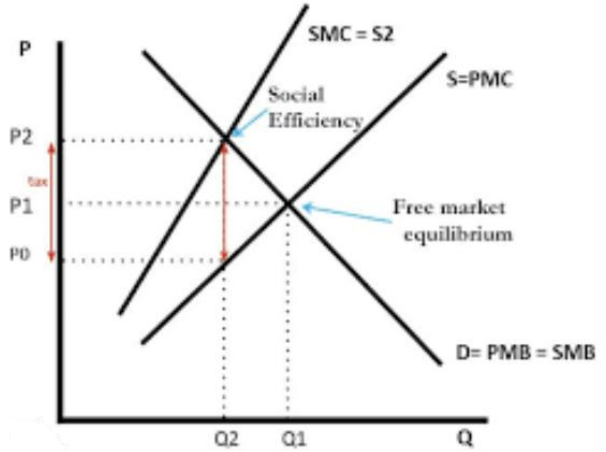
- **Theory of externalities in energy choices**

  Understanding the **theory of externalities** helps illustrate how carbon pricing can shift energy consumption patterns, favoring **renewable energy** over fossil fuels, promoting a sustainable future.

- **Elasticity of demand for energy sources**

  The **elasticity of demand** for fossil fuels compared to renewable energy is crucial in determining how carbon pricing influences consumer behavior and energy market dynamics.

Pigovian taxes



Named after British economist Arthur C. Pigou, these taxes aim to internalize the external costs

Environmental Impacts of Carbon Pricing

Examining the effectiveness of carbon pricing in reducing greenhouse gas emissions

Emissions reduced in pricing regions

25%

Countries implementing **carbon pricing** have observed a **25%** reduction in **greenhouse gas emissions**, demonstrating its effectiveness.

Innovation in renewables driven

40%

Regions with **carbon pricing** have seen a **40%** increase in **technological innovation** within **renewable energy sectors**, fostering sustainable practices.

Emissions intensity decrease

15%

Adoption of **carbon pricing** has led to a **15%** decrease in **emissions intensity** across various countries, highlighting its positive environmental impact.

Timeframe for notable effects

3 years

Significant benefits from **carbon pricing** can often be observed within **3 years** of implementation, as evidenced by various case studies.

Users affected globally

200 million

Approximately **200 million** people benefit from policies influenced by **carbon pricing**, as countries strive for sustainable development goals.

Evaluating Global Carbon Pricing Mechanisms

Analyzing successes and shortcomings of carbon pricing strategies worldwide

40%

EU emissions reductions since 2005

The EU has achieved a 40% reduction in emissions through carbon pricing.

5 KPIs

Key indicators for mechanism evaluation

Five KPIs include emissions reductions, economic growth, and public acceptance.

75%

Public support for carbon pricing

About 75% of the public supports carbon pricing mechanisms.

30%

Lagging emissions in certain regions

Some areas have only reduced emissions by 30% due to weaker pricing.

$22billion

Revenue generated by carbon pricing

Revenue from carbon pricing can exceed $22 billion annually in some regions.

2%

Economic growth linked to carbon pricing

Regions with effective pricing saw a 2% growth in GDP.

Comparative Analysis of Carbon Pricing Successes and Failures

Examining the impact of political and economic factors on carbon pricing

Sweden	High	Strong political support, revenue recycling
British Columbia	Moderate	Localized resistance, gradual implementation
Australia	Low	Policy reversals, lack of consensus

In Australia

Clean Energy Act 2011:

Introduced a fixed carbon price that rose with inflation for the first three years, transitioning to a cap-and-trade system with price floors and caps in 2015.

repeal:

Despite a 7% reduction in covered emissions, the scheme was unpopular and was repealed in 2014, backdated to July 1, 2014, after a change in government.

Current Carbon Pricing Mechanisms

Safeguard Mechanism:

This mechanism sets baselines for the largest emitting facilities and has been reformed to include Safegard Mechanism Credits (SMCs), which reward facilities that reduce emissions below their baseline.

Australian Carbon Credit Unit (ACCU) Scheme:

Under this scheme, projects that reduce or store carbon can earn ACCUs, which can then be sold to other entities. The government purchased ACCUs for the Emissions Reduction Fund (ERF) to fund carbon abatement projects.

Current Proposals and Market Activity

Australian electricity and gas markets

AEMC Recommendation:

The AEMC proposed a "shadow carbon price" of $70 per tonne in 2024, which would rise steadily to $420 by 2050, to be incorporated into energy market rule changes.

Exploring Sweden's Carbon Pricing Success

An in-depth look at how Sweden balances carbon pricing with economic growth and renewable energy investment.

Sweden's carbon pricing model is a global benchmark.

Sweden's approach to carbon pricing has set a standard for other nations, demonstrating effective strategies for reducing emissions while promoting sustainable economic growth. This model has influenced global discussions on climate policy and pricing mechanisms.

Carbon tax introduction began in 1991, evolving over decades.

The carbon tax initiated in 1991 has been progressively refined, reflecting the changing economic landscape and environmental needs. This ongoing evolution illustrates Sweden's commitment to adapting its policies for effective climate action.

Significant emissions reduction paired with economic growth.

Sweden has achieved impressive reductions in greenhouse gas emissions without stifling economic development, proving that environmental sustainability and economic prosperity can go hand in hand through strategic policy implementation.

Revenue from carbon taxes funds renewable energy initiatives.

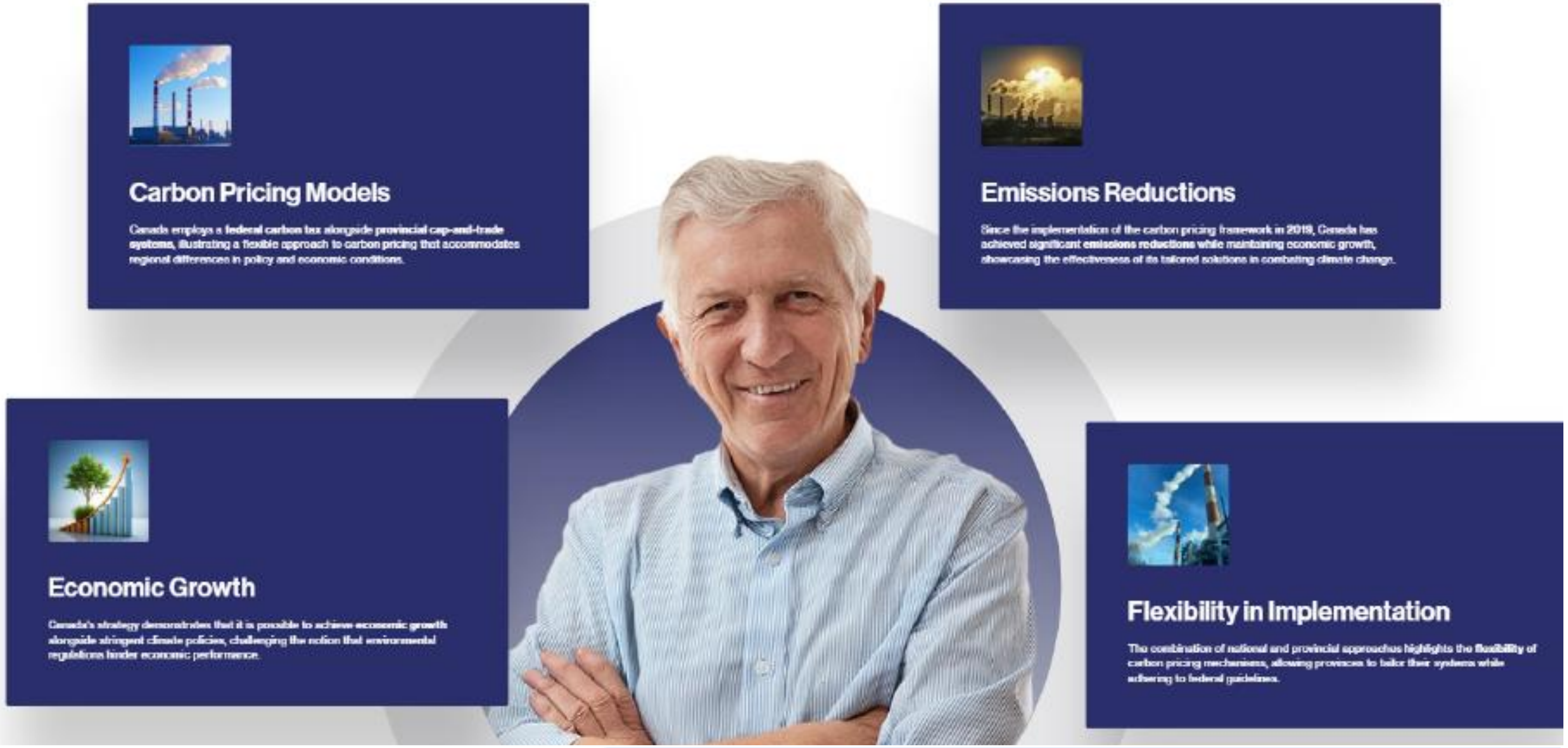
The revenue generated from carbon taxes is strategically reinvested into renewable energy projects and energy efficiency programs, creating a sustainable cycle that supports both environmental goals and economic stability.

Political will and public support are crucial for success.

The success of Sweden's carbon pricing model underscores the need for strong political leadership and public backing, which are essential for implementing and maintaining effective climate policies that resonate with citizens.

Canada's Carbon Pricing Framework: A Comprehensive Case Study

Exploring the effectiveness and challenges of Canada's carbon tax and cap-and-trade systems



Canada's carbon pricing system allows provinces to choose between a cap-and-trade program or an explicit price-based system, provided they meet federal benchmark standards for stringency. Historically, Quebec operated a cap-and-trade system, while Ontario previously had one before it was cancelled. The federal government provides a backstop system, which can be applied to jurisdictions not meeting the benchmark, and the federal government also returns the proceeds from the federal fuel charge to the provinces and territories.

Canada's Carbon Pricing Framework:

Since 2019, the Government has ensured it is no longer free to pollute by establishing a national minimum price on carbon pollution starting at $20 per tonne in 2019, increasing at $10 per tonne to $50 in 2022.

The Government's approach to pricing carbon pollution gives provinces and territories the flexibility to implement the type of system that makes sense for their circumstances as long as they align with minimum national stringency standards, or 'benchmark' criteria.

This approach also reflects the leadership of some provinces. Alberta and Quebec led the way in 2007 – the former with a carbon pricing system for heavy industry and the latter with a carbon levy that became its cap-and-trade system in 2013. British Columbia implemented an economy-wide carbon tax in 2008. In 2016, Canada published the Pan Canadian Approach to Pricing Carbon Pollution. This committed to an increasing carbon price, to $50 per tonne in 2022, set out the benchmark criteria, and committed to establishing a federal system to serve as a 'backstop' where needed.

REMINDER: The EU Emissions Trading System (EU ETS) started in 2005

Navigating Political and Social Hurdles in Carbon Pricing

Understanding the resistance and misinformation surrounding carbon pricing initiatives

- **Resistance from fossil fuel industries**

  Industries reliant on fossil fuels often oppose carbon pricing due to fears of increased operational costs and reduced competitiveness within the market.

- **Public opposition to economic impacts**

  Many citizens express concern that carbon pricing may lead to higher energy costs and economic burdens, causing pushback against these policies among the general public.

- **Misinformation affects perceptions**

  Misinformation campaigns can distort the public's understanding of carbon pricing, leading to increased resistance and skepticism towards the policy's benefits.

- **Lobbying efforts against carbon pricing**

  Powerful lobby groups often work to undermine carbon pricing initiatives, leveraging political influence to sway decision-makers and public opinion.

- **Need for public acceptance strategies**

  To successfully implement carbon pricing, strategies must be developed to enhance public understanding and acceptance, addressing fears and misconceptions effectively.

- **Political viability of carbon pricing**

  For carbon pricing to be effective, it must gain political support across various stakeholders, which requires addressing the concerns of both the public and industries.

Exploring Future Trends in Carbon Pricing

An Insight into International Cooperation and Innovations in Carbon Pricing

Kyoto Protocol

The United States signed the Kyoto Protocol but never ratified it, and Australia signed but later withdrew its support. Canada also signed but withdrew its participation in 2011. Developing nations like China, India, and Brazil were never included in the original Protocol's binding emission targets, with the US opposing these exclusions.

1	2	3	4	5
Broader International Cooperation	Integration with Environmental Policies	Border Carbon Adjustments	Digital Technologies in Emission Monitoring	Implications for Global Climate Goals

As of January 2025, all UN countries have endorsed the **Paris Agreement**, but Iran, Libya, and Yemen have not formally ratified it, making them the only nations not formally part of the agreement. The United States is the only country that has withdrawn from the agreement, a decision made by President Trump in 2017 and reaffirmed in 2025

193 member countries of the UN + 2 UN General Assembly observer states, the Holy See and Palestine.

Integrating Carbon Pricing with Environmental Policies

Exploring the synergy between carbon pricing and other environmental initiatives

Policy Integration

The **integration** of carbon pricing with other environmental policies enhances overall effectiveness, creating a synergistic approach to tackle climate change challenges.

Renewable Incentives

Combining carbon pricing with **renewable energy incentives** promotes investments in clean energy technologies, accelerating the transition to a sustainable energy future.

Energy Efficiency

Incorporating **energy efficiency regulations** alongside carbon pricing optimizes energy use, reduces emissions, and lowers operational costs for businesses and households.

Conservation Efforts

Linking carbon pricing with **conservation efforts** supports biodiversity and ecosystem health, ensuring a holistic approach to environmental protection and sustainable resource management.

Successful Case Studies

Examining **case studies** where integrated policies have been implemented showcases best practices and lessons learned, providing valuable insights for future policy development.

THANK YOU

QUESTIONS?

TETHYS

Environmental & Regulatory Barriers

1^{st} TETHYS summer school - Day 4

George Xydis

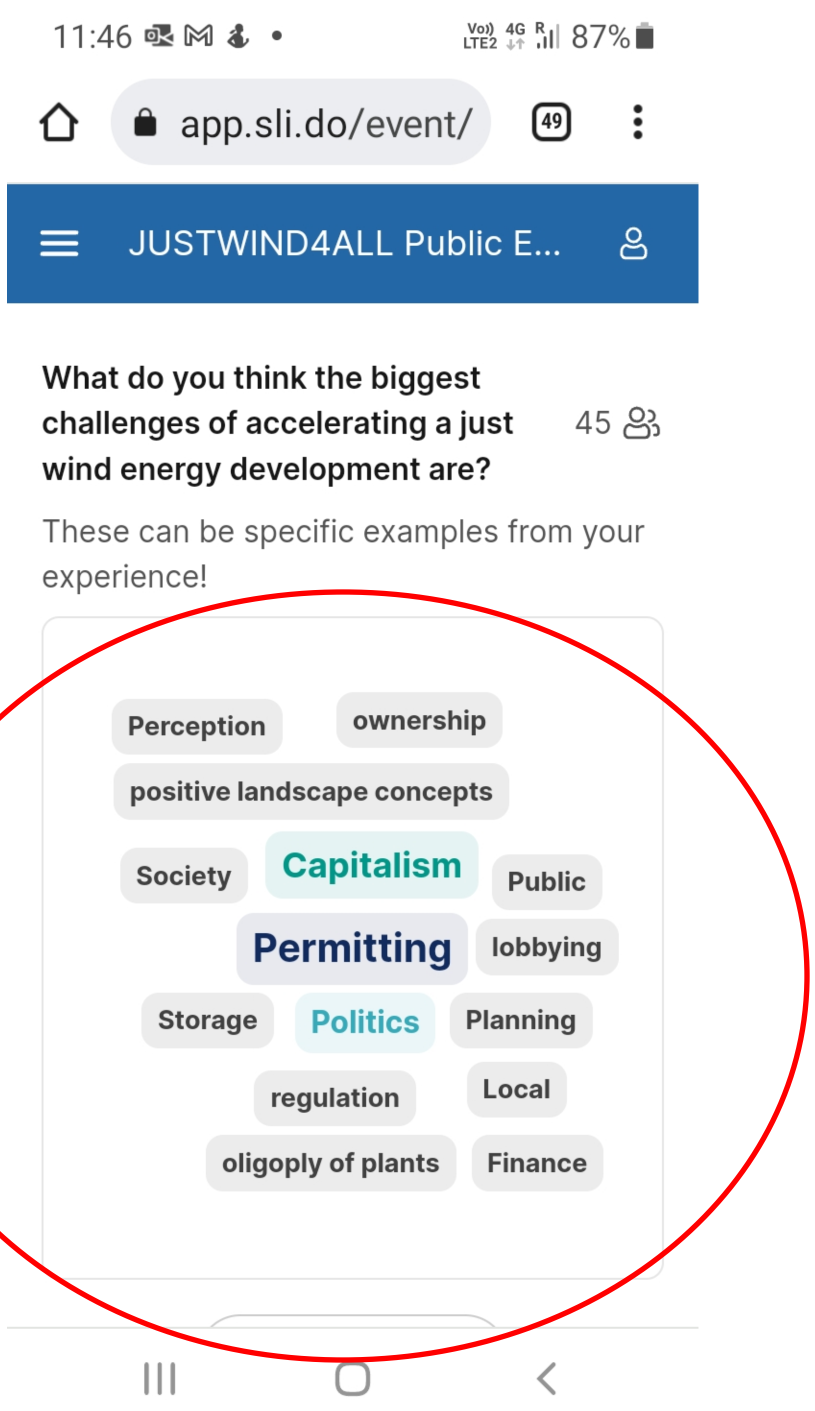
Funded by the European Union

University of Cyprus

Università degli Studi Firenze

NEEST New Energy & Environmental Solutions and Technologies

Aarhus BSS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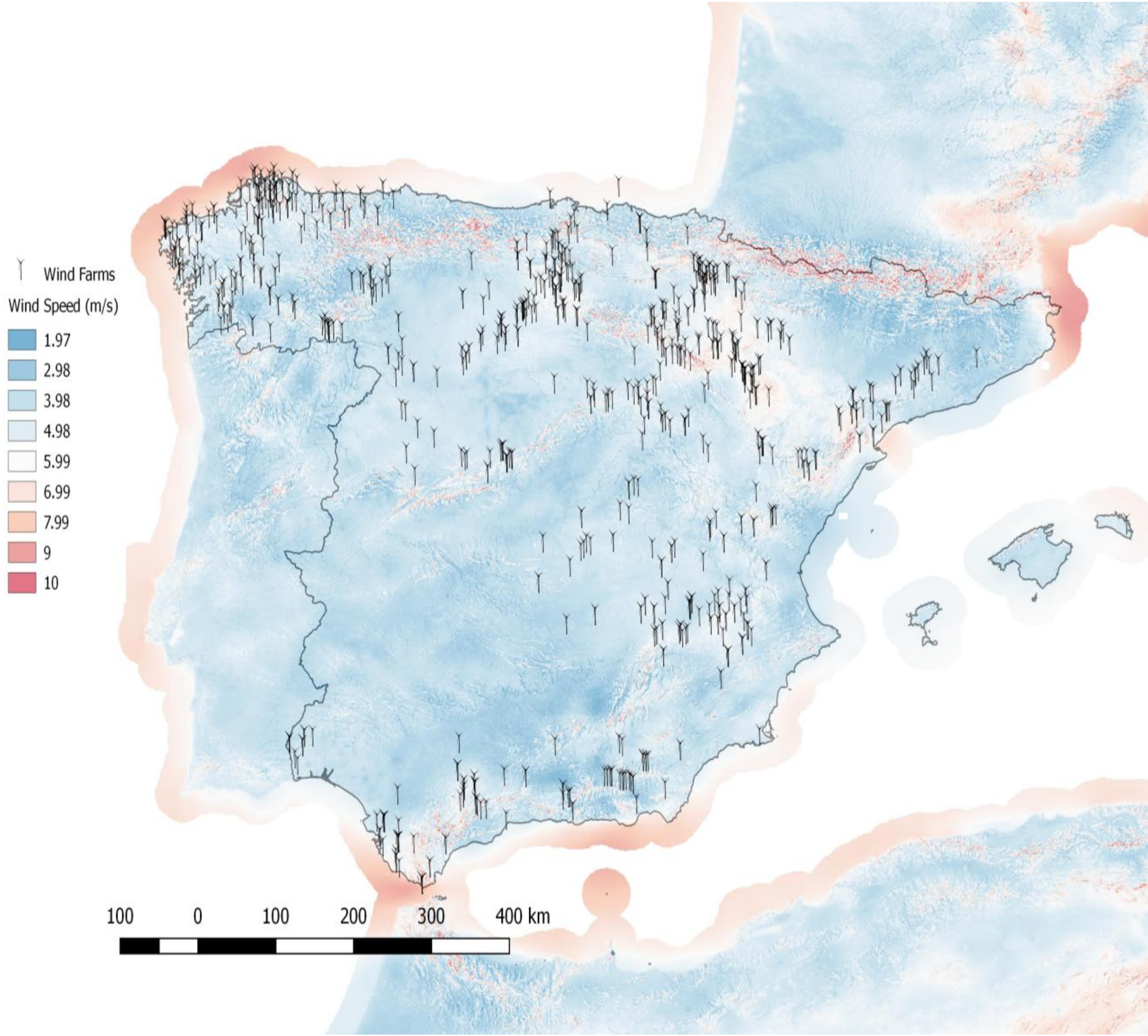
87%
app.sli.do/event/
49
JUSTWIND4ALL Public E...
What do you think the biggest challenges of accelerating a just wind energy development are?
45
These can be specific examples from your experience!
Perception
ownership
positive landscape concepts
Society
Capitalism
Public
Permitting
lobbying
Storage
Politics
Planning
regulation
Local
oligoply of plants
Finance

EVERY NEW PROJECT APPLICATION PROJECT NEEDS 2 THINGS:

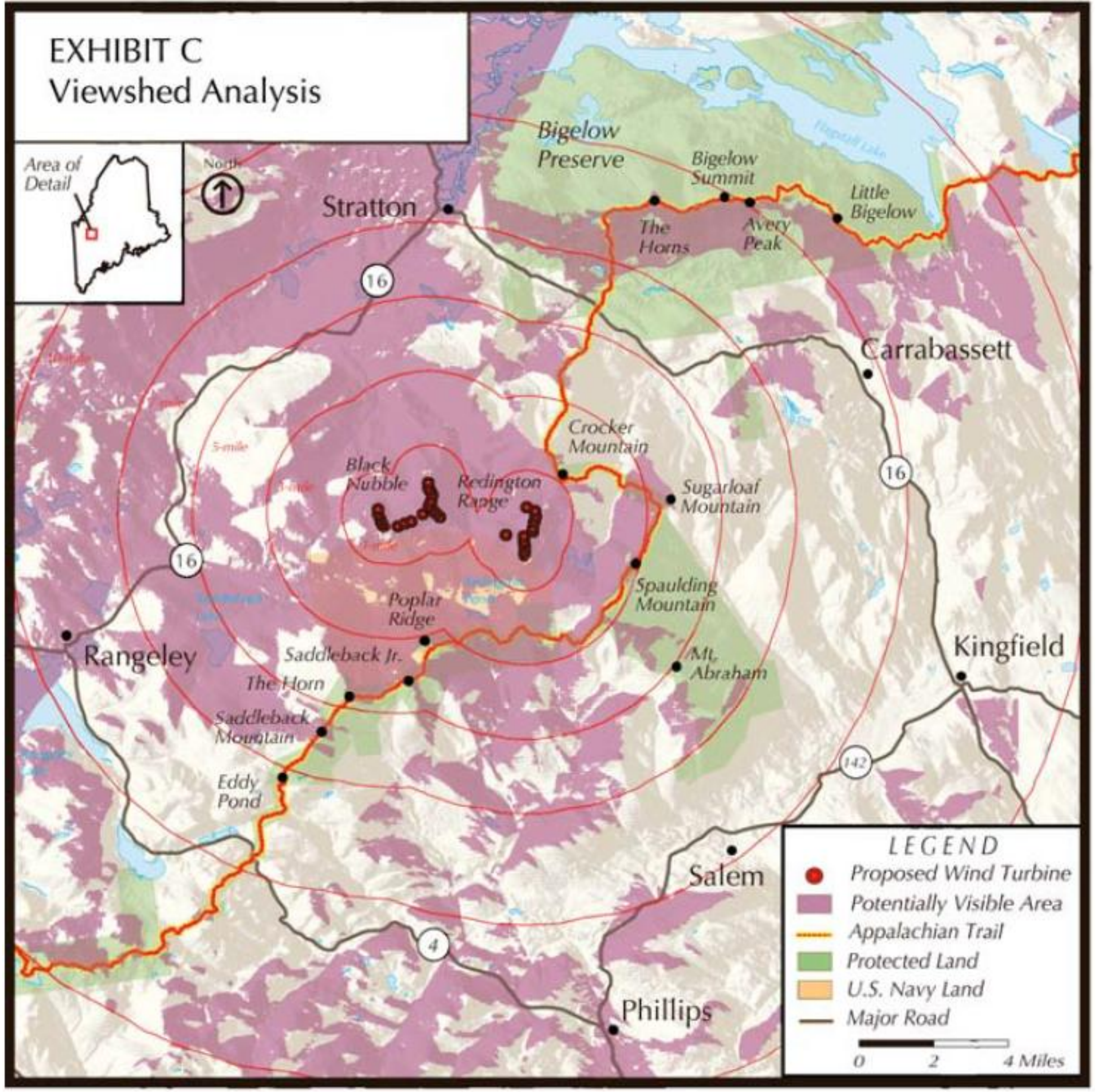
1. ENVIRONMENTAL IMPACT ASSESSMENT

2. ENERGY ANALYSIS



ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

EIA of a project is the assessment of the environmental consequences (positive & negative) prior to the decision to move forward



WHY DO WE NEED AN EIA?

Energy company to pay $1 million in wind turbine eagle deaths

November 24, 2013 | By Soumya Karlamangla

Email | Share | +1 10 | Tweet 0 | Recommend 4

In the first case of its kind, a large energy company has pleaded guilty to killing birds at its large wind turbine farms in Wyoming and has agreed to pay $1 million as punishment.

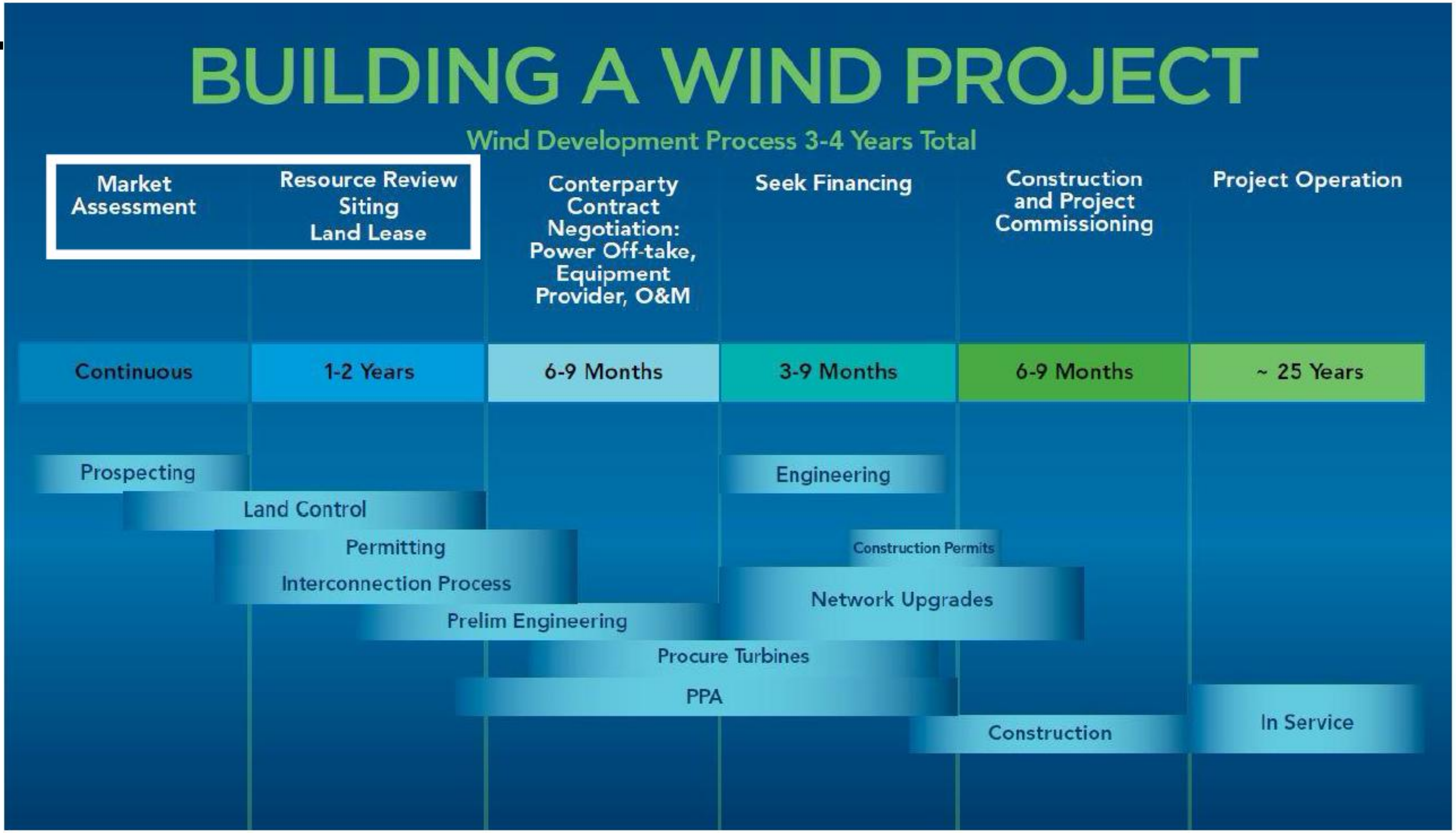
Duke Energy Renewables -- a subsidiary of the Fortune 250 Duke Energy Corp. -- admitted to violating the federal Migratory Bird Treaty Act in connection with the deaths of more than 160 birds, including 14 golden eagles, according to court documents.

A golden eagle flies over a wind turbine on Duke Energy's wind farm... (Dina Cappiello / Associated...)

HOW DO WE START ?

HOW DO WE START ?

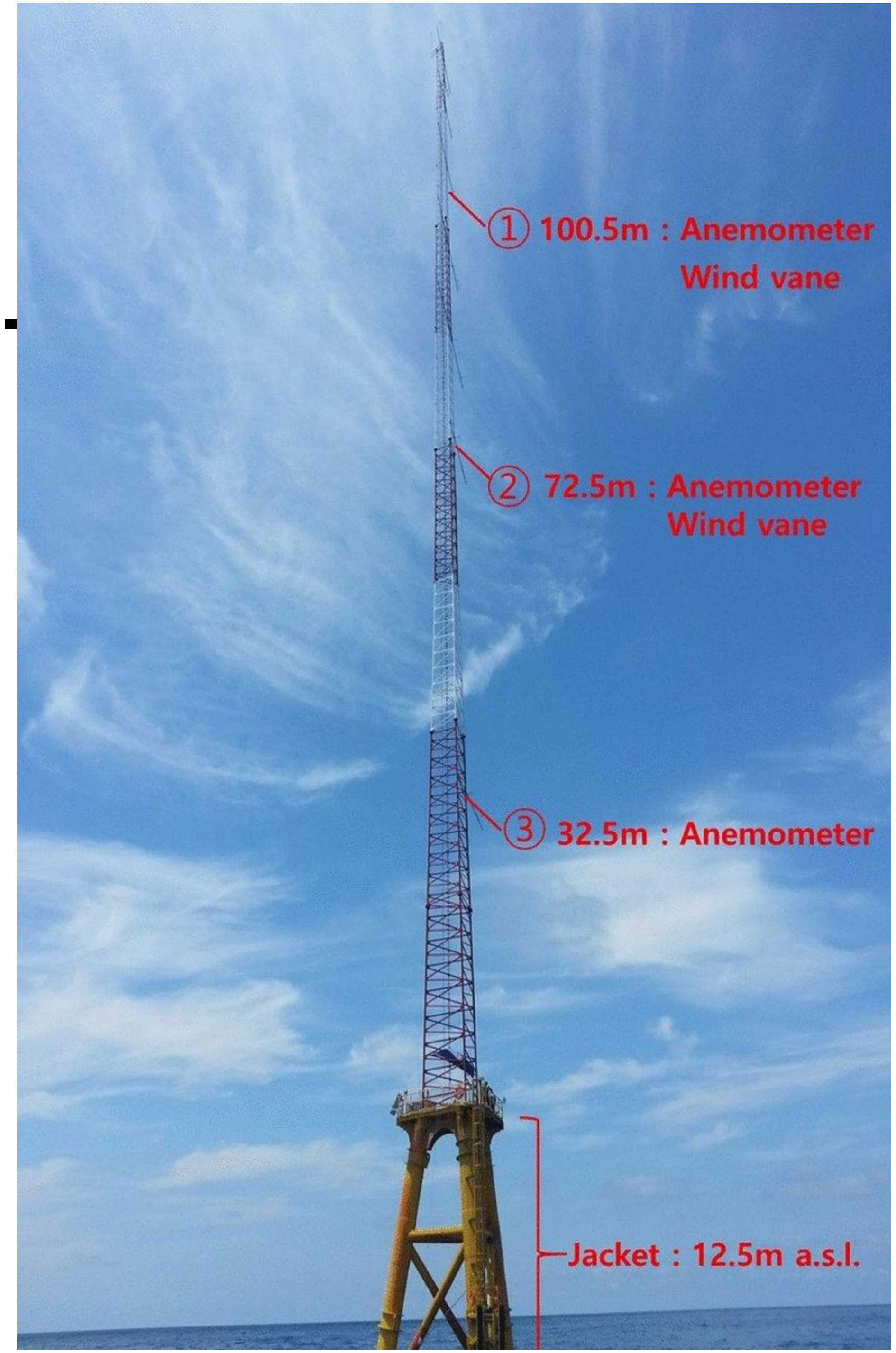
Wind Siting Process is Long and Complex



Source: AWEA

HOW AND WHAT TO MEASURE?

HOW AND WHAT TO MEASURE?



Floating Offshore Turbines are the New Frontier

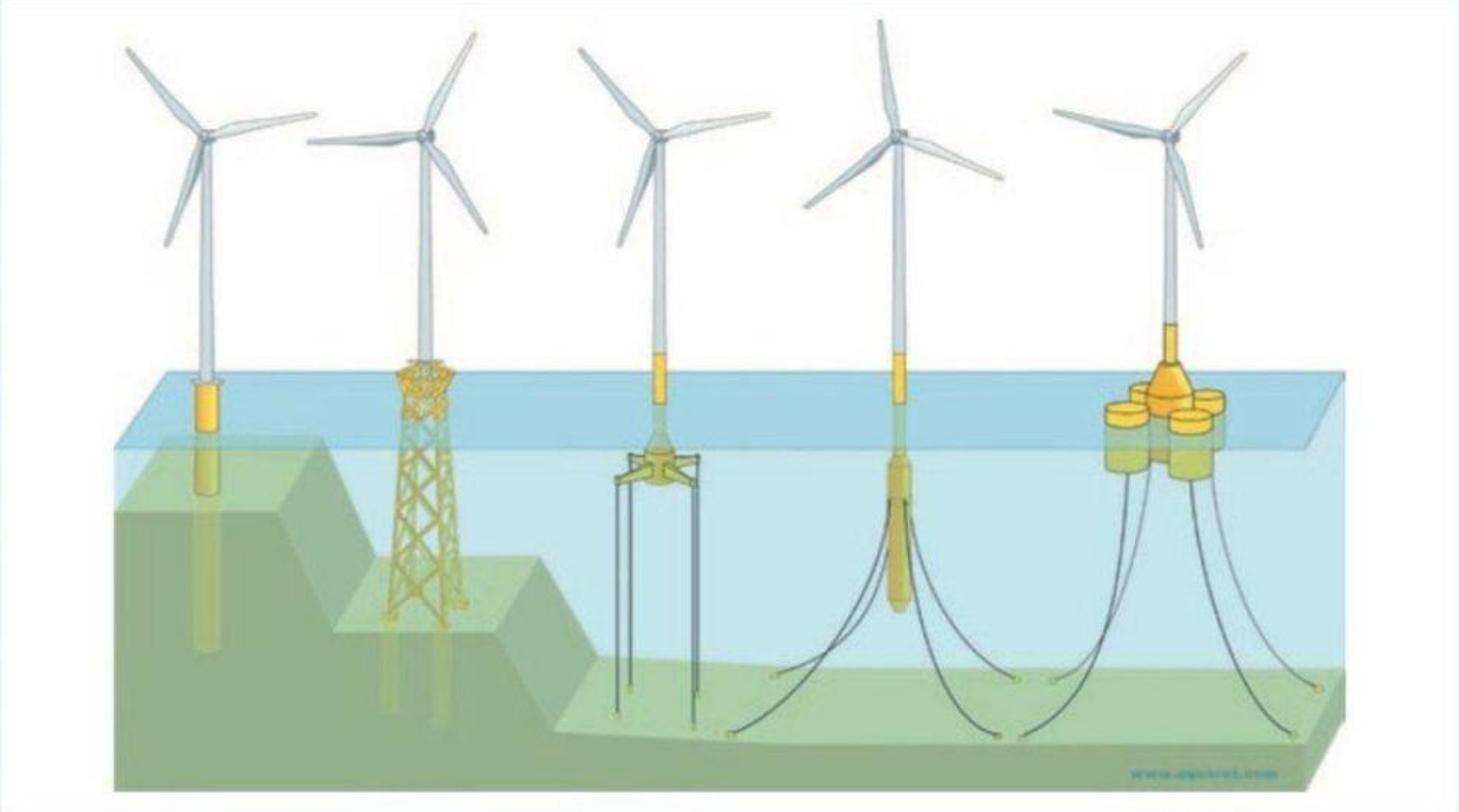
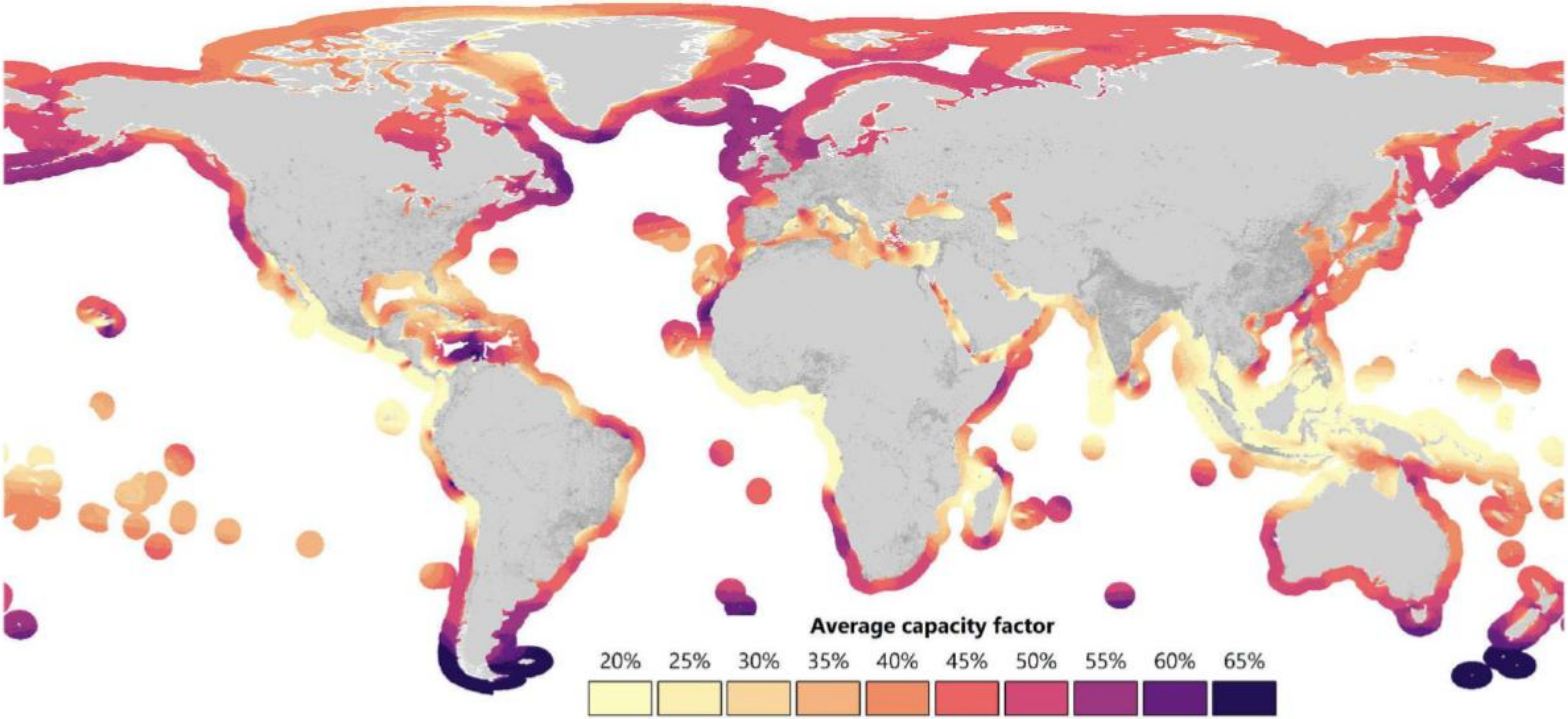


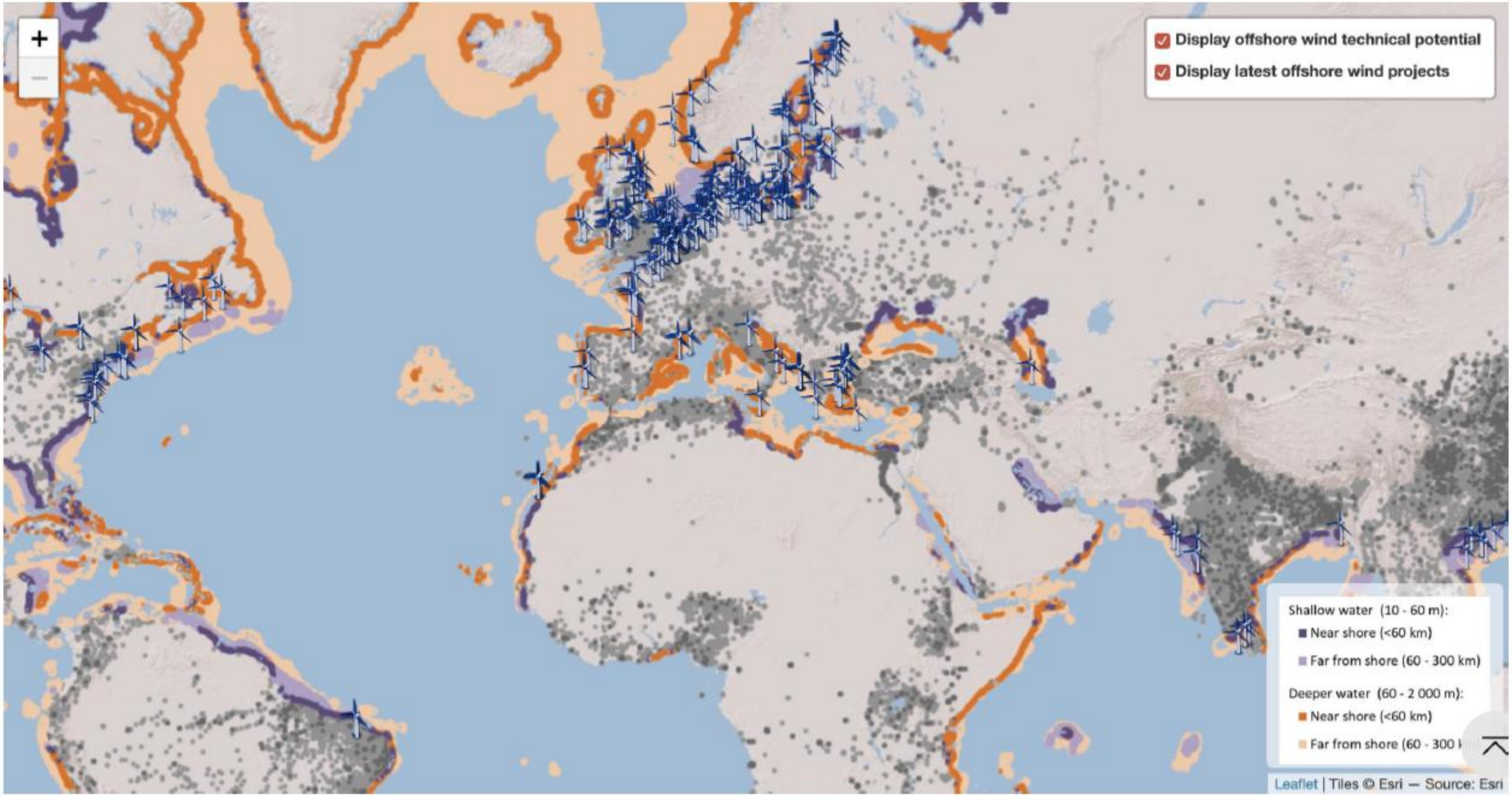
Figure 1: Common fixed and floating offshore wind structure designs (Source: www.aquaret.com).
From left to right: driven monopile; steel jacket tower; tension leg platform; spar buoy; semi-submersible

Global Offshore Average Capacity Factors



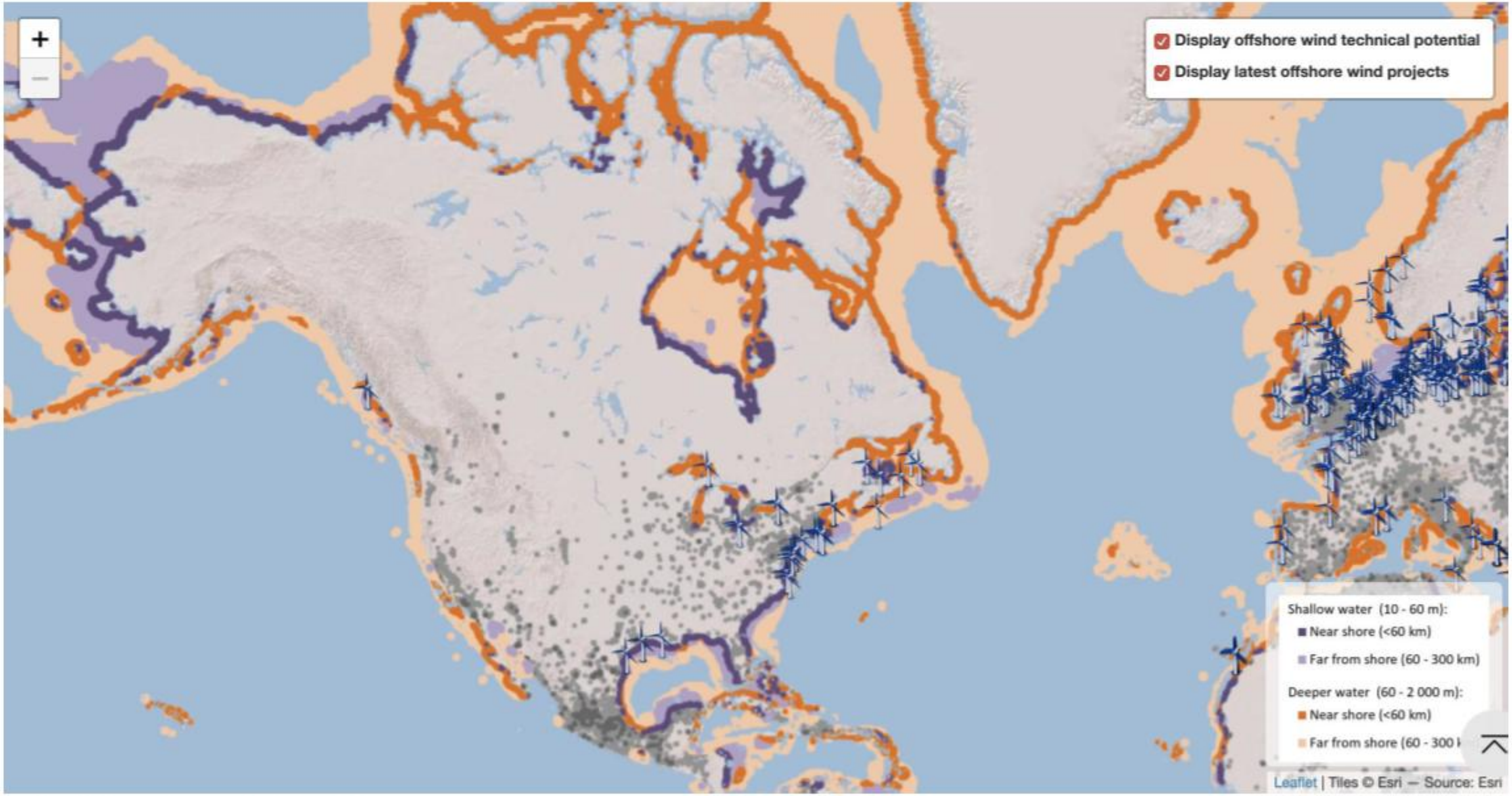
Source: IEA Offshore Wind Outlook 2019

Existing Offshore Resources and Population Density



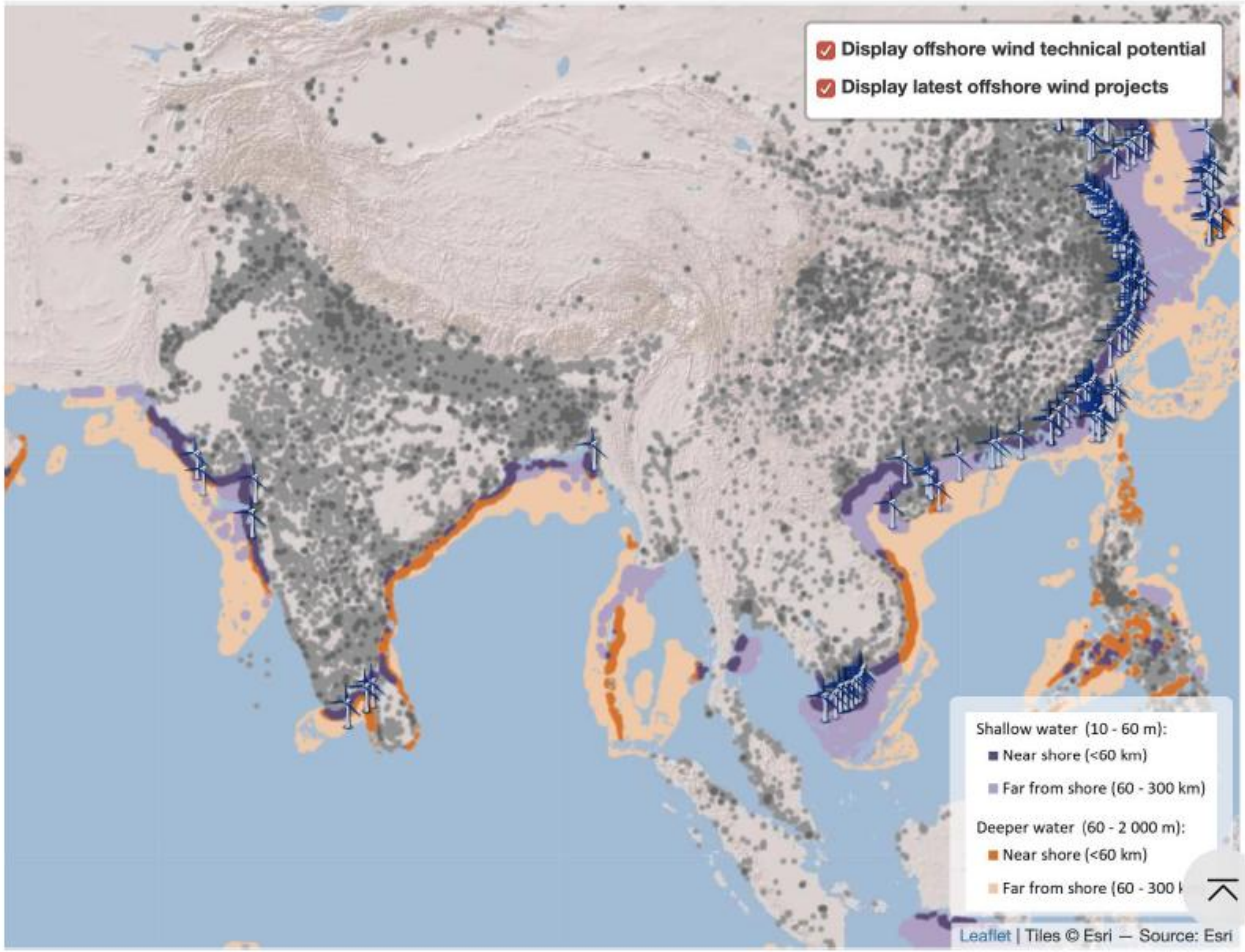
Source: IEA Offshore Wind Outlook 2019

North American Offshore Resources



Source: IEA Offshore Wind Outlook 2019

Asian Offshore Resources



Source: IEA Offshore Wind Outlook 2019

Leading Manufacturers of Offshore Wind Turbines – 2023

As of 2023, the leading manufacturers of offshore wind turbines, along with their approximate market shares, are:

- **Siemens Gamesa Renewable Energy**: Market Share: ~40%
  Siemens Gamesa is a dominant player in the offshore wind turbine market and has been a leader for several years. The company's large offshore turbines, such as the SG 14-222 DD, are popular in Europe and beyond.
- **Vestas**: Market Share: ~20-25%
  Vestas is a significant player in the offshore market. With the merger of its offshore division with Mitsubishi Heavy Industries (MHI Vestas), it has strengthened its position, and its new turbines are increasingly being adopted globally.
- **Goldwind**: Market Share: ~10-15%
  Goldwind, a Chinese company, has made significant strides in the offshore wind sector, particularly in the Chinese market, which has grown rapidly in recent years.
- **MingYang** Smart Energy: Market Share: ~10-15%
  Another Chinese manufacturer, MingYang, is expanding rapidly, benefiting from the growth of offshore wind installations in China.
- **GE Renewable Energy**: Market Share: ~10-12%
  GE Renewable Energy is making waves with its Haliade-X turbine, one of the largest and most powerful offshore wind turbines in the market. Its market share has been growing, especially with projects in the U.S. and Europe.

HOW DO WE START?
HOW AND WHAT TO MEASURE ?

- Anemometers, Vanes, Data Loggers, Masts
- Measured Parameters
  - wind speed, direction, temperature
  - 1-3 second sampling; 10-min or hourly recording
- Derived Parameters
  - wind shear, turbulence intensity, air density
- Multiple measurement heights
  - best to measure at hub height (not always practical)
  - can use shorter masts by using wind shear derived from two other heights to extrapolate speeds to hub height
- Multiple tower locations, especially in complex terrain
- Specialty measurements of growing importance
  - Sodar
  - Lidar

IN THEORY…

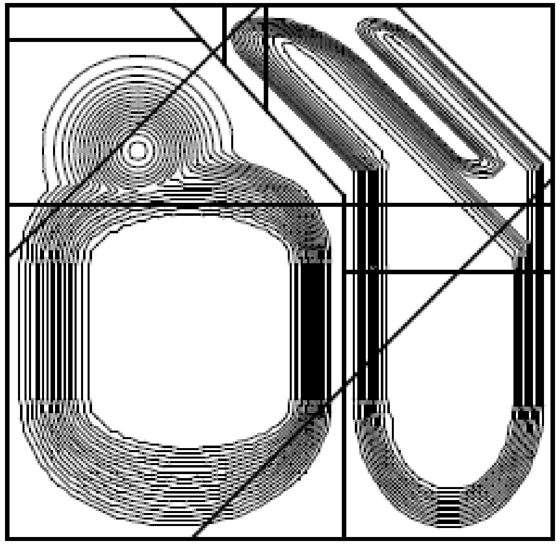
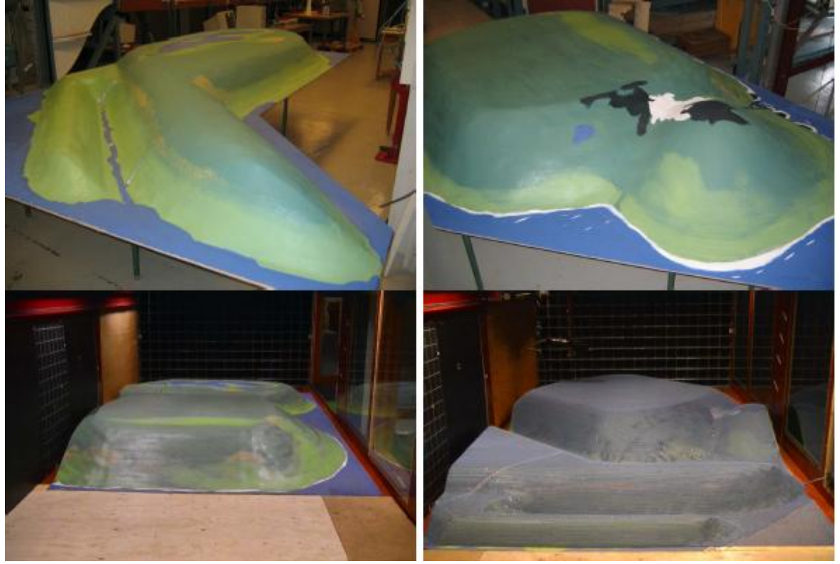


Figure : Division of the terrain model



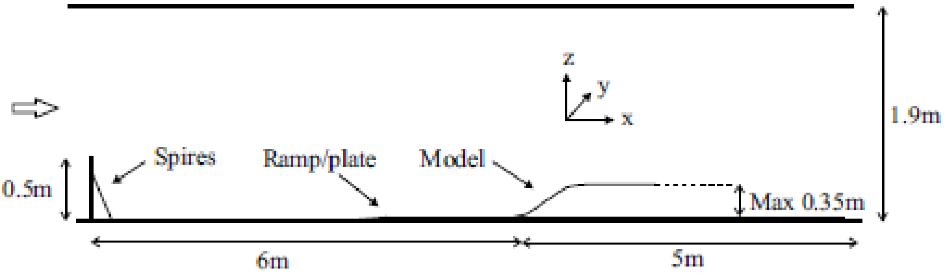
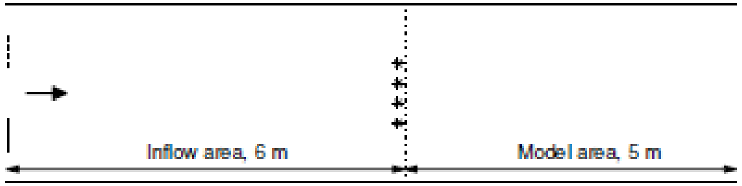


Figure : Sketch of wind tunnel test section with spires, plate and model



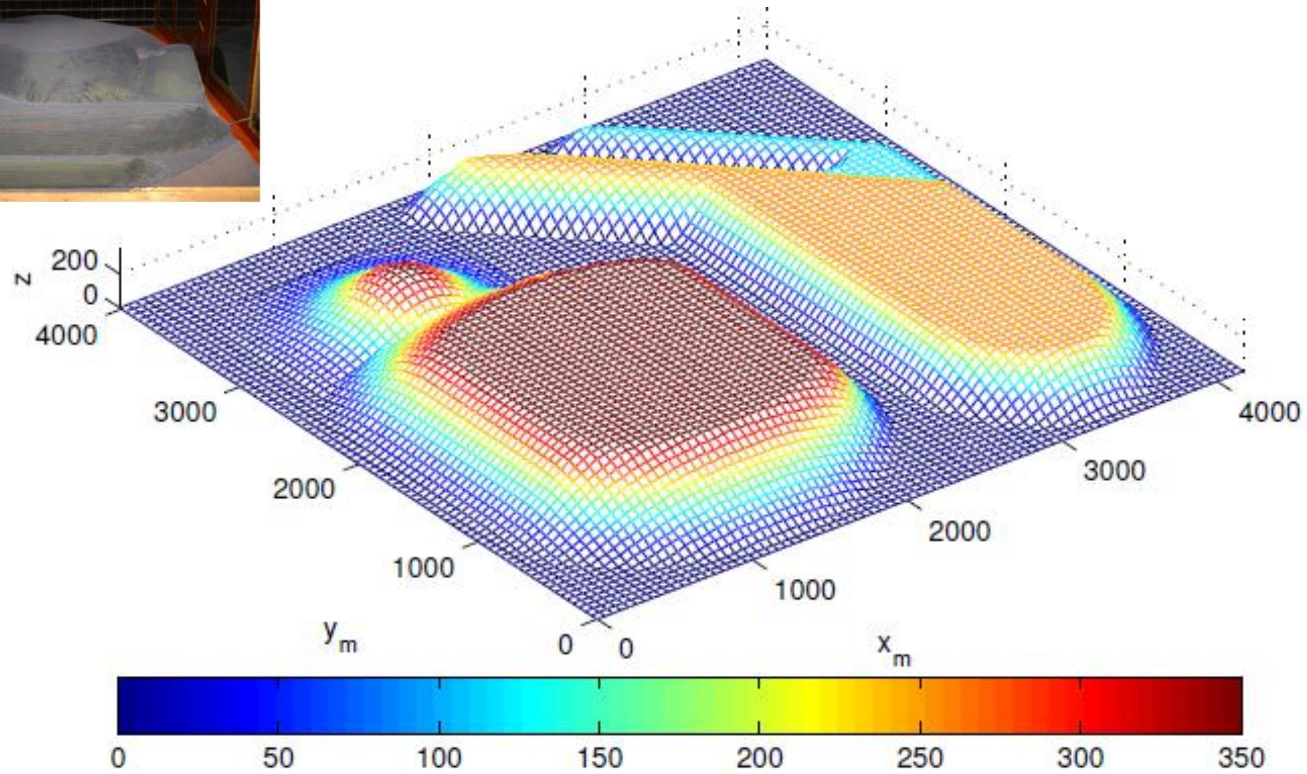
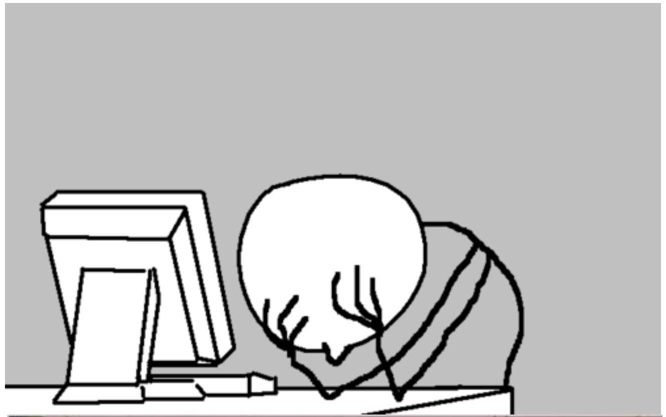
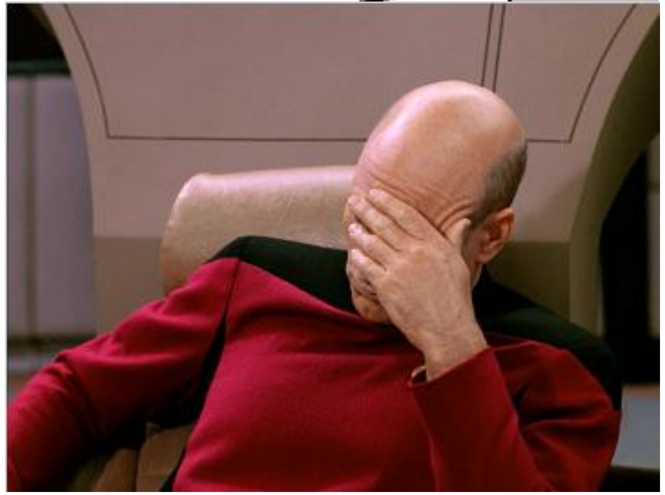


Figure : An overview of the entire terrain model. All the numbers are in mm.

GOING BACK TO THE OFFICE

Step 1: Create a project folder and transfer all notes on your PC



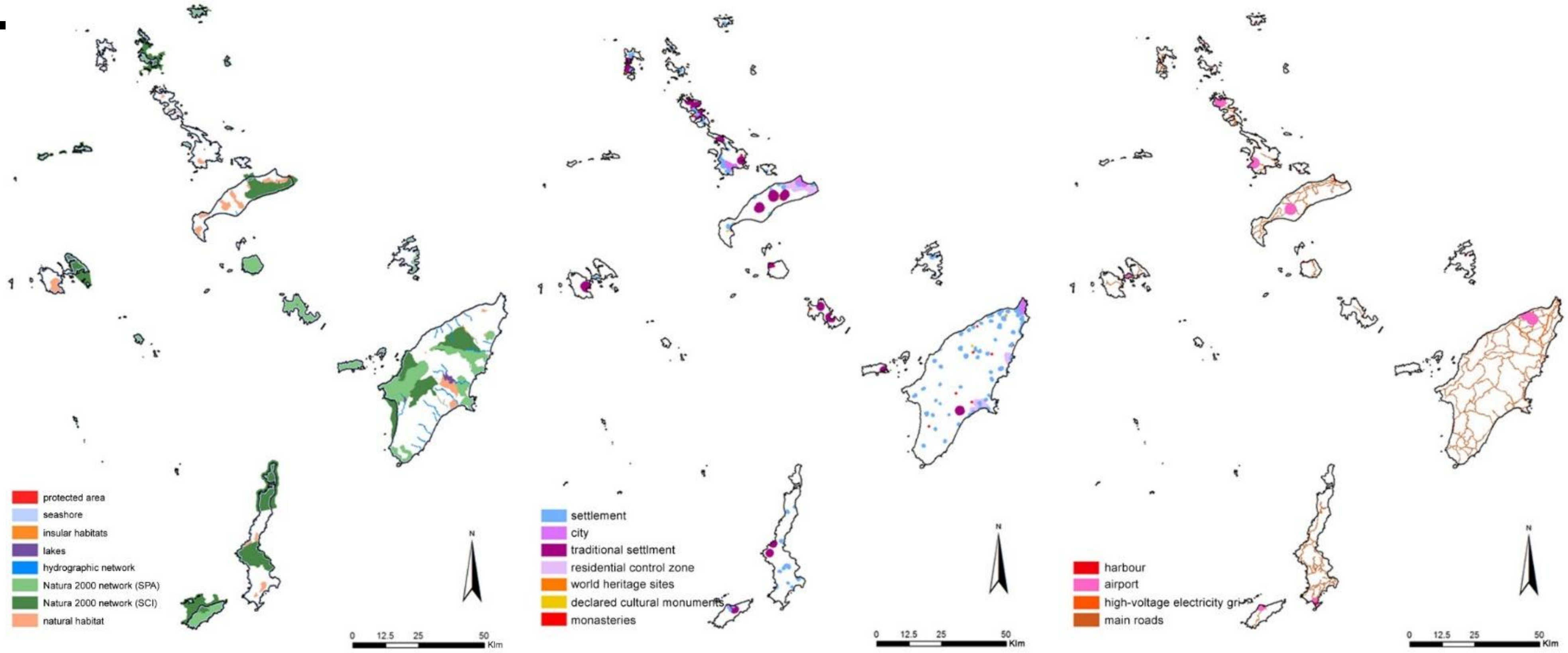


Step 2: Understanding how hard it is!!!

@ THE OFFICE

i) EIA

Step 3: Preparing the application

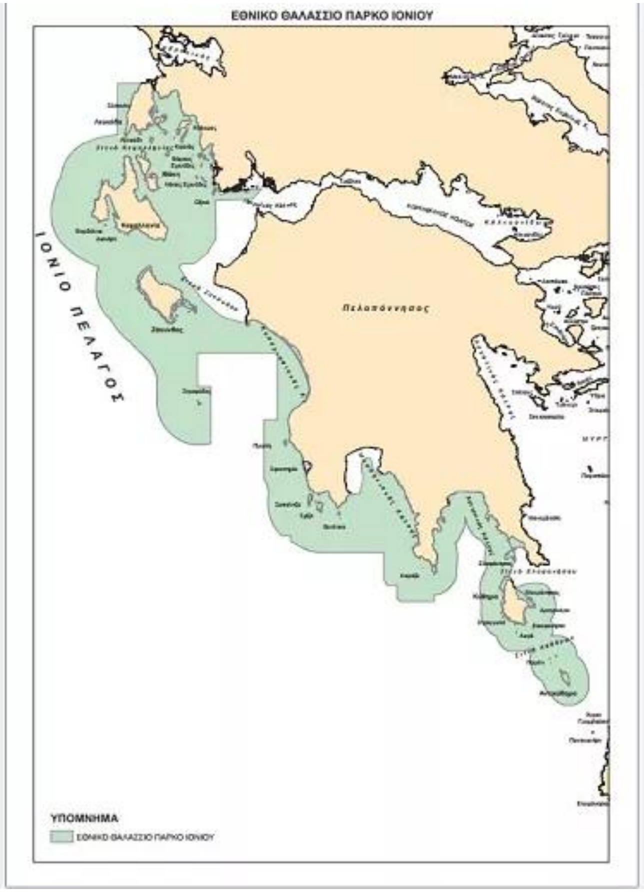


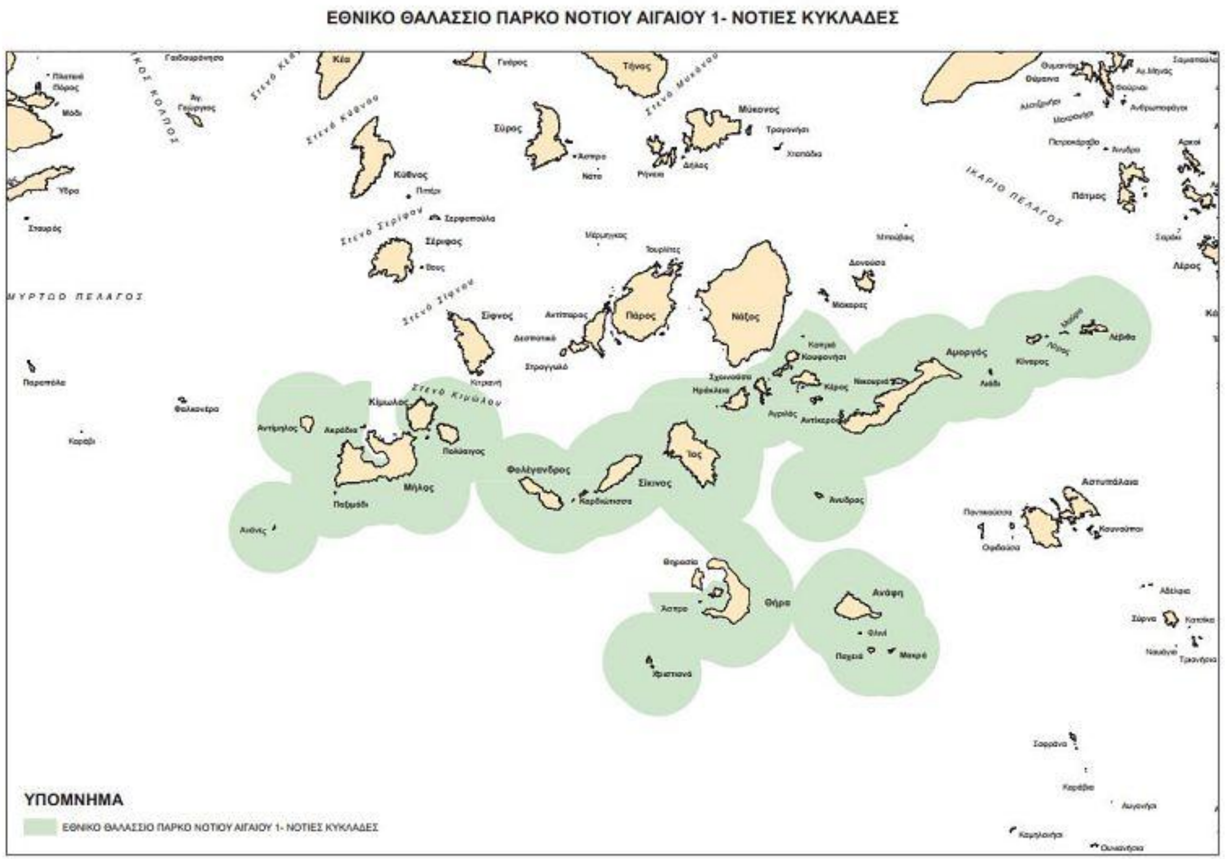
Project is developed around: i) EIA and ii) Energy Analysis

@ THE OFFICE

i) EIA

Step 3: Preparing the application





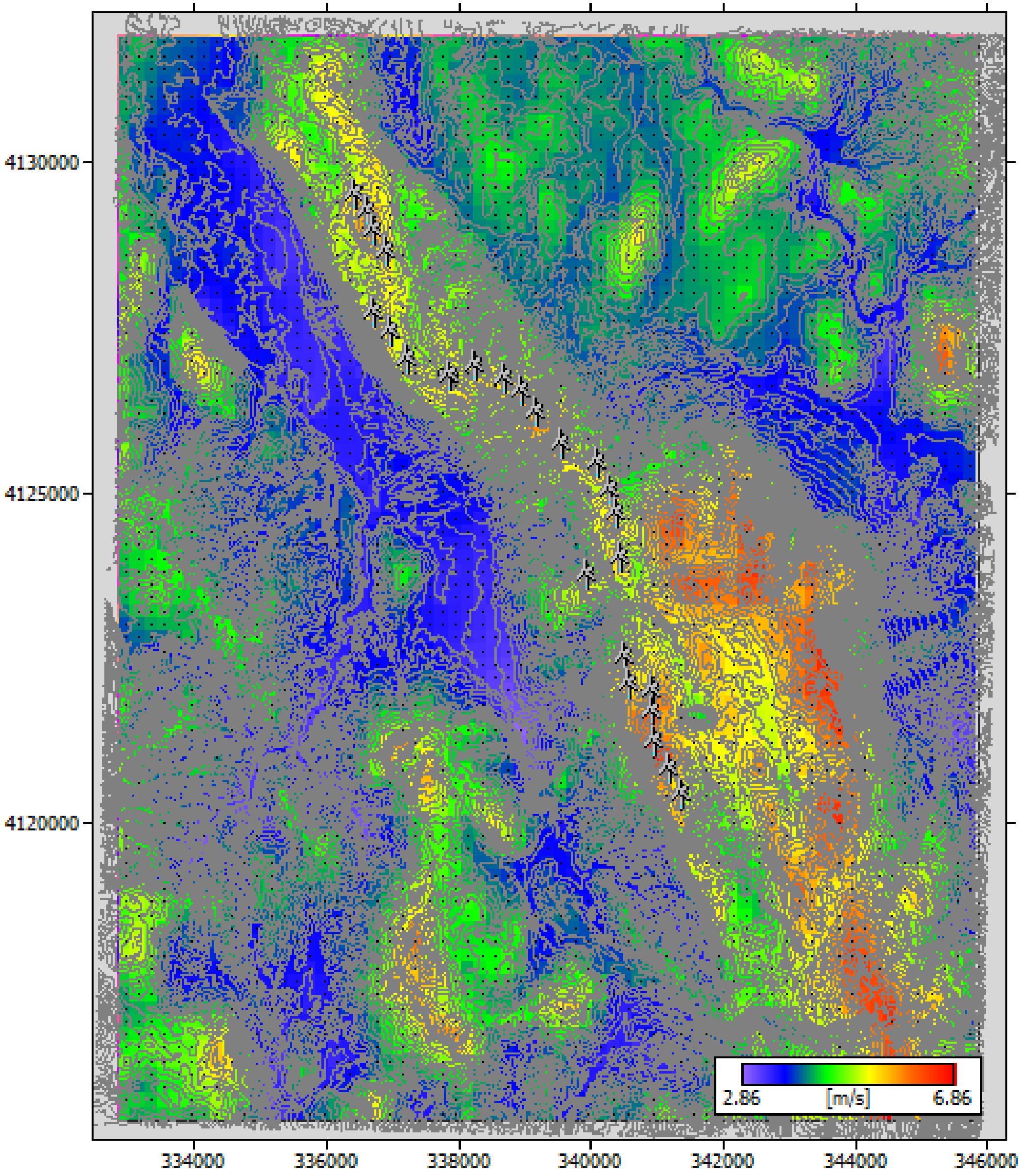
Project is developed around: i) EIA and ii) Energy Analysis

@ THE OFFICE

Step 3: Preparing the application

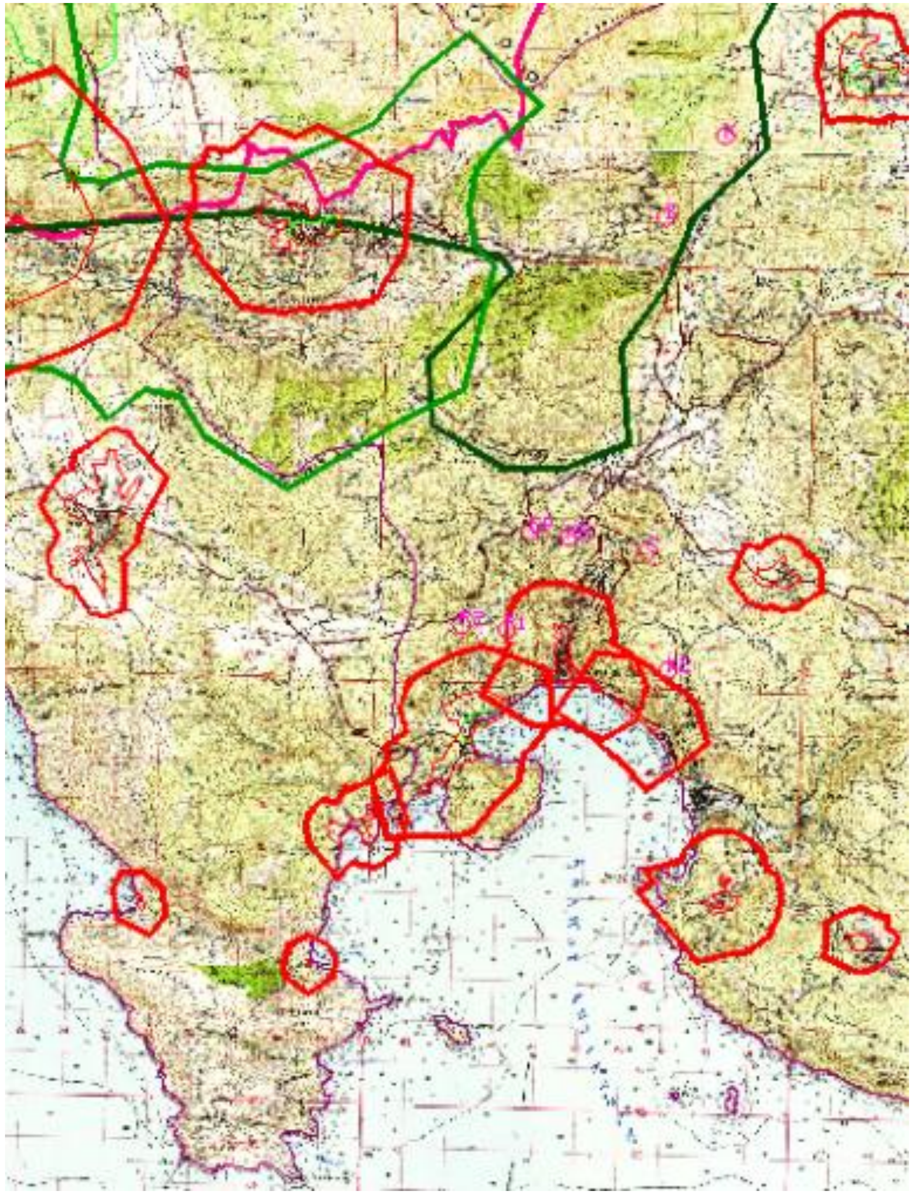
ii) Energy Analysis

Important Piece of Advice: Work with Layers!!!

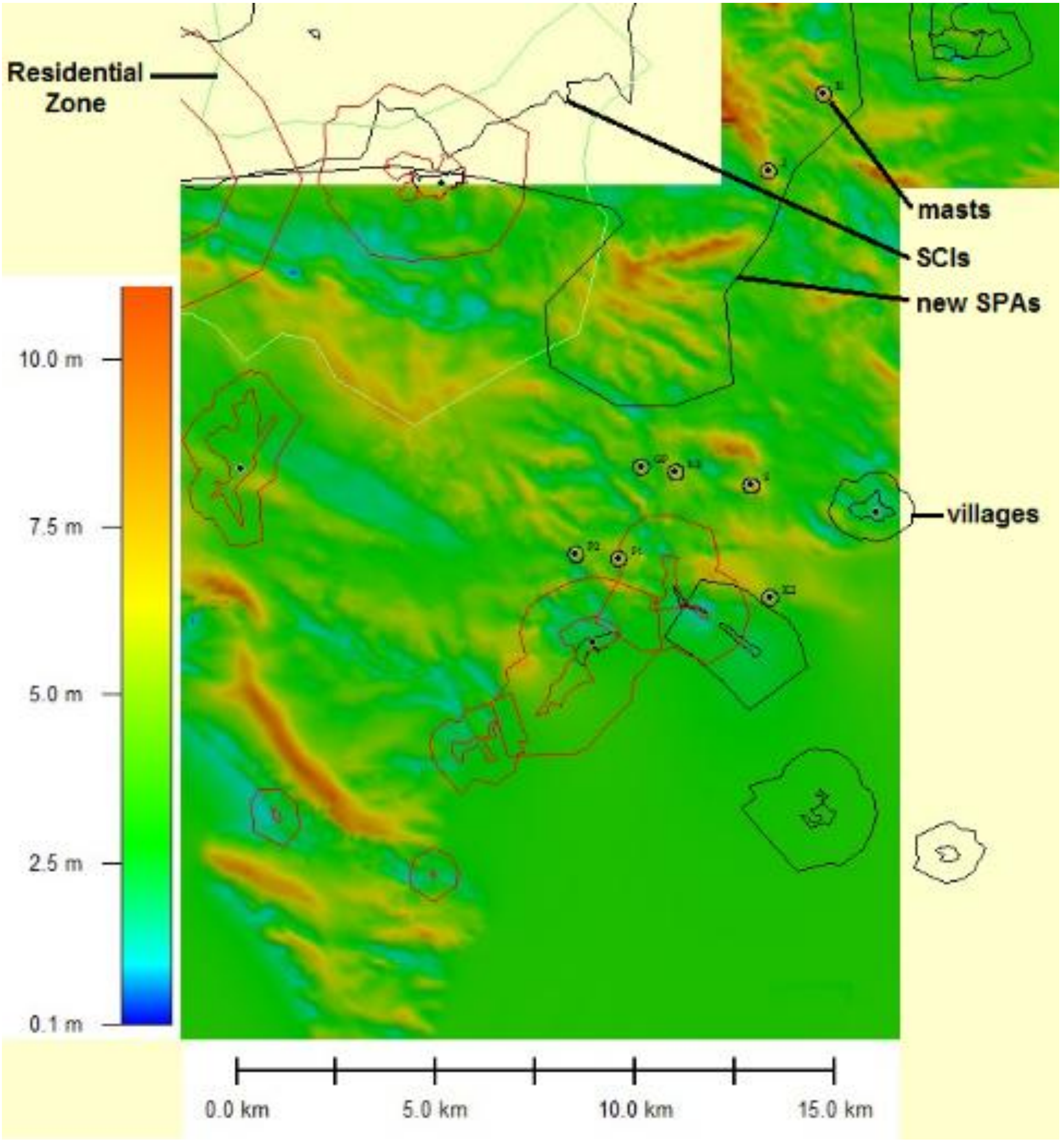


Gather all the info-constraints-parameters under 1 plaform

(GE, GIS, DXF)



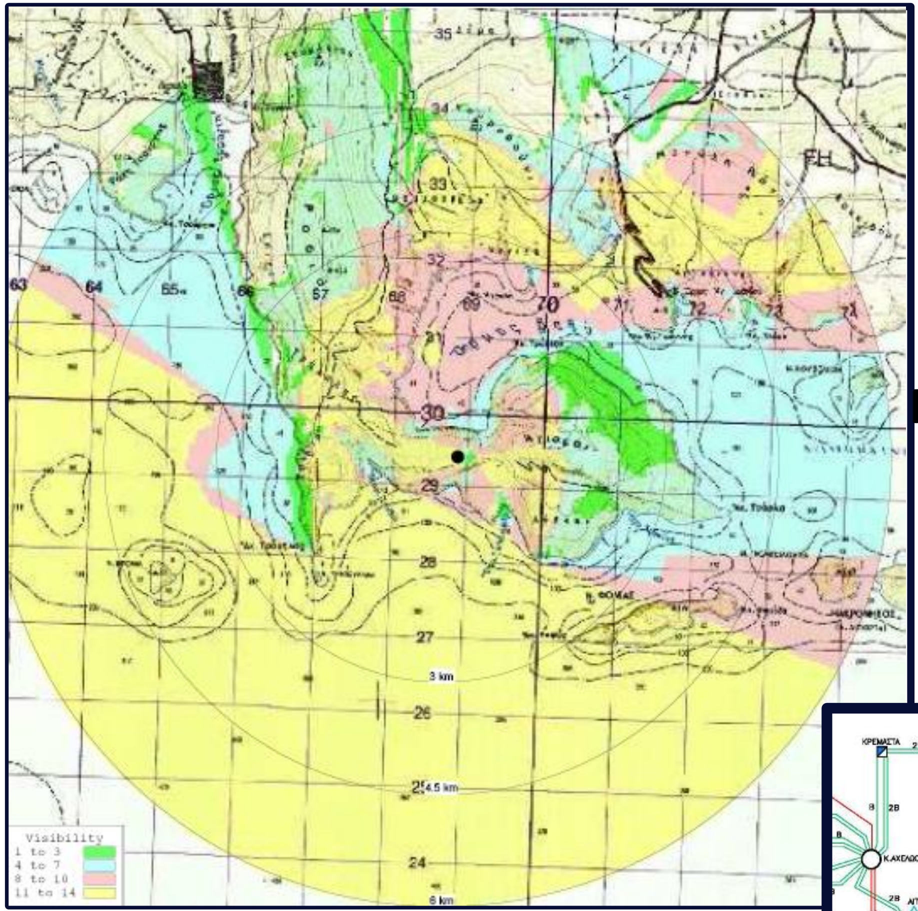
PLANNING CONSTRAINTS

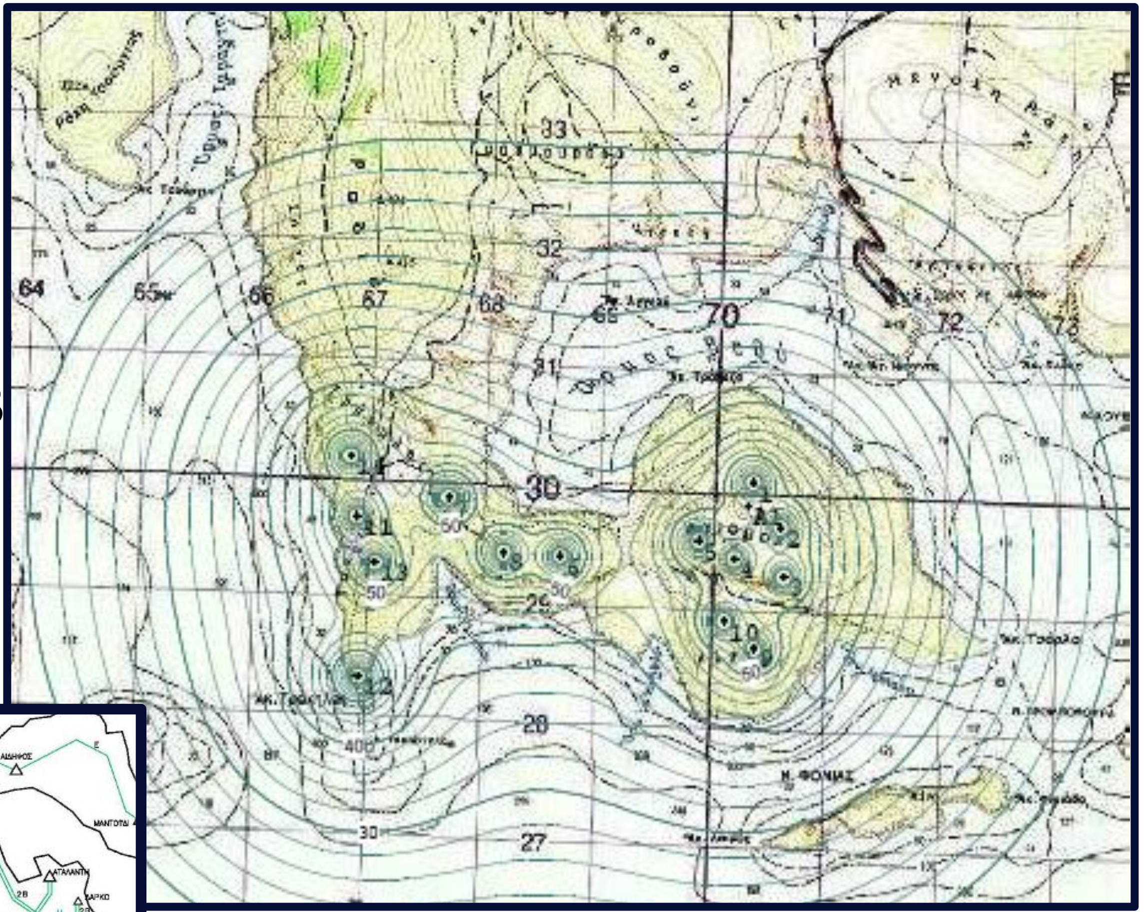


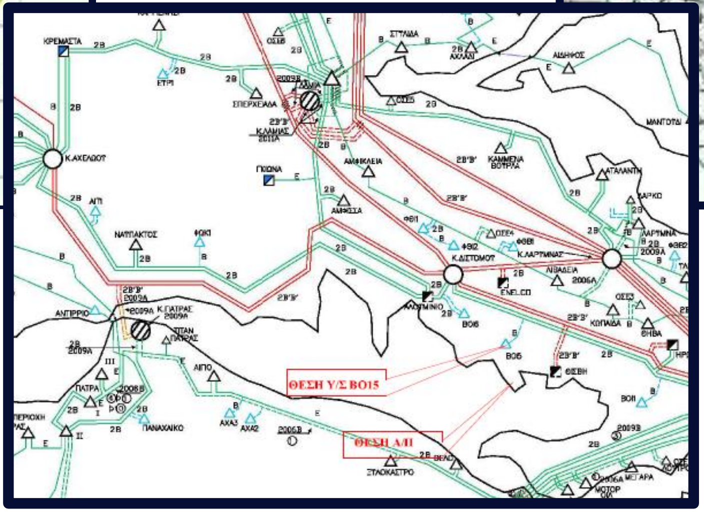
Wind Farm Siting Factors

- Wind resource
- Compatibility of land or area
- Environmental impacts
- Community input
- Proximity to transmission lines
- Property boundaries
- Airplane radar/flight interference
- Accessibility
- Permitting

MORE CONSTRAINTS







Building from Existing Wind Atlas: European Study

ELSEVIER

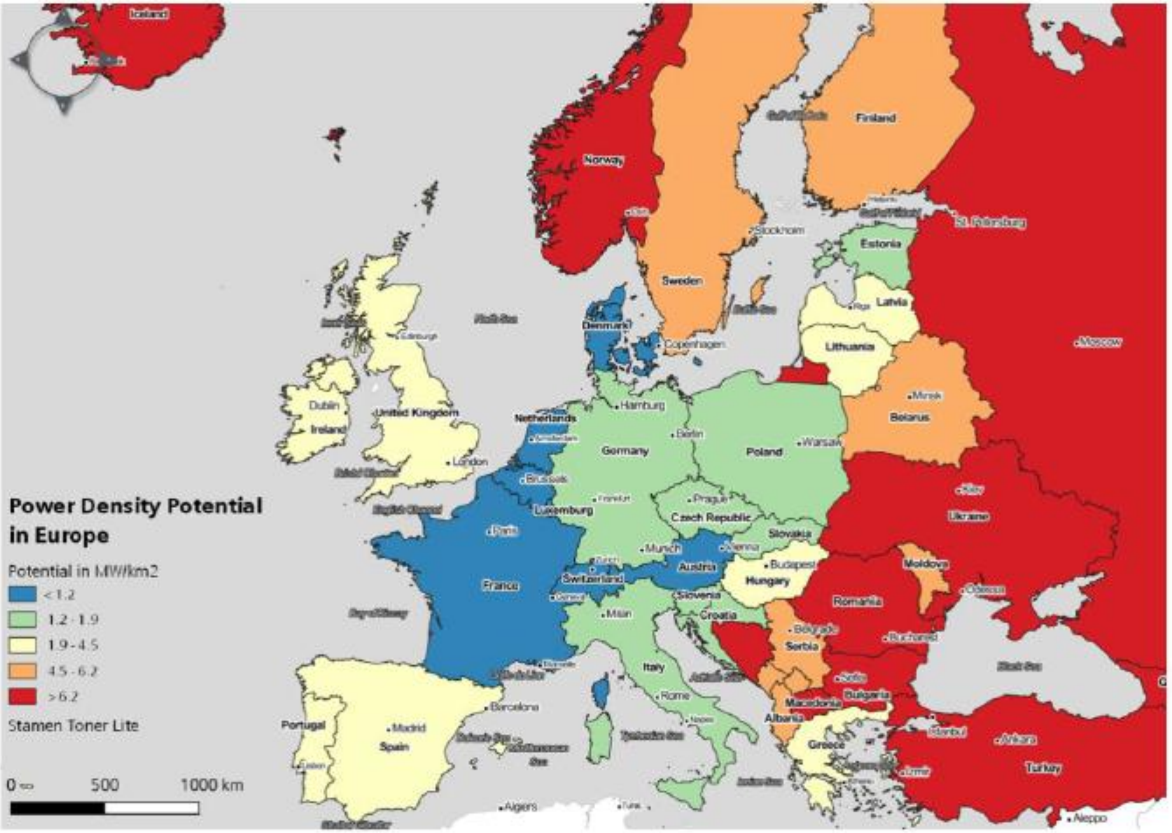
Energy Policy
Volume 132, September 2019, Pages 1092-1100

How much wind power potential does europe have? Examining european wind power potential with an enhanced socio-technical atlas

Peter Enevoldsen [a], Finn-Hendrik Permien [b], Ines Bakhtaoui [c, d], Anna-Katharina von Krauland [e], Mark Z. Jacobson [e], George Xydis [a], Benjamin K. Sovacool [a, f], Scott V. Valentine [g], Daniel Luecht [h], Gregory Oxley [i]

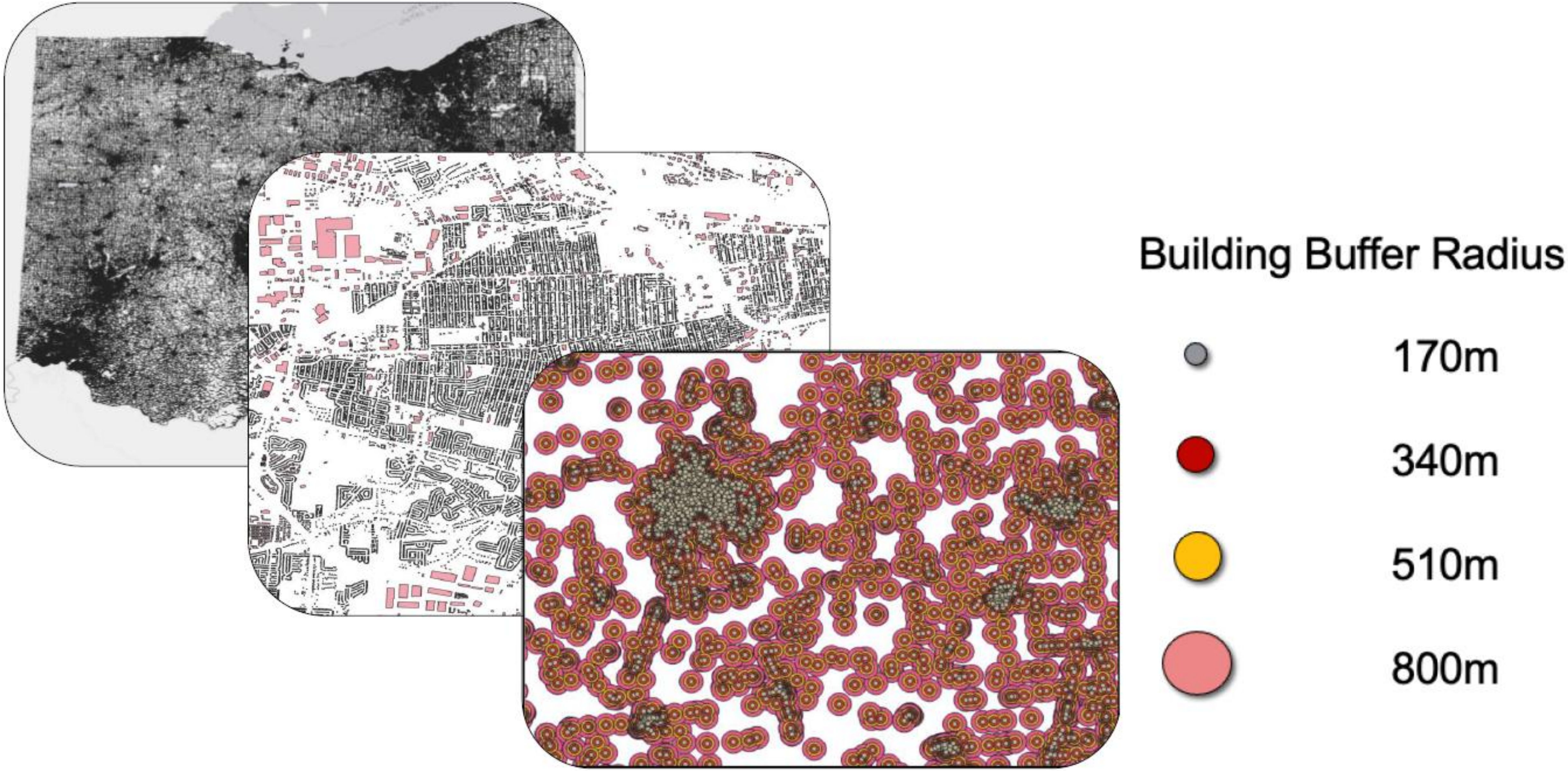
- 52 TW onshore nameplate capacity
- 54% of land area is restricted
- Potential is 4.893 MW/km^2

The onshore potential for wind energy in Europe (MW/km2)

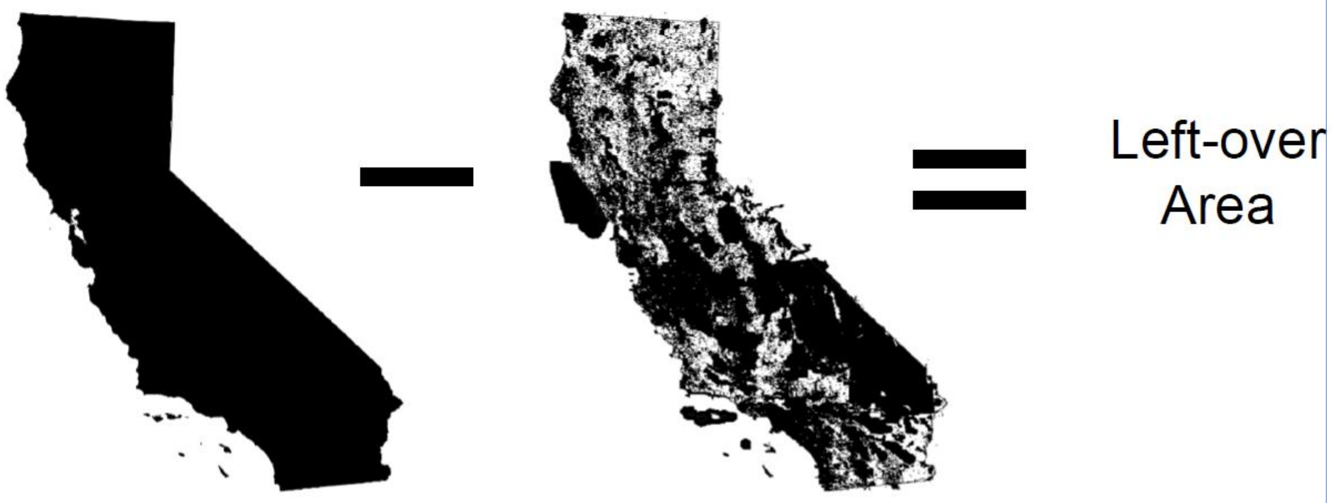


Source: Enevoldsen et al. 2019

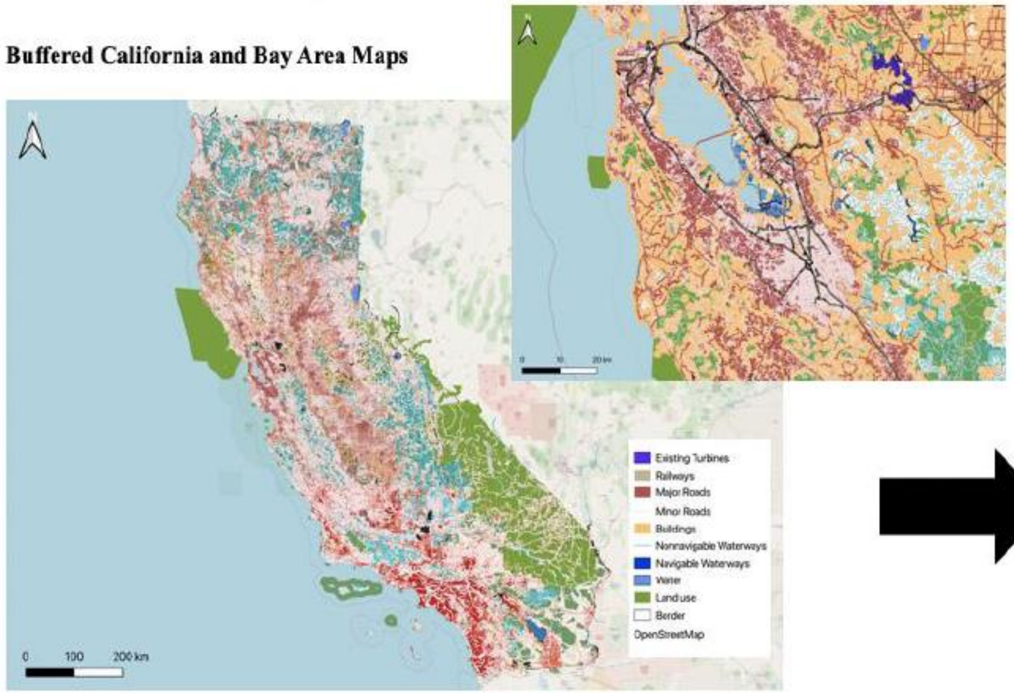
Buffer Visualization

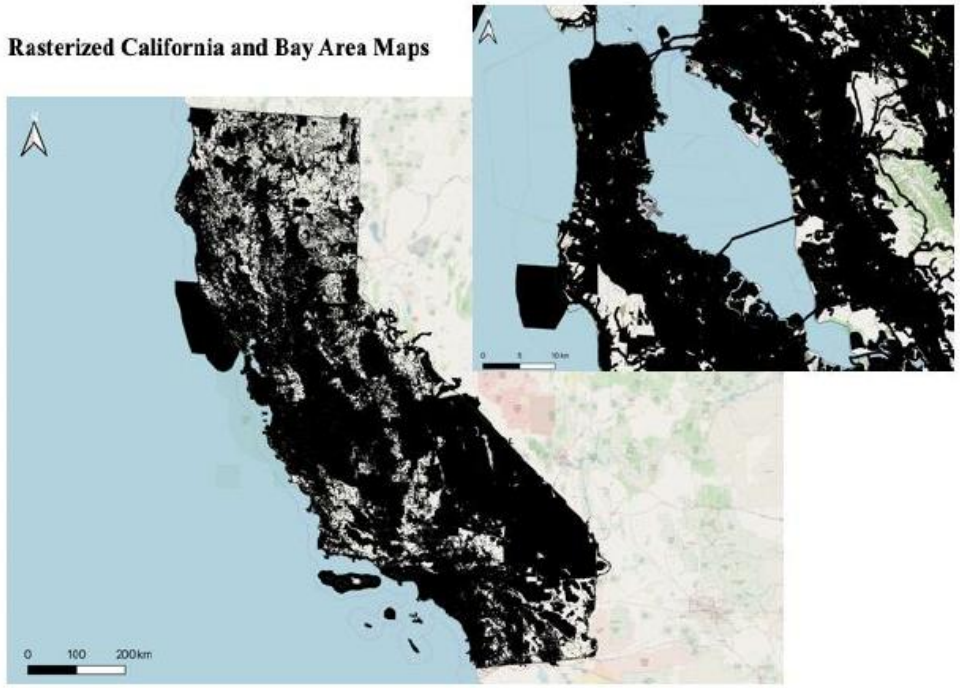


Rasterizing Process



Buffer to Raster Conversion

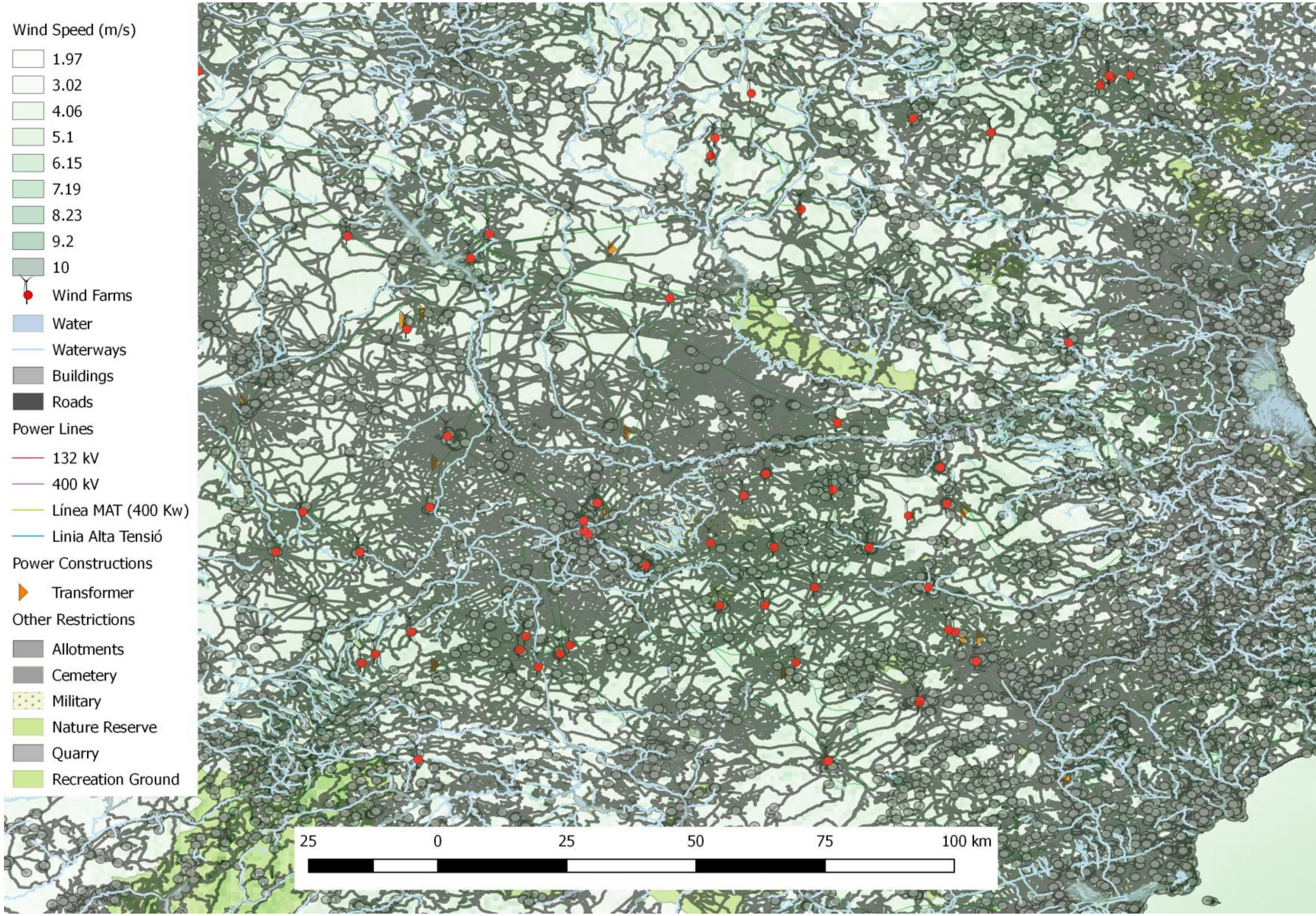




Zooming allows us to:

(Enevoldsen & Bakhtaoui, 2018)

- **Determine areas of interest for wind project development**
- **Export site boundaries to siting software**
- **Optimize wind farm location based on opportunities**
- **Identify socio-political risks**



Spain as an example

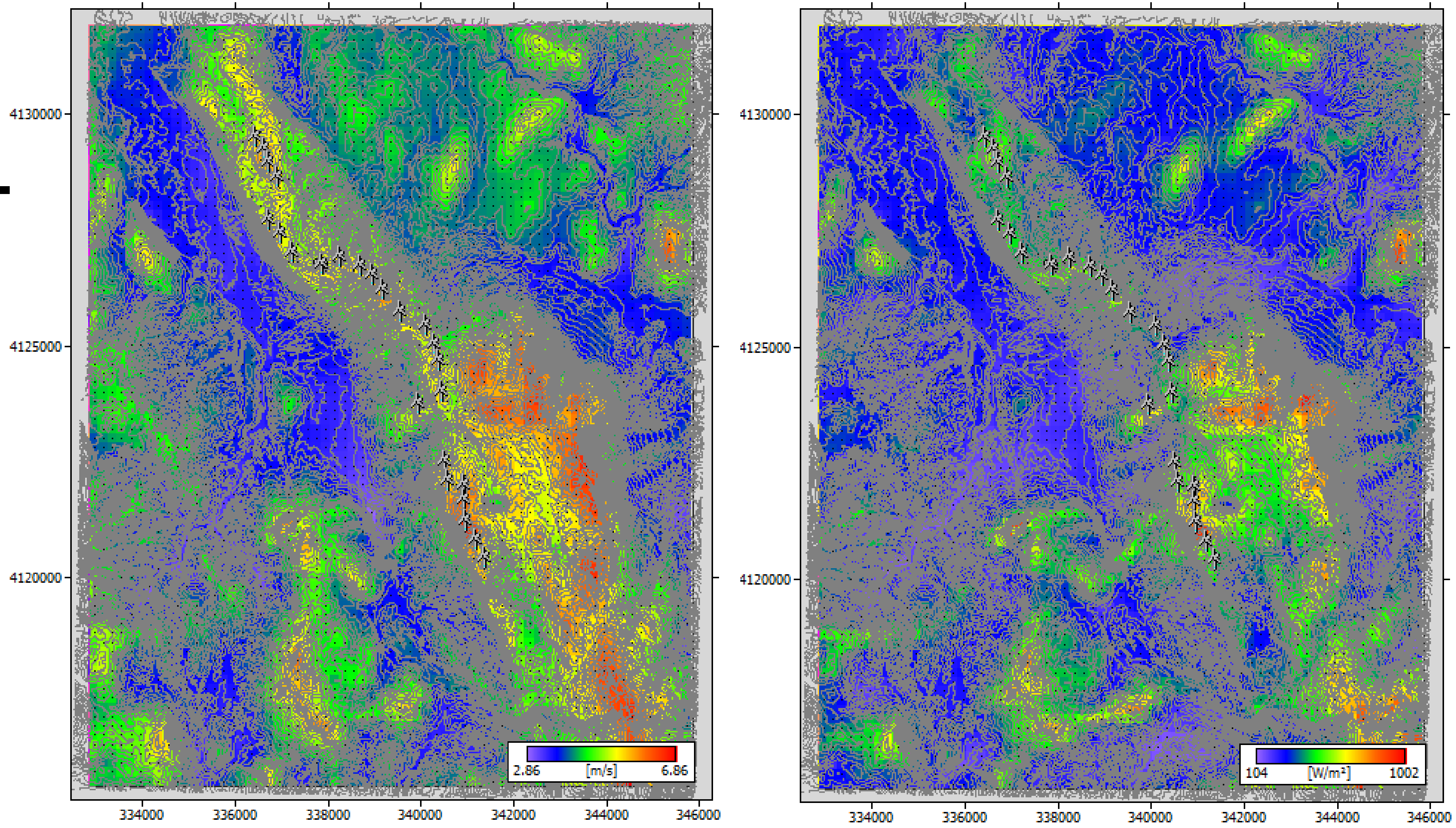
Enevoldsen & Jacobson (2021) found that the European spacing distance for multi-megawatt wind turbines are

- 19.8 (6.2-46.9) and 20.5 (16.5-48) MW/km^2.(Onshore)
- 7.2 MW/km^2 (3.3-20.2) (Offshore)

Year	2020	2030	2050
Land Required (km2)	1,650	2,482	6,460

The current available Spanish area is approx. 203,725 km^2

TOOLS YOU USE @ THE OFFICE – PRIMARY WRA RESULTS

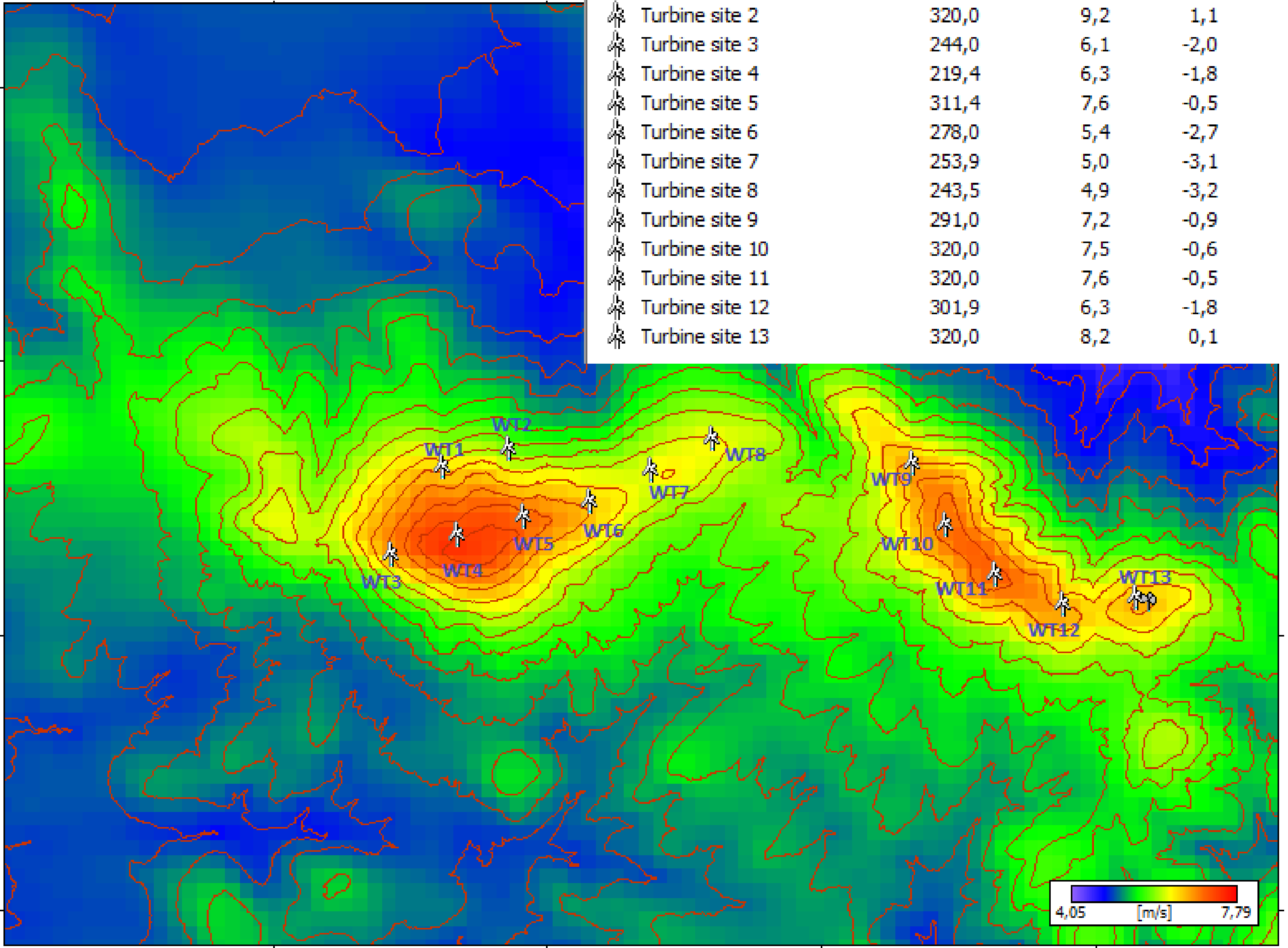


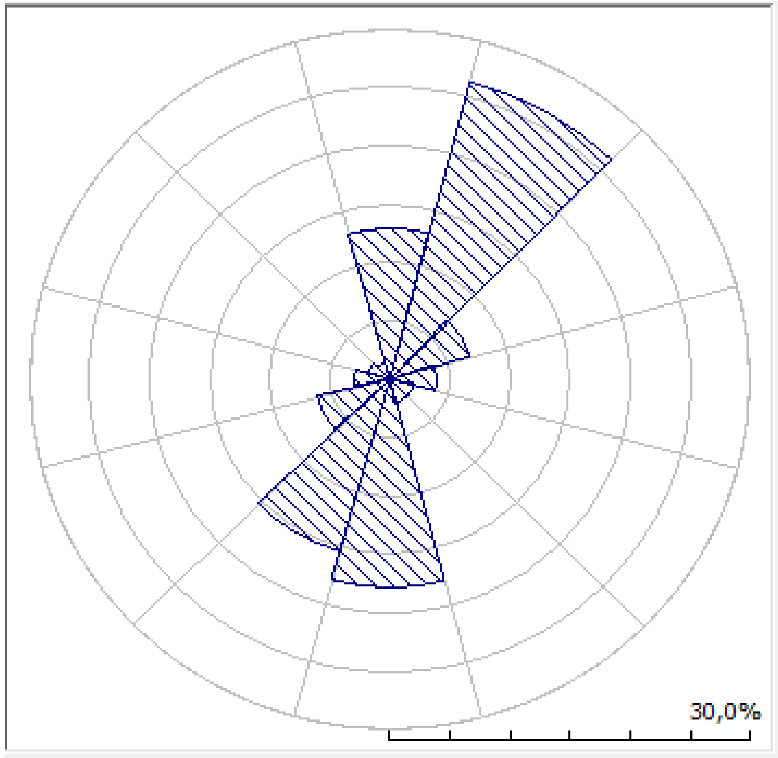
WF SITING EXERCISE

['Wind farm 1' Wind farm (72,908 GWh Net)]

Settings | Site list | Statistics | WF Power curve

Site description	Elev. [m]	RIX [%]	d.RIX [%]	Height. [m]	Speed [m/s]	Gross AEP [GWh]	Net AEP [GWh]	Wake loss [%]
Turbine site 1	254,8	4,8	-3,3	78,0	6,61	5,844	5,177	11,42
Turbine site 2	320,0	9,2	1,1	78,0	7,42	7,029	6,143	12,61
Turbine site 3	244,0	6,1	-2,0	78,0	6,57	5,713	5,148	9,88
Turbine site 4	219,4	6,3	-1,8	78,0	5,99	4,812	4,356	9,48
Turbine site 5	311,4	7,6	-0,5	78,0	7,08	6,585	5,997	8,93
Turbine site 6	278,0	5,4	-2,7	78,0	6,58	5,848	5,499	5,98
Turbine site 7	253,9	5,0	-3,1	78,0	6,25	5,324	5,008	5,94
Turbine site 8	243,5	4,9	-3,2	78,0	6,28	5,341	5,201	2,62
Turbine site 9	291,0	7,2	-0,9	78,0	6,78	6,008	5,931	1,29
Turbine site 10	320,0	7,5	-0,6	78,0	7,00	6,310	6,211	1,57
Turbine site 11	320,0	7,6	-0,5	78,0	7,06	6,451	6,382	1,07
Turbine site 12	301,9	6,3	-1,8	78,0	6,73	6,024	5,934	1,49
Turbine site 13	320,0	8,2	0,1	78,0	6,68	5,960	5,922	0,63





OFFSHORE WIND DEVELOPMENT CONSTRAINTS

Technical and Environmental Constraints

Extreme Weather:

High winds, wave action, and storms can damage turbines and create challenging conditions for installation and maintenance.

Environmental Impact:

Wind farms can affect local wildlife, particularly birds, and disrupt marine habitats requiring comprehensive environmental assessments.

Grid Connection:

Transmitting electricity from offshore turbines to land requires expensive subsea power cables, a significant infrastructure cost.

Radar Interference:

Offshore wind farms can interfere with radar systems, leading to safety and operational issues.

Economic and Supply Chain Challenges

High Costs and Long Lead Times:

Developing offshore wind farms is a lengthy and expensive process, with projects often taking a decade before construction begins, making them susceptible to inflation and market forces.

Supply Chain Bottlenecks:

There are often insufficient resources, services, and manufacturing capabilities to support the rapid growth of the offshore wind industry, leading to delays and increased costs.

Skilled Labor Shortages:

A lack of trained workers and specialized expertise can hinder project development and operations, necessitating targeted education and training programs.

OFFSHORE WIND DEVELOPMENT CONSTRAINTS

Social and Regulatory Issues

Conflict with Existing Activities:

Wind farms must be carefully sited to avoid conflicts with shipping traffic, established ports, and other maritime users.

Public and Stakeholder Acceptance:

Wind farms can face opposition due to visual impacts and concerns about effects on local wildlife and property values.

Regulatory Hurdles:

Navigating complex regulations, such as the Habitats Regulations in the UK, adds layers of complexity and time to the development process.

OFFSHORE WIND DEVELOPMENT OBSTACLES

- Time it takes to get projects started
- Maintenance and Support
- Heavy storms or hurricanes, can damage wind turbines
- Waste Management

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Proceedings of the Institution of Civil Engineers - Energy   Journal Home   Issues

RESEARCH ARTICLE | AUGUST 11 2025

Extreme wind design standards and tropical cyclone–resilient wind turbines: a review

Thomas Wojahn; George Xydis

+ Author & Article Information

Proceedings of the Institution of Civil Engineers - Energy (2025)

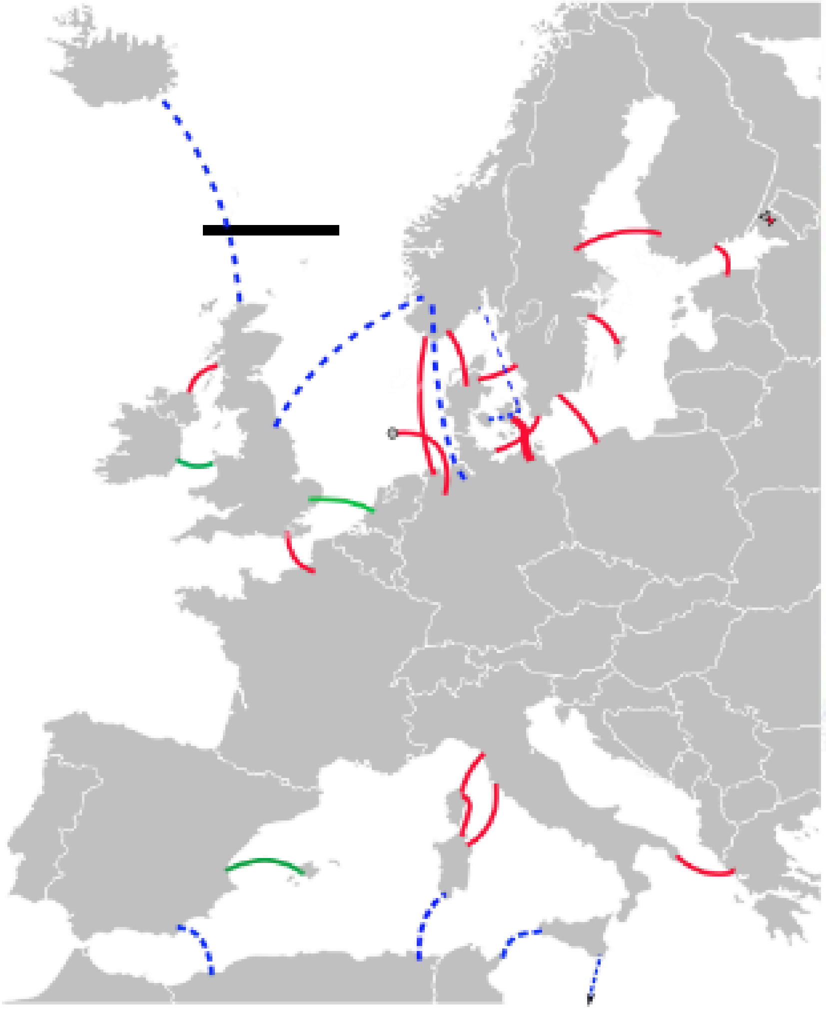
https://doi.org/10.1680/jener.25.00005   Article history

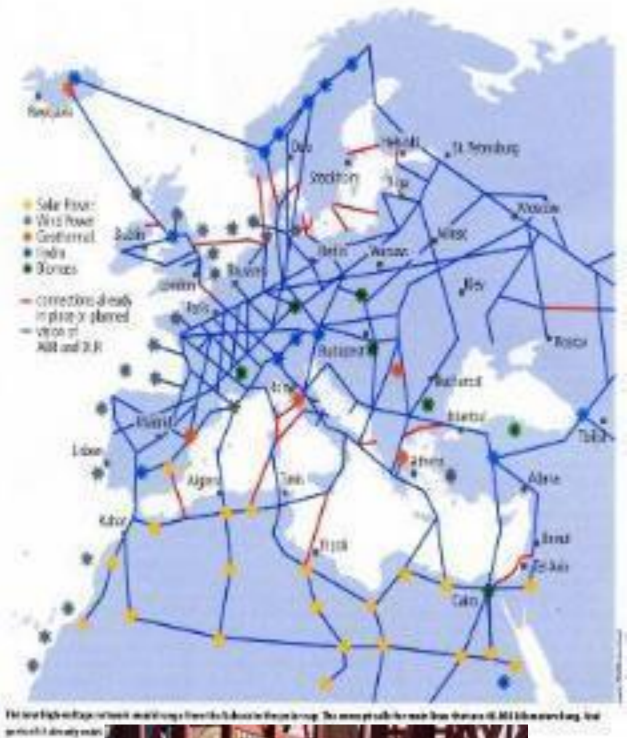
Share   Get Permissions   Cite

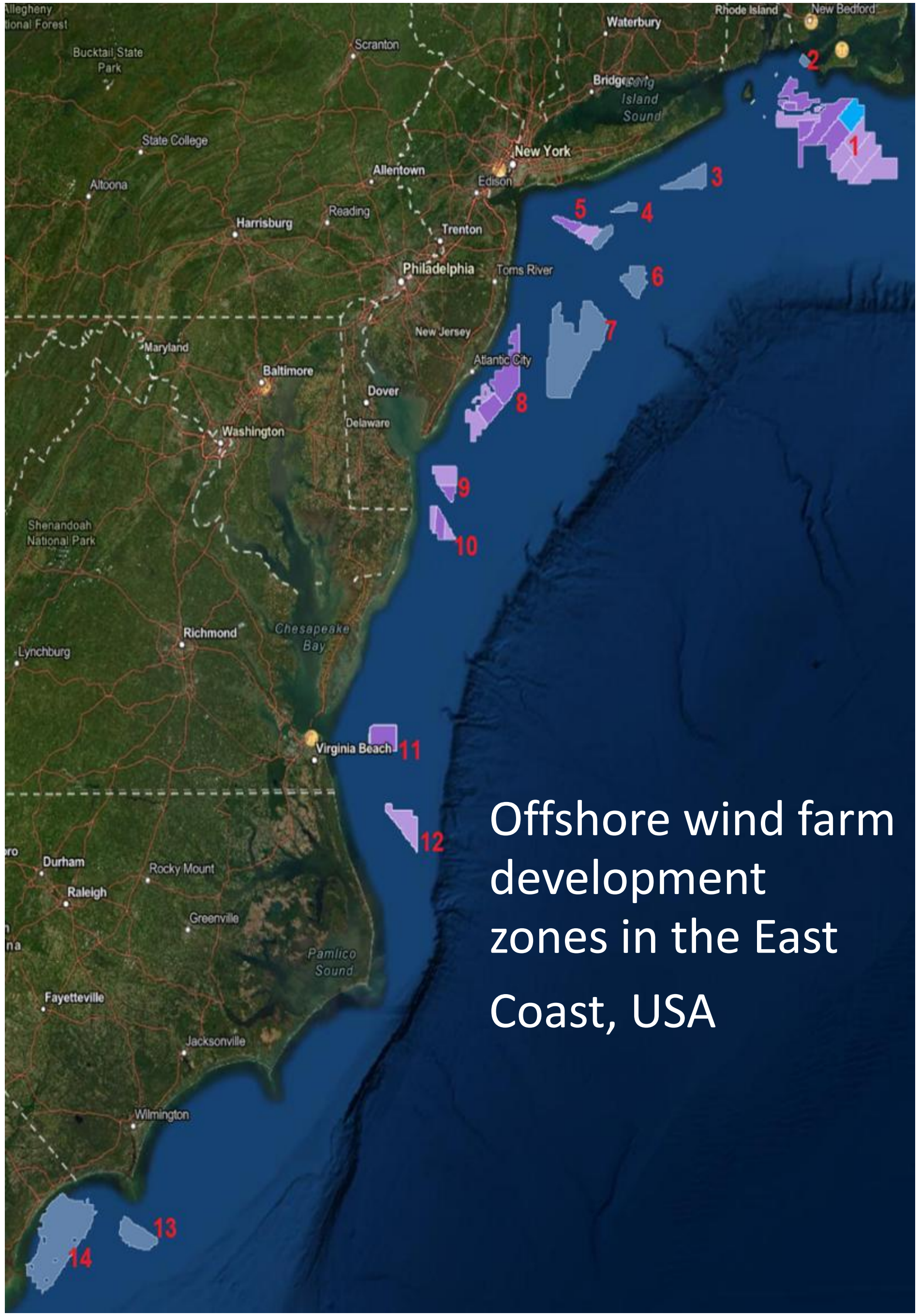
Large numbers of wind farms have been built onshore and many more are planned for offshore areas in tropical cyclone regions. A review of past wind turbine failures in tropical cyclones reveals six general types of design weaknesses. Several key studies show that extreme winds in tropical cyclones, especially in Saffir–Simpson hurricane classes 3 through 5 (major tropical cyclones), are poorly understood. In response to evolving tropical cyclone wind turbine design standards, known design weaknesses in tropical cyclones (and more frequent and intense winds due to climate change) promising wind turbine design innovations may significantly reduce the risk of wind turbine failures and financial losses associated with tropical cyclones. This study identifies three key priorities: (1) adoption of site-specific (Class S) assessments to account for localised cyclone dynamics, (2) implementation of a 100-year return period design standard for structural resilience, and (3) integration of innovative blade force survivability technologies, such as adaptive pitch control and composite reinforcement. Leveraging innovative solutions will play a pivotal role in securing the viability of wind farms in tropical cyclone-prone regions.

SUPPLY CHAIN CONSTRAINTS: WINDFARM SUPPORT VESSELS

INTERCONNECTION SCENARIOS IN EUROPE







Offshore wind farm development zones in the East Coast, USA

EXERCISE

Go to: 4C Offshore

Let's assume that the average size of the wind blades that will be used is going to be approximately of the 10 MW wind turbine. A 2.3 MW wind blade weights approximately 10 metric tons (t), while a blade of a 9.5 MW turbine could reach up to 35 t. It is given that the tot. area of all the polygones is 15,000 km^2, and that the capacity density equals 15 MW/km^2.

1. *What's the Total Offshore Wind Capacity to be installed in the East Coast? Roughly, how many wind turbines?*
2. *What's the cumulative Total Offshore Blade Waste?*
3. *What's the amount of plastic waste in the world today? **Comments? Thoughts?***

THANK YOU

QUESTIONS?

Oil & Gas Economics: Benchmarking for Renewable Energy Investments

1st TETHYS summer school - Day 4

George Xydis

Funded by the European Union

University of Cyprus

UNIVERSITÀ DEGLI STUDI FIRENZE

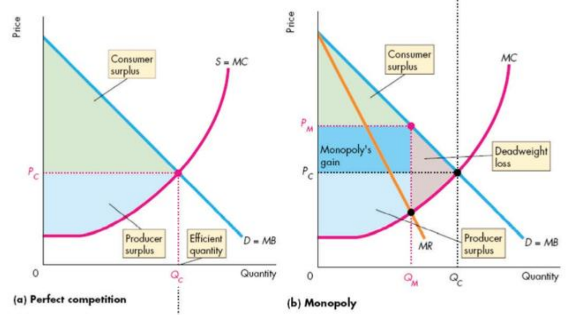
NEEST NEW ENERGY & ENVIRONMENTAL SOLUTIONS AND TECHNOLOGIES

AARHUS BSS

Oil & Natural Gas

Oil Majors - Seven Sisters

Competition vs Monopoly



???

The 10 largest oil[1] producers and share of total world oil production[2] in 2021[3]

Country	Million barrels per day	Share of world total
United States	18.88	20%
Saudi Arabia	10.84	11%
Russia	10.78	11%
Canada	5.54	6%
China	4.99	5%
Iraq	4.15	4%
United Arab Emirates	3.79	4%
Brazil	3.69	4%
Iran	3.46	4%
Kuwait	2.72	3%
Total top 10	68.82	72%
World total	95.57	

[1] *Oil* includes crude oil, all other petroleum liquids, and biofuels.

[2] Production includes domestic production of crude oil, all other petroleum liquids, biofuels, and refinery processing gain.

[3] Source: International Energy Statistics, Total oil (petroleum and other liquids) production, as of May 10, 2022

The 10 largest oil[1] consumers and share of total world oil consumption in 2019[2]

Country	Million barrels per day	Share of world total
United States	20.54	20%
China	14.01	14%
India	4.92	5%
Japan	3.74	4%
Russia	3.70	4%
Saudi Arabia	3.18	3%
Brazil	3.14	3%
Canada	2.63	3%
South Korea	2.60	3%
Germany	2.35	2%
Total top 10	60.81	61%
World total	100.23	

[1] *Oil* includes crude oil, all other petroleum liquids, and biofuels.

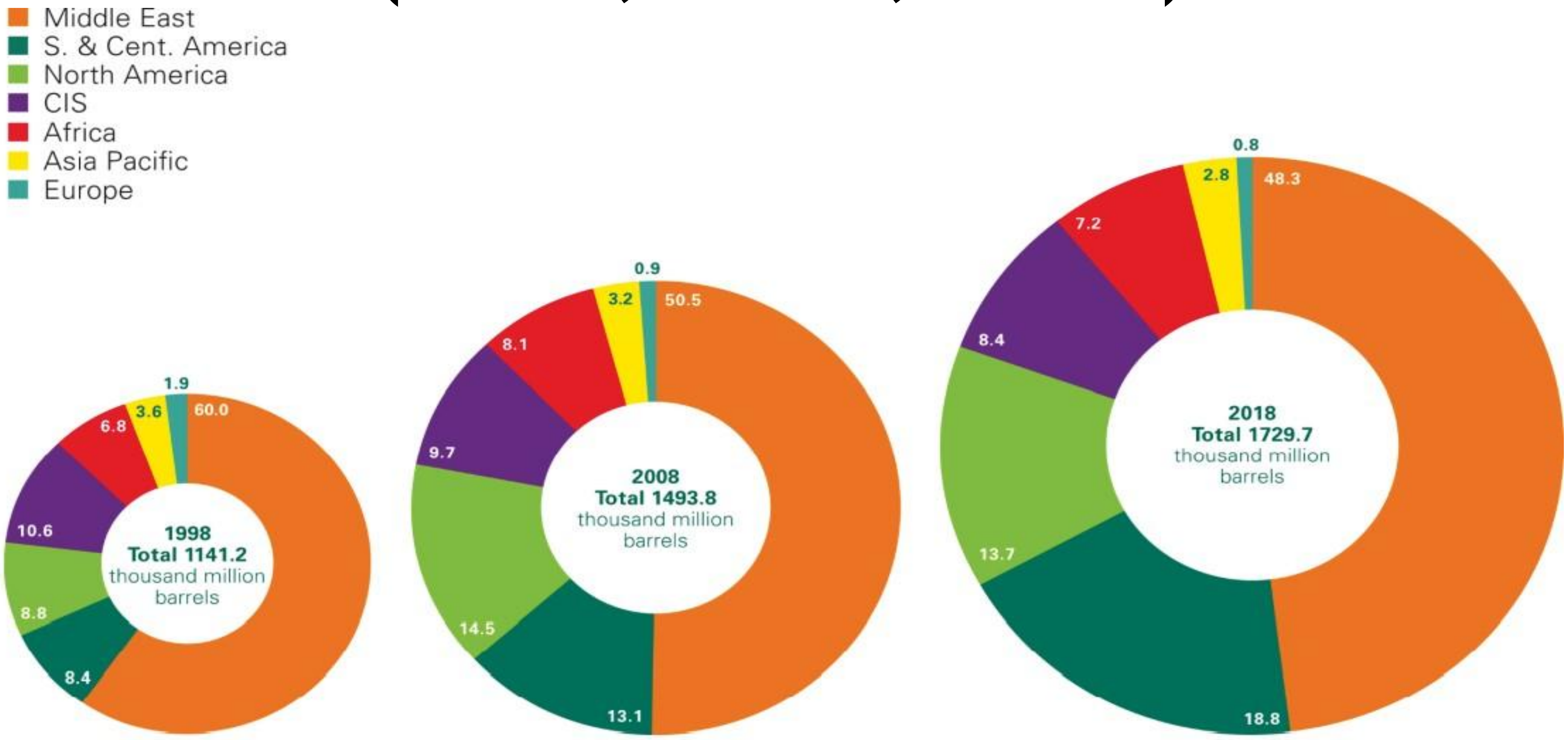
[2] Source: International Energy Statistics, Total oil (petroleum and other liquids) consumption, as of May 10, 2022

Learn more:

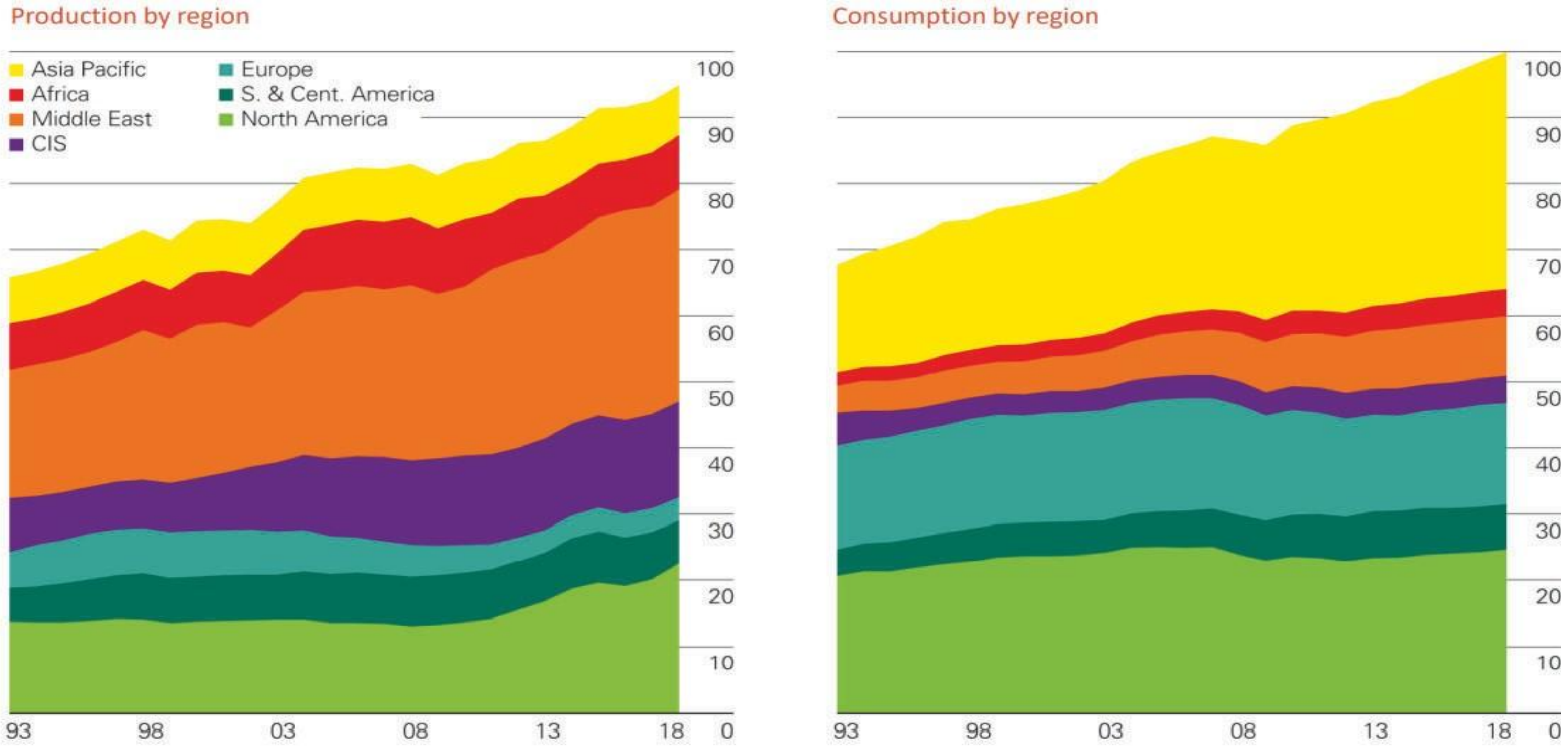
Energy Explained: Where our oil comes from

Last updated: May 10, 2022, with most recent data available at the time of update.

(1997, 2007, 2018)



Source: BP Statistical Review of World Energy 2019



Source: BP Statistical Review of World Energy 2019

How much?

OIL RESERVES

1,650,585,140,000 barrels

47 years of oil left

(at current consumption levels)

In the 1970s, drilling under a mile or more of water to a reasonable ground depth was unheard of.

Offshore technology advancements incl. the North Sea and Gulf of Mexico

Other major areas that could also contribute more to global oil production, i.e. the the Albertan oil sands

More recently, shale gas has come onto the scene

How much?

TASS NEWS AGENCY

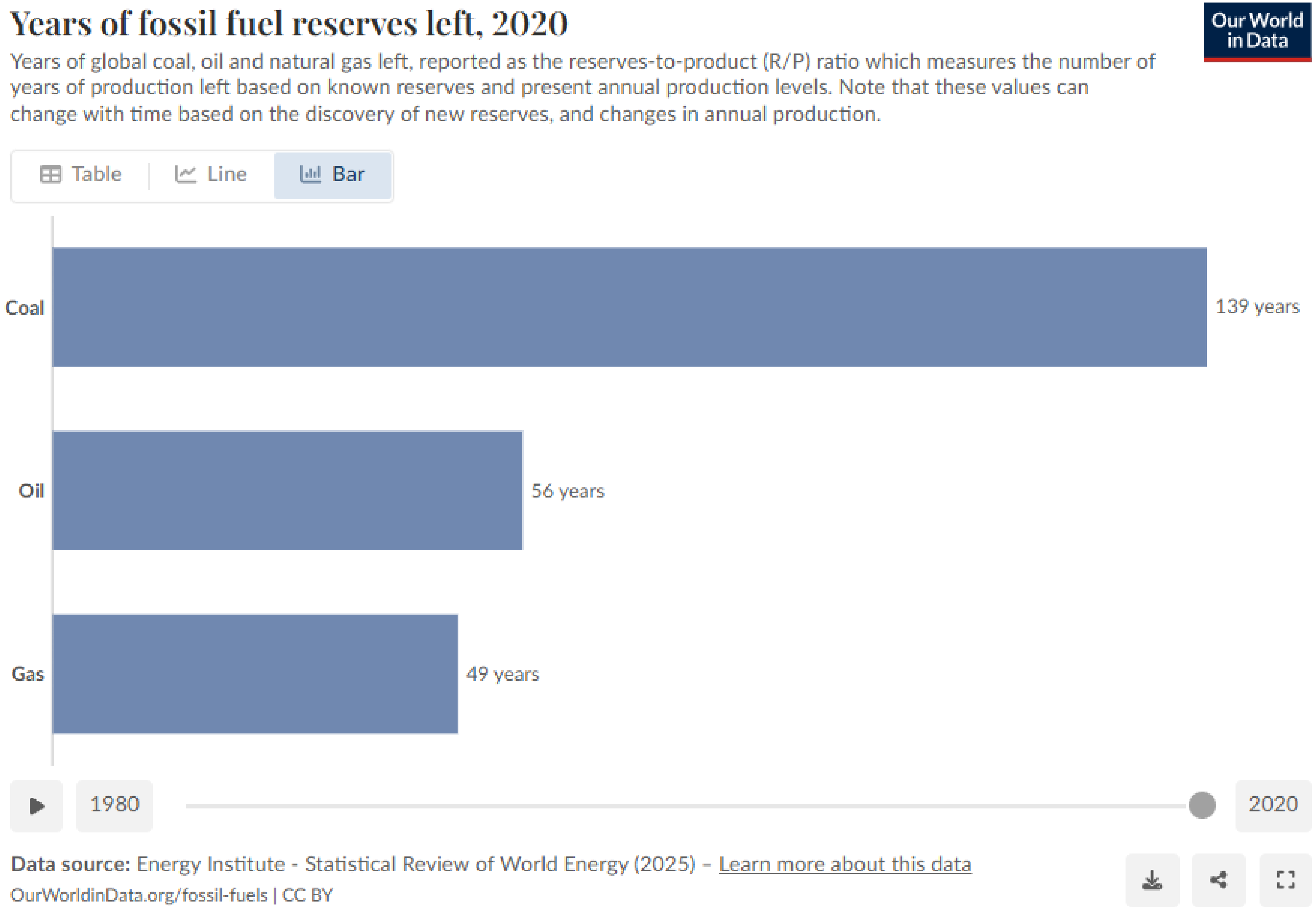
TASS

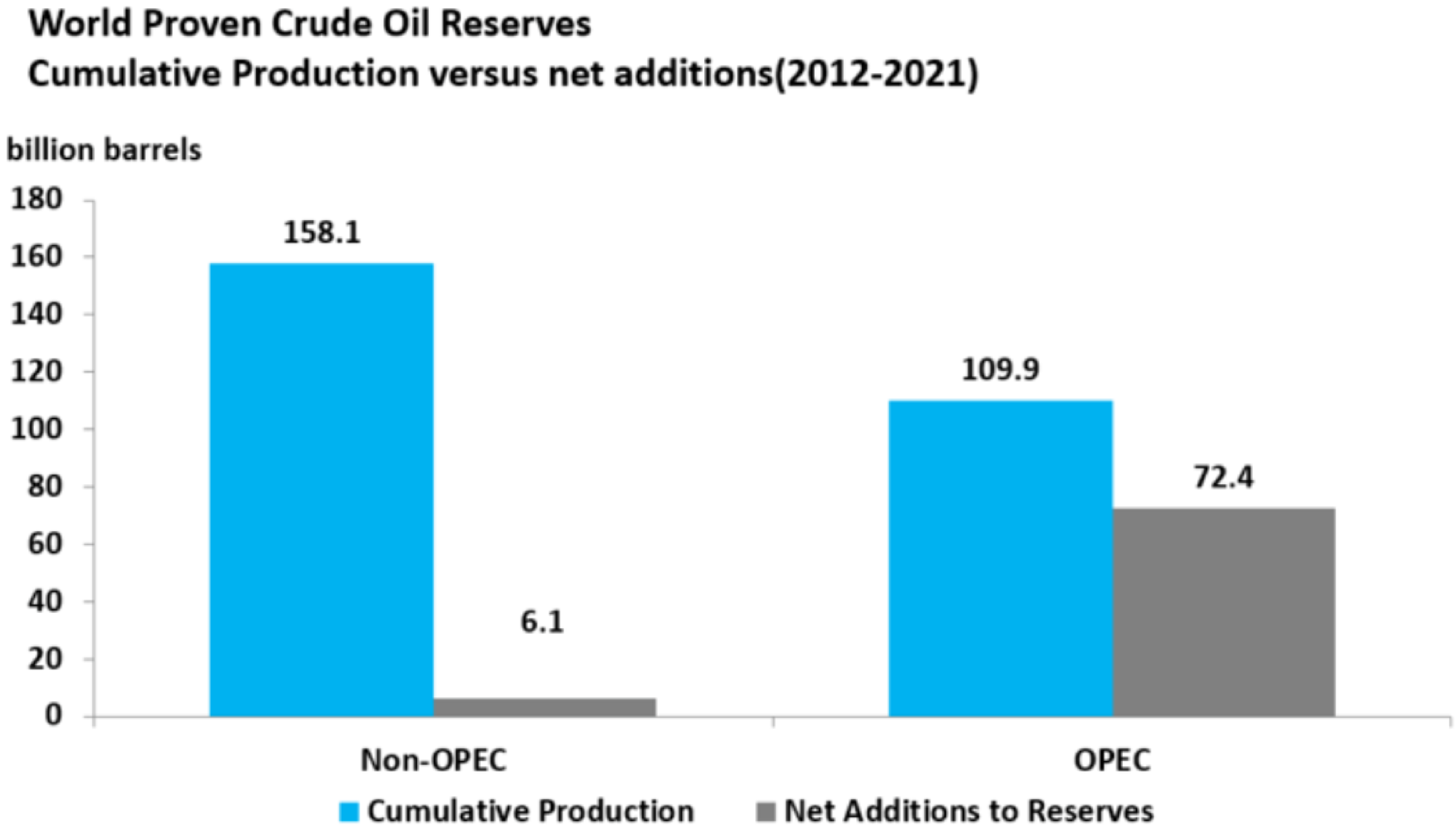
Russia's coal reserves will last for almost a thousand years — Putin

Business & Economy September 04, 11:26

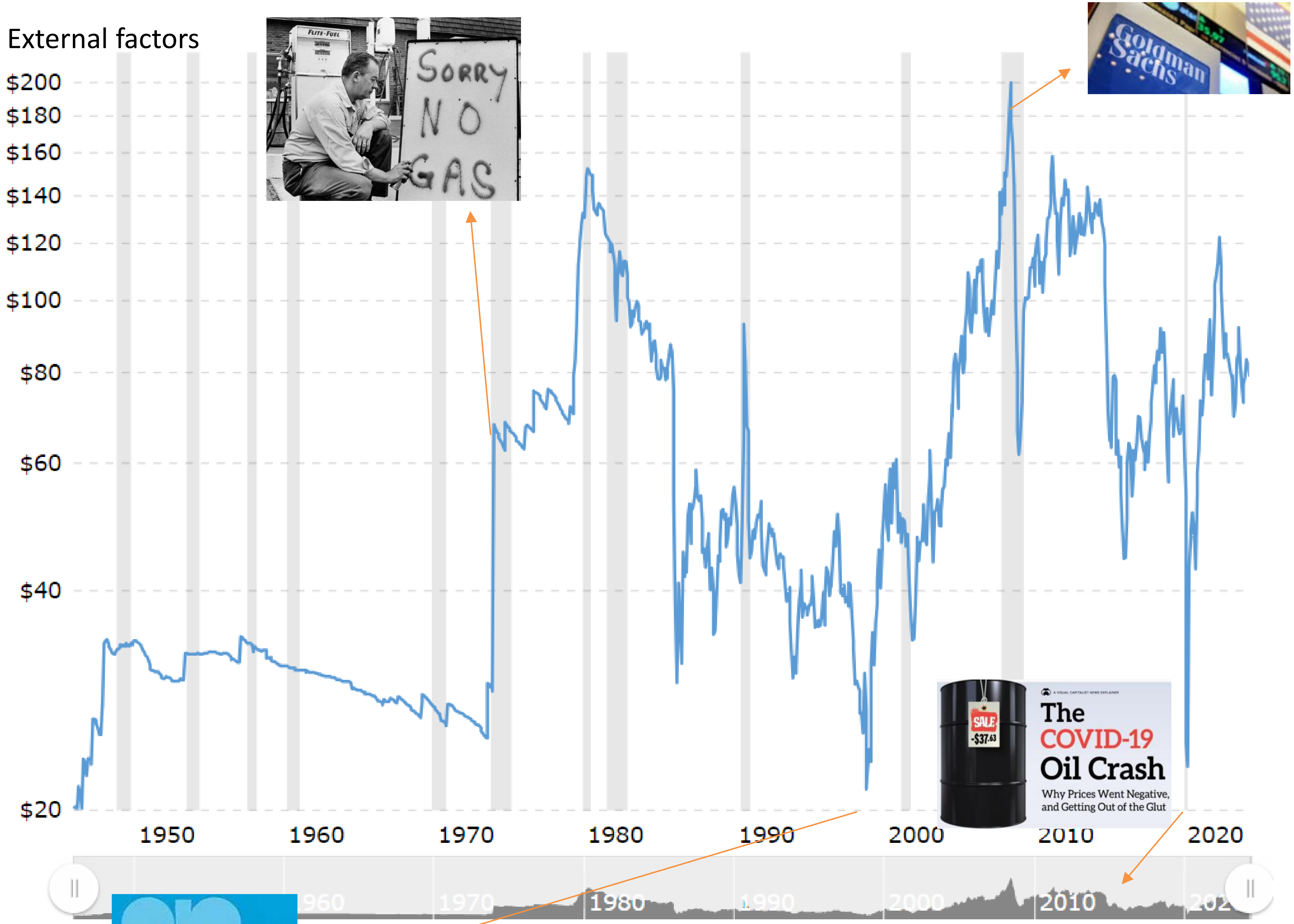
The Russian leader said that coal can be used much more efficiently, with greater efficiency and in compliance with all environmental requirements

VLADIVOSTOK, September 4. /TASS/. Russian President Vladimir Putin demanded that coal be used more efficiently in the energy sector in the Far East, especially in the context of a possible gas shortage. At the presentation of the results of the development of the Far Eastern regions, which is underway as part of the Eastern Economic Forum (EEF), Putin noted that later today he will hold a meeting on the development of the energy sector in the Far East.




World Proven Crude Oil Reserves
Cumulative Production versus net additions(2012-2021)
billion barrels
180
160
140
120
100
80
60
40
20
0
158.1
6.1
109.9
72.4
Non-OPEC
OPEC
Cumulative Production
Net Additions to Reserves

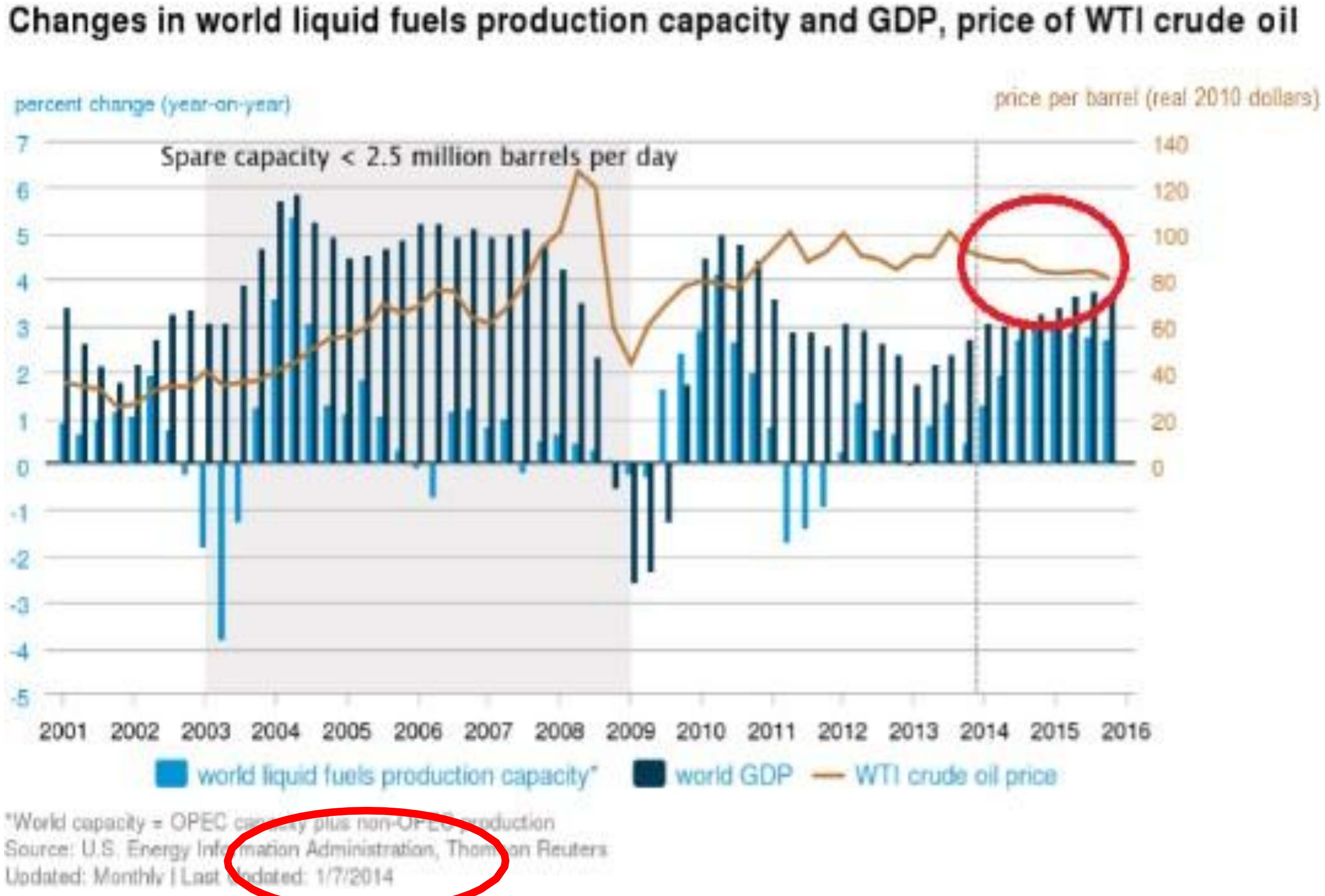
External factors



This map shows the current position of tankers, mostly filled with oil. They are "stranded" around the world because there is no way to unload, since onshore warehouses are full, pipelines are full, and without flow, due to the low demand for oil.

External factors

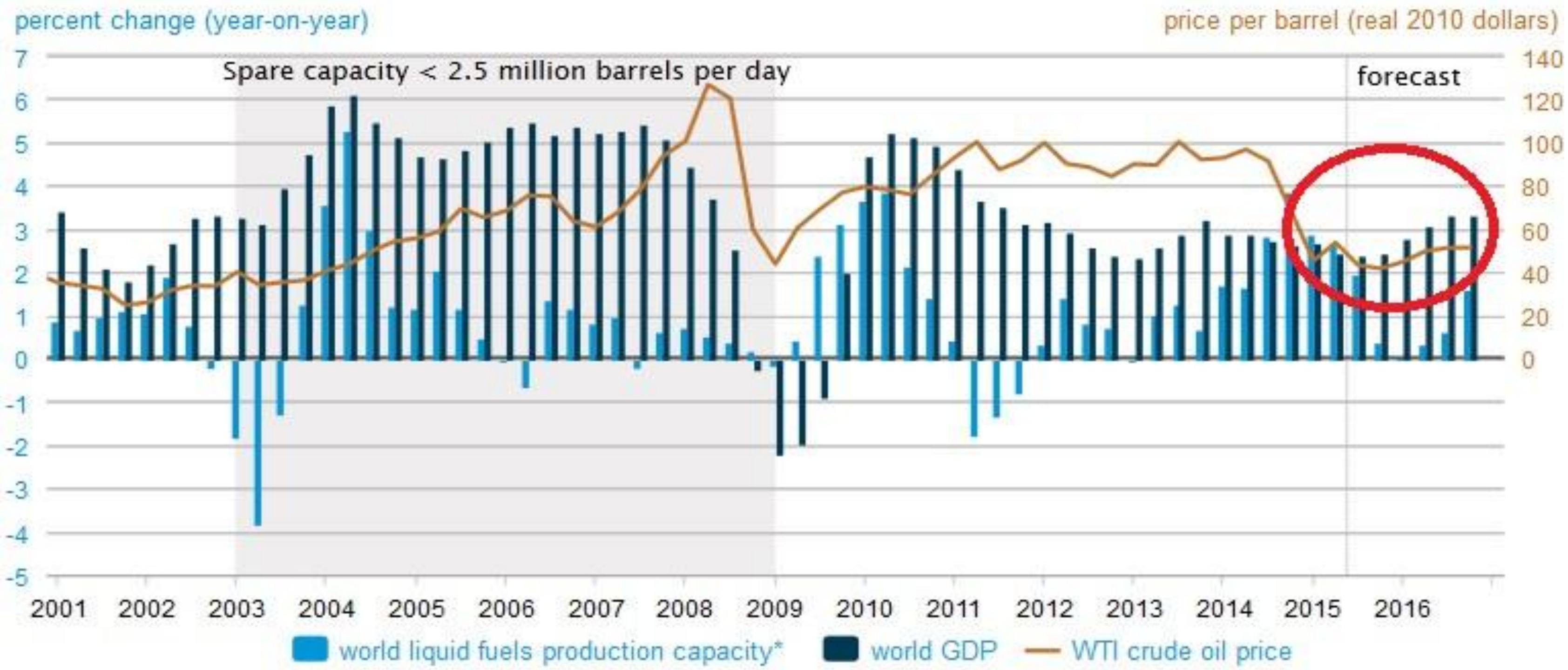
BASE LOAD…VOLATILE PRICE



BASE LOAD…VOLATILE PRICE

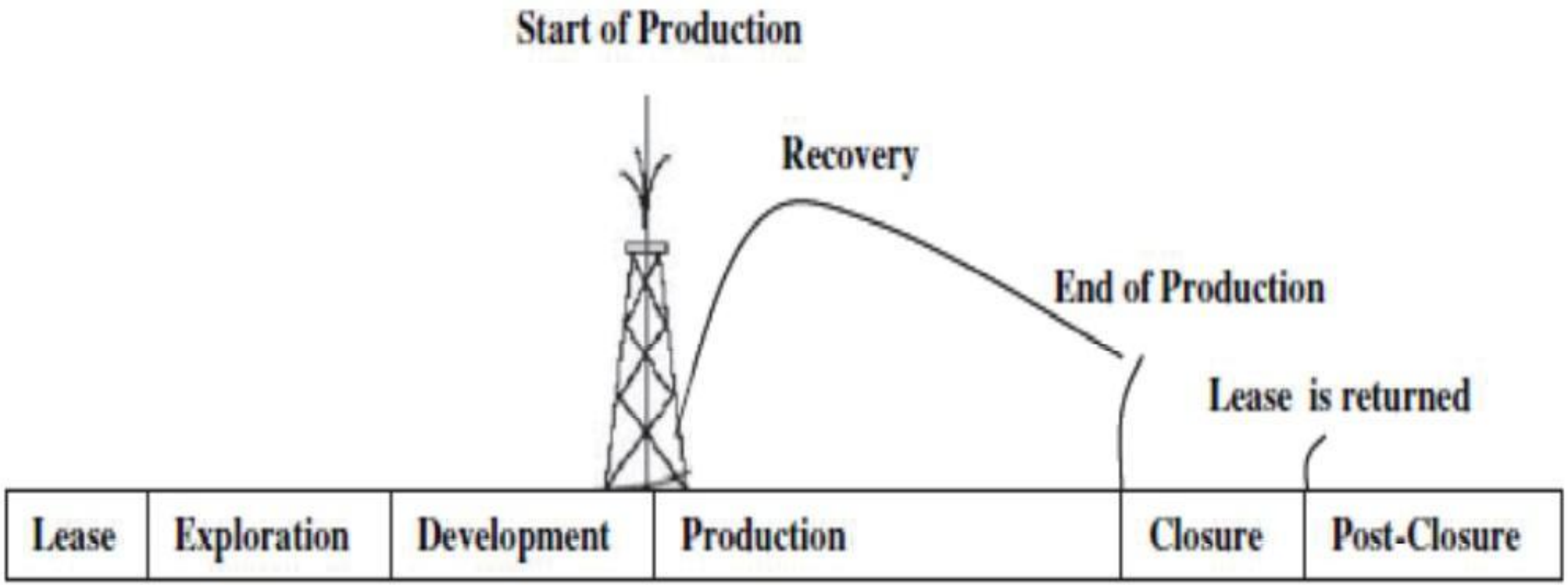
The years 2003-2008 experienced periods of very strong economic and oil demand growth, slow supply growth and tight spare capacity

Changes in world liquid fuels production capacity and GDP, price of WTI crude oil

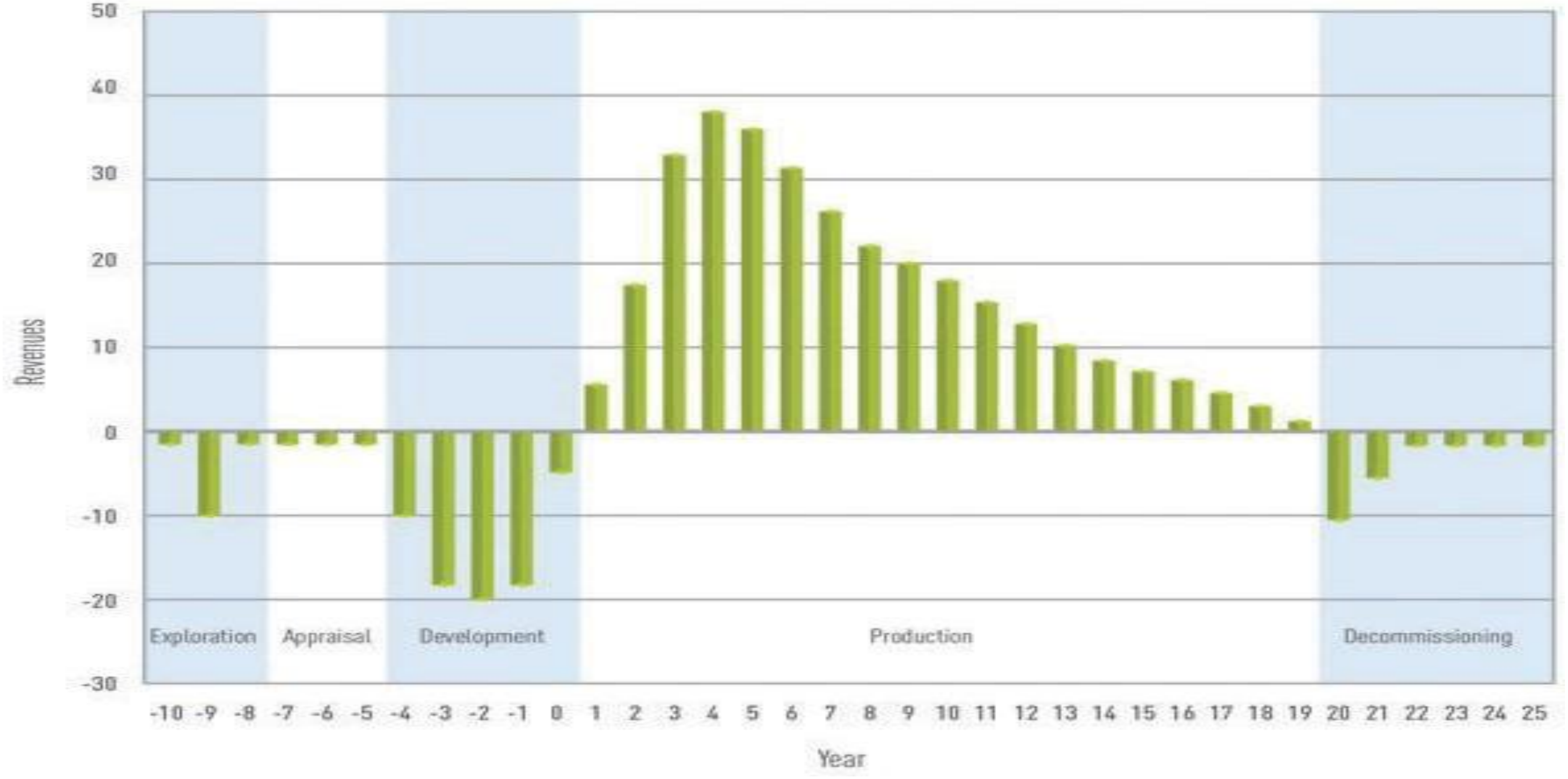


*World capacity = OPEC capacity plus non-OPEC production
Source: U.S. Energy Information Administration, Thomson Reuters
Updated: Monthly | Last Updated: 08/11/2015

Figure 1. The Project Cycle

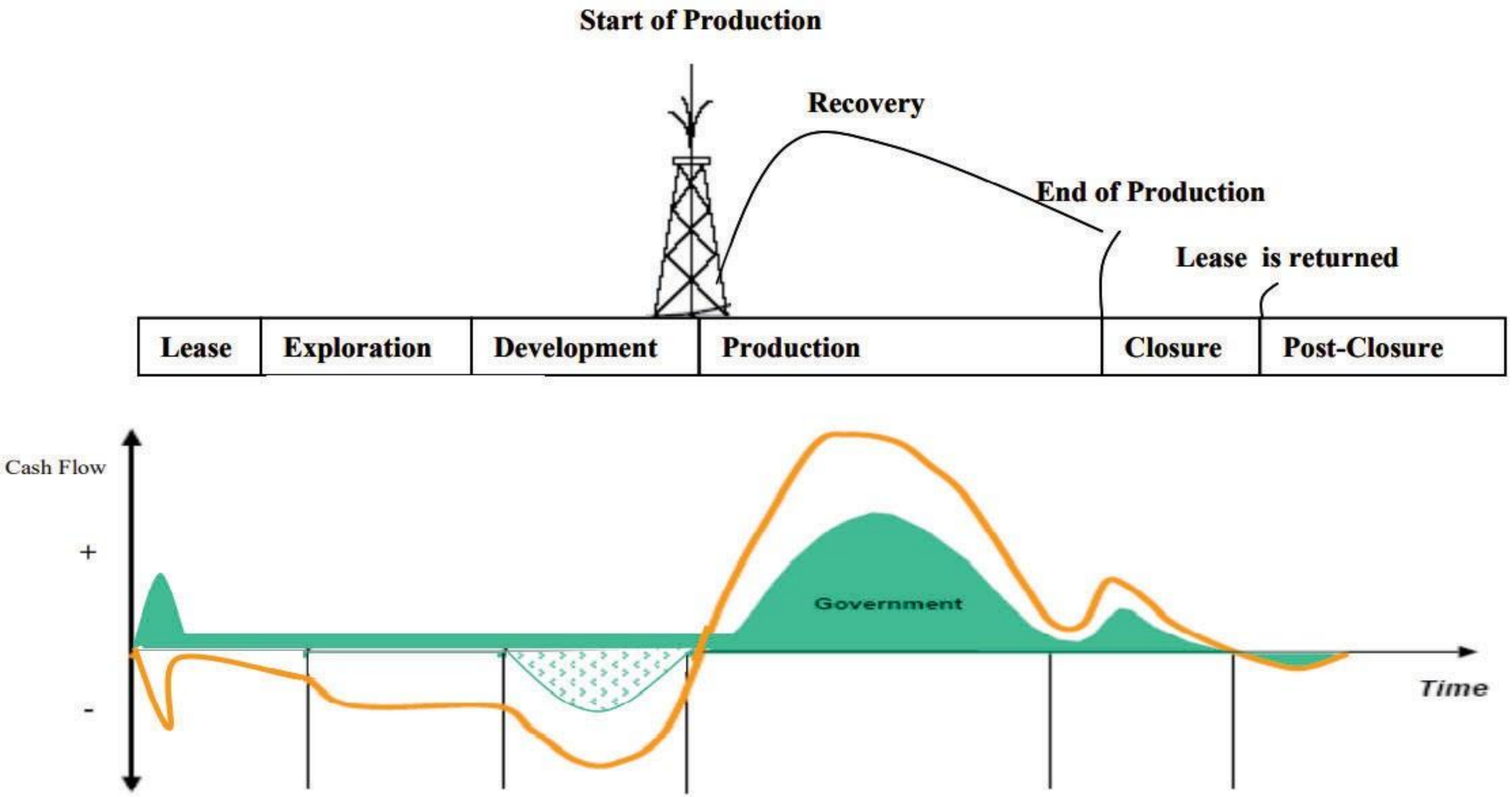


For How long?

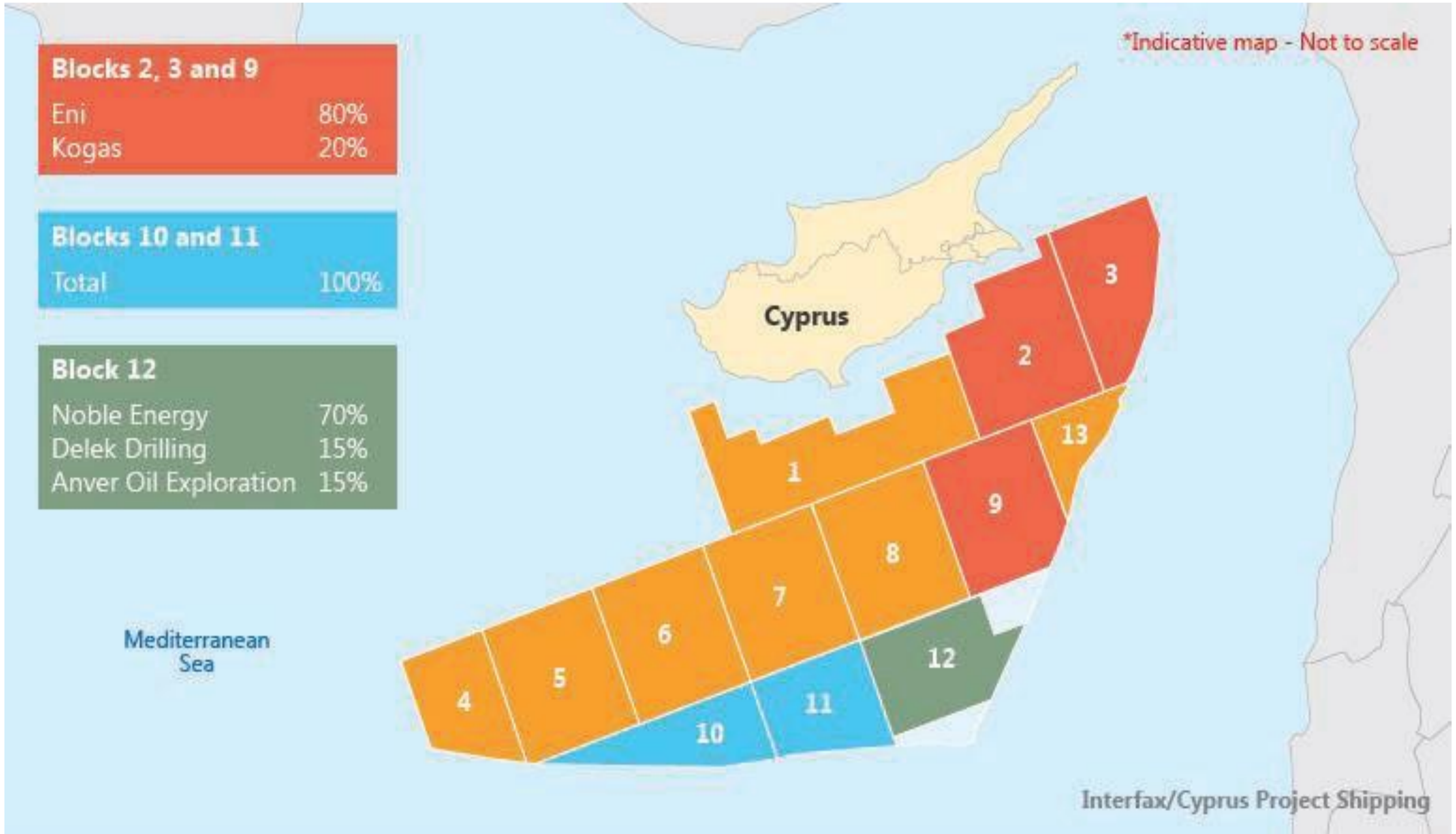


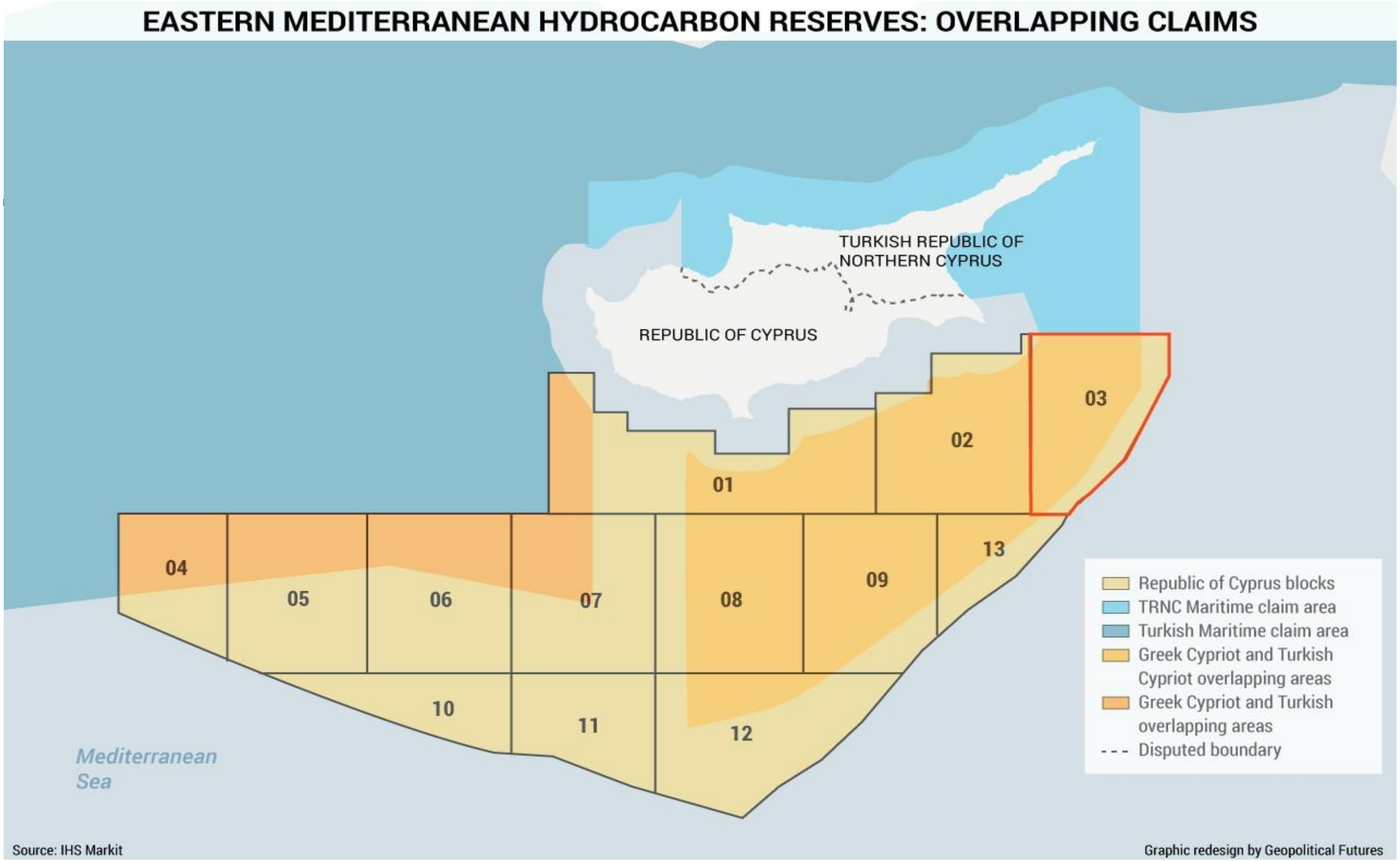
Revenues
50
40
30
20
10
0
-10
-20
-30
Exploration
Appraisal
Development
Production
Decommissioning
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Year

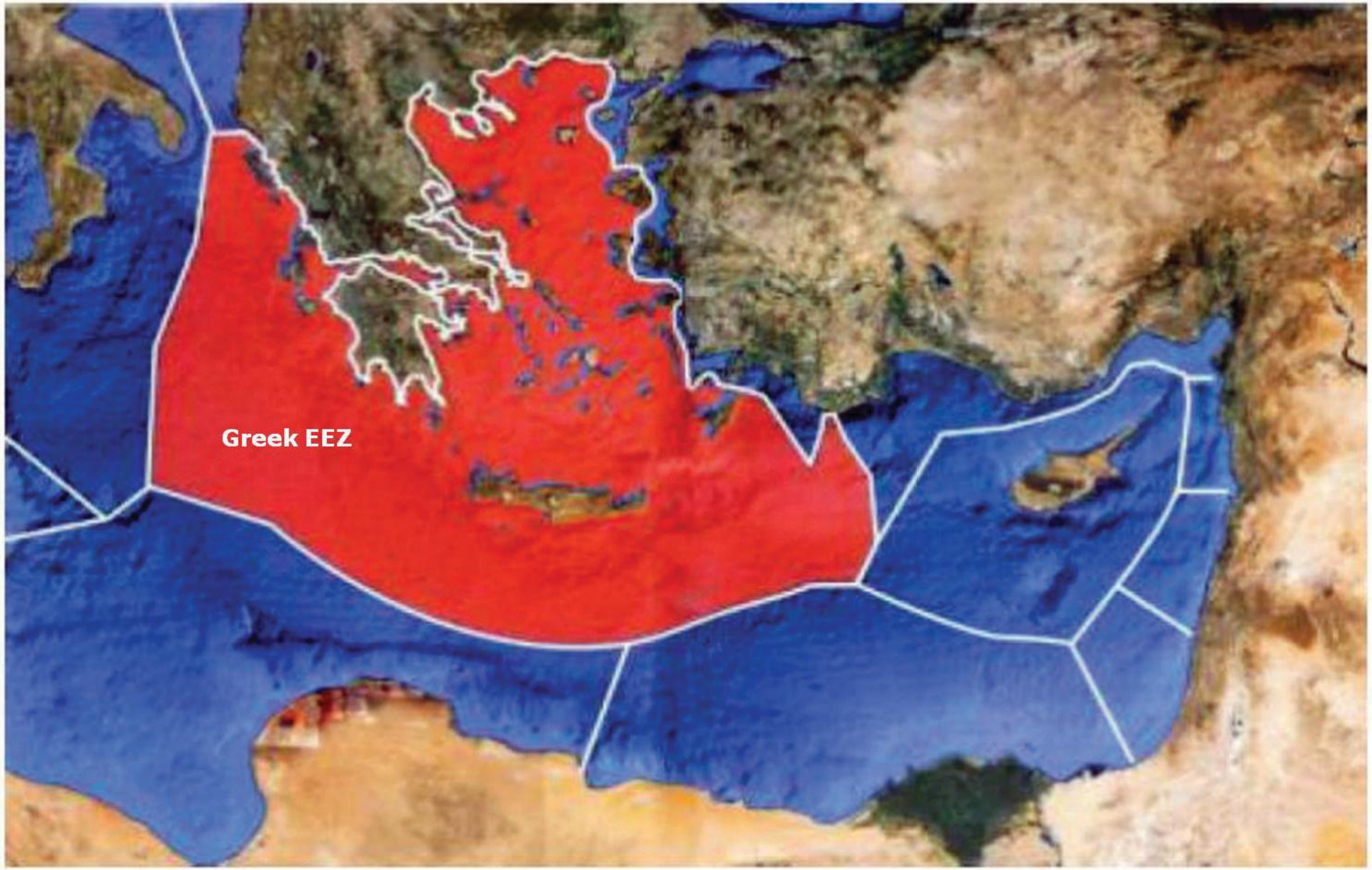
Profits per stage



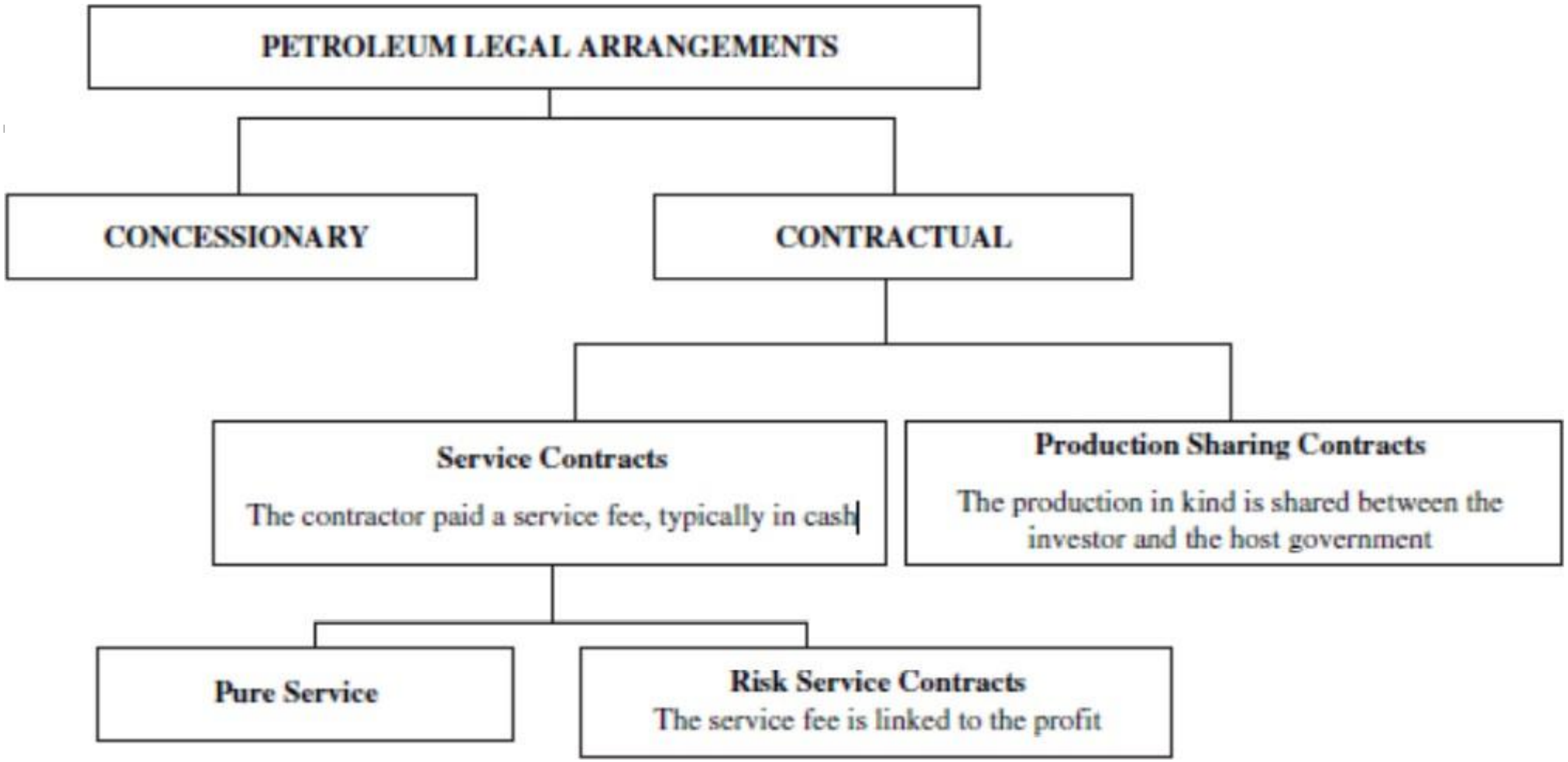
Politics…
Overlapping Claims




EASTERN MEDITERRANEAN HYDROCARBON RESERVES: OVERLAPPING CLAIMS
TURKISH REPUBLIC OF NORTHERN CYPRUS
REPUBLIC OF CYPRUS
01
02
03
04
05
06
07
08
09
10
11
12
13
Mediterranean Sea
Republic of Cyprus blocks
TRNC Maritime claim area
Turkish Maritime claim area
Greek Cypriot and Turkish Cypriot overlapping areas
Greek Cypriot and Turkish overlapping areas
Disputed boundary
Source: IHS Markit
Graphic redesign by Geopolitical Futures


Greek EEZ

Contracts


PETROLEUM LEGAL ARRANGEMENTS
CONCESSIONARY
CONTRACTUAL
Service Contracts
The contractor paid a service fee, typically in cash
Production Sharing Contracts
The production in kind is shared between the investor and the host government
Pure Service
Risk Service Contracts
The service fee is linked to the profit

Contracts

Contracts

The **Power of Siberia** natural gas pipeline, which runs from Russia to China, was completed and began operations in **2019**.

Key Details:

- **Construction Start**: 2014
- **Completion & Launch**: December 2, 2019
- **Length**: Approximately **3,000 km** (1,864 miles)
- **Capacity**: 38 billion cubic meters (bcm) of gas per year → Q1, Q2
- **Supplier**: Gazprom (Russia)
- **Buyer**: China National Petroleum Corporation (CNPC)

This pipeline delivers gas from Russia's Siberian fields (e.g., Chayandinskoye and Kovykta) to northeastern China, supporting a **30-year supply agreement** between the two countries.

Reuters World Business Markets Sustainability Legal Commentary Technology Investigations

Exclusive: China seeks more Russian gas via old link as new pipeline stalled

By Chen Aizhu and Vladimir Soldatkin

August 29, 2025 2:23 PM GMT+3 · Updated August 29, 2025

Summary Companies

- Gazprom may ship extra 6 bcm per year to China via existing link
- Power of Siberia 2 pipeline talks stalled, sources say
- Putin-Xi meeting to focus on energy cooperation
- Russia seeks to send gas to China after losing EU markets

Contracts

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Q1 — 2021: Russia exported ~**175 BCM** of pipeline gas to the EU and UK. This supplied about 40% of Europe's total gas consumption.

Q2 — Combined Total (Pipeline + LNG): total Russian gas exports to **Europe** in 2023 were in the range of **40-45 BCM.**

Reuters

World Business Markets Sustainability Legal Commentary Technology Investigations

Exclusive: China seeks more Russian gas via old link as new pipeline stalled

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Aa

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Contracts

BBC

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How oil has brought Russia, China and India closer

2 days ago

Share Save

Osmond Chia Business reporter, BBC News, Singapore

Transit time: 18 vs 28 days through Suez

Last year, China purchased a record of more than 100 million tonnes of Russian crude oil, which accounted for almost 20% of its total energy imports.

Likewise, oil exports to India, which made up only a small fraction of its imports before the Ukraine war, has since grown to some $140bn (£103.5bn) since 2022.

Together, China and India make up the majority of Russia's energy exports.

Trump's administration imposed an additional 25% tariff as a punishment for buying Russian oil. New Delhi described the White House's decision as "unjustified", given their history of trade.

Contracts

Mark Jacobson • 2nd

Professor-Civil & Environ Eng, Director-Atmos/Energy Progra...

2w •

So long as we keep getting fooled by fossil fuel circus tricks - carbon capture, direct air capture, blue hydrogen, and electrofuels, subsidies to the fossil-fuel industry will only increase.

Globally, fossil fuel direct+indirect subsidies were $7 trillion in 2022 or 7.1 percent of world GDP

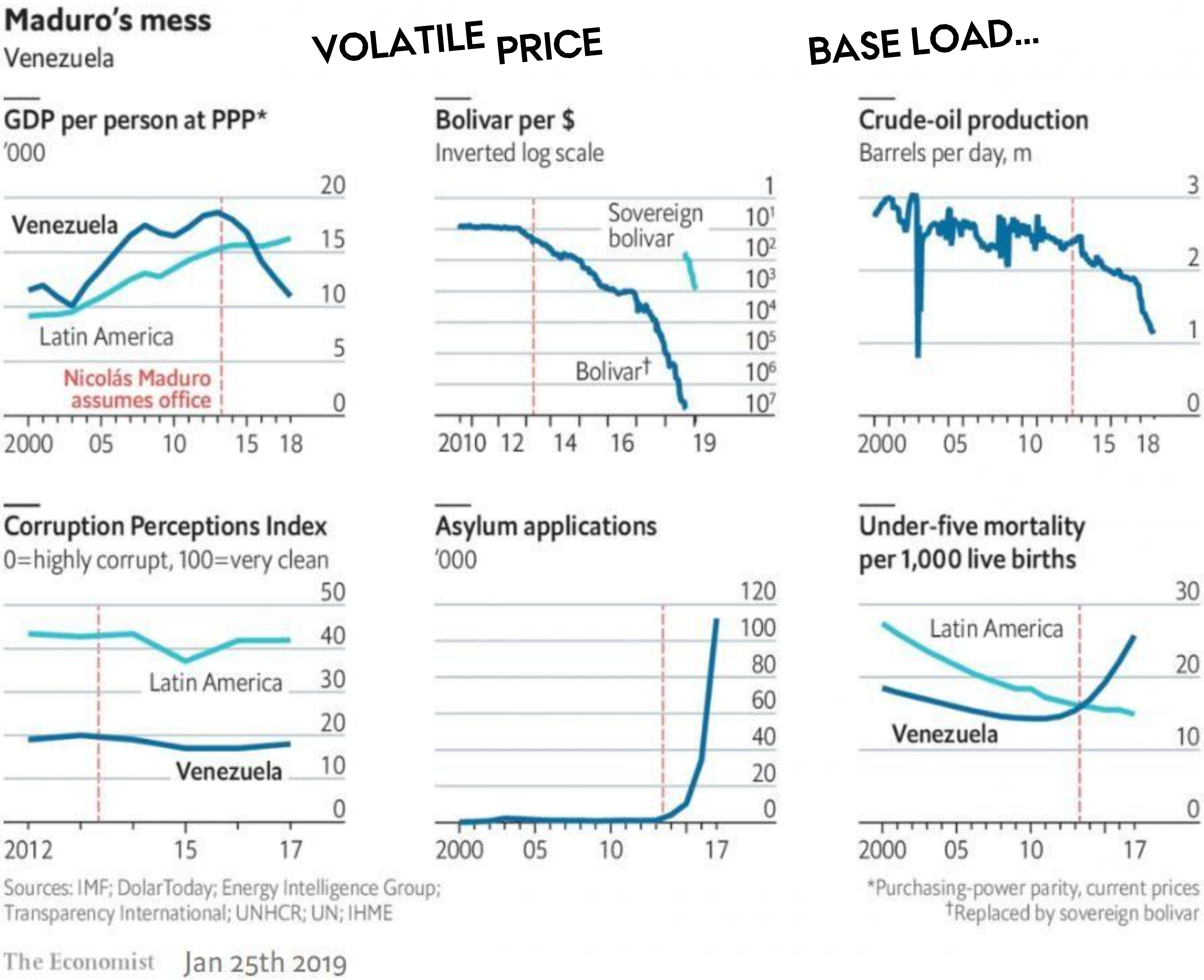
https://lnkd.in/gG4E4bs6 International Monetary Fund

IMF Fossil Fuel Subsidies Data: 2023 Update

imf.org • 1 min read

VOLATILE PRICE

BASE LOAD...



ANALYSIS

A powerful oil cartel controls the price you pay at the petrol pump, but its influence could wane

By business reporter Nassim Khadem

Posted Mon 18 Sep 2023 at 8:55pm, updated Tue 19 Sep 2023 at 2:33am

OPEC cuts production, tries to recruit new members

The OPEC group recently announced it will scale back oil production by more than a million barrels of oil a day, on top of existing cuts of 2 million barrels a day agreed on in October 2022.

The move also comes off the back of Russia's decision to maintain its ongoing production cut of 500,000 barrels a day for the rest of 2023.

This move was made over fears of a possible worldwide recession.

A Saudi energy ministry official told the official Saudi Press Agency that the move was "a precautionary measure aimed at supporting the stability of the oil market".

In other words, if a recession were to occur and OPEC was oversupplying the world with oil, it would crash the price of the fuel.


ALL RIGHT, WHICH ONE OF YOU CLOWNS YELLED "PEAK OIL?"
OPEC
KU-WAIT
edSTEIN '10

KPMG

Top risks facing the oil and gas industry in 2022 - and what you can do about it

Seven keys to get your company ready for the unexpected.

The oil and gas workforce of the future[1]

43% of current energy workers want to leave the industry altogether within the next five years

56% of those currently working in oil and gas said they'd consider jobs with renewables organizations

85% of university students considering a career in the oil and gas industry said it is important that their future employer has policies aimed at addressing climate change and environmental factors5

[1] Brunel International/Oil and Gas Job Search, Energy outlook Report 2021–2022.

Energy executives have noted that their companies lack employees with skills needed for the successful delivery of their decarbonization strategy, including

technical/engineering

18%

carbon markets expertise

17%

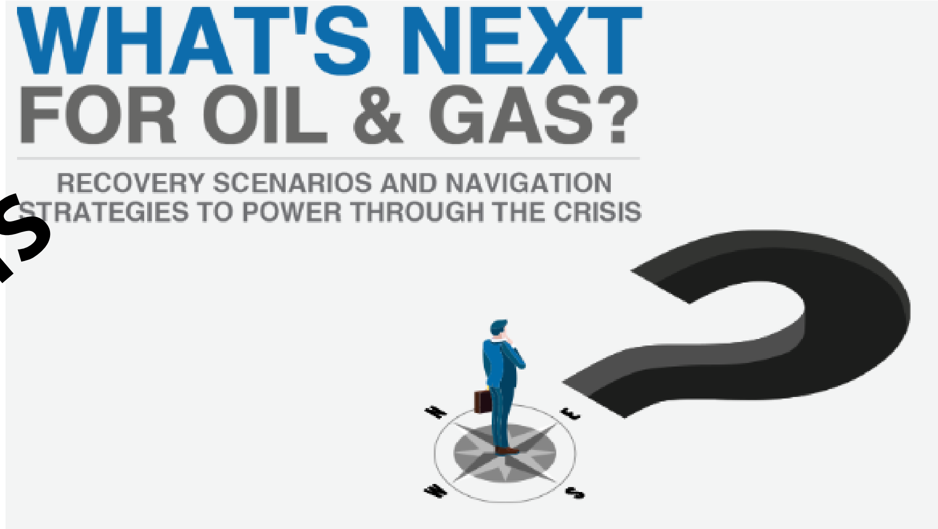
or policy, regulation, or government relations expertise

16%[1]

[1] Eversheds Sutherland/KPMG, Climate change and the people factor (2021).

AARHUS BSS
CENTRE FOR ENERGY TECHNOLOGIES
DEPARTMENT OF BUSINESS DEVELOPMENT AND TECHNOLOGY
AARHUS UNIVERSITY

Cash Flow Analysis



Is Apple savings account a good idea?

It has a high APY

The 4.15% APY that Apple's savings account comes with is considerable. That's more than 10 times the average 0.40% interest rate you can get with a regular savings account, according to the FDIC. 18 May 2023

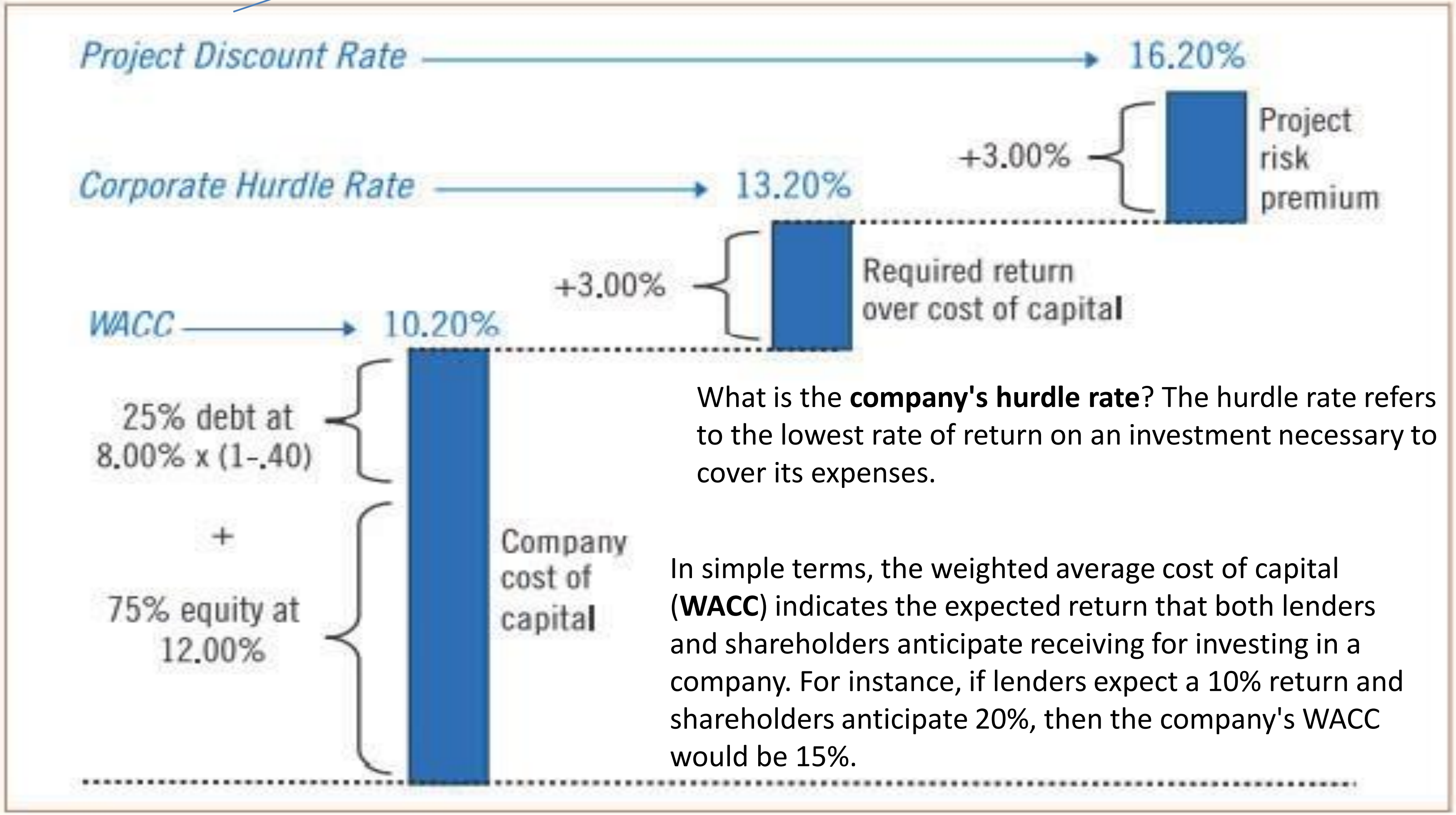
cbsnews.com
https://www.cbsnews.com › news › why-apples-savings-a...

Why Apple's savings account may be worth it for you (and why it may not ...

Company ABC

		2018		2019		2020	*Common Size Analysis* 2018	2019	2020
Cash Flow Statement									
Net Profit	$	5,249,971	$	8,431,264	$	15,746,001	15%	15%	14%
Non-Cash Charges	$	217,500	$	525,487	$	1,199,008	1%	1%	1%
Net Profit + Non-Cash Charges	$	5,467,471	$	8,956,751	$	16,945,010	16%	16%	15%
Receivables Change (-)	$	587,692	$	1,260,621	$	3,285,261	2%	2%	3%
Inventories Change (-)	$	762,849	$	1,533,686	$	3,881,743	2%	3%	3%
Payables Change (+)	$	693,499	$	1,394,260	$	3,539,903	2%	2%	3%
Working Capital Change	$	(642,594)	$	(1,372,937)	$	(3,588,878)	-2%	-2%	-3%
CFO	$	4,824,877	$	7,583,813	$	13,356,131	14%	13%	12%
Investment in PP&E	$	(700,000)	$	(1,210,000)	$	(2,060,000)	-2%	-2%	-2%
Other Fixed Assets	$	(28,896)	$	(54,220)	$	454	0%	0%	0%
M&As Net of Cash	$	-	$	-	$	(830,665)	0%	0%	-1%
CFI	$	(728,896)	$	(1,264,220)	$	(2,890,211)	-2%	-2%	-3%
Net Cash Flow from Debt	$	492,052	$	721,079	$	(549,571)	1%	1%	0%
Other Long Term Liabilities	$	28,896	$	54,220	$	92,546	0%	0%	0%
Additional Paid-In Capital	$	-	$	2,500,000	$	-	0%	4%	0%
Dividens Paid	$	-	$	-	$	-	0%	0%	0%
CFF	$	520,948	$	3,275,299	$	(457,025)	1%	6%	0%

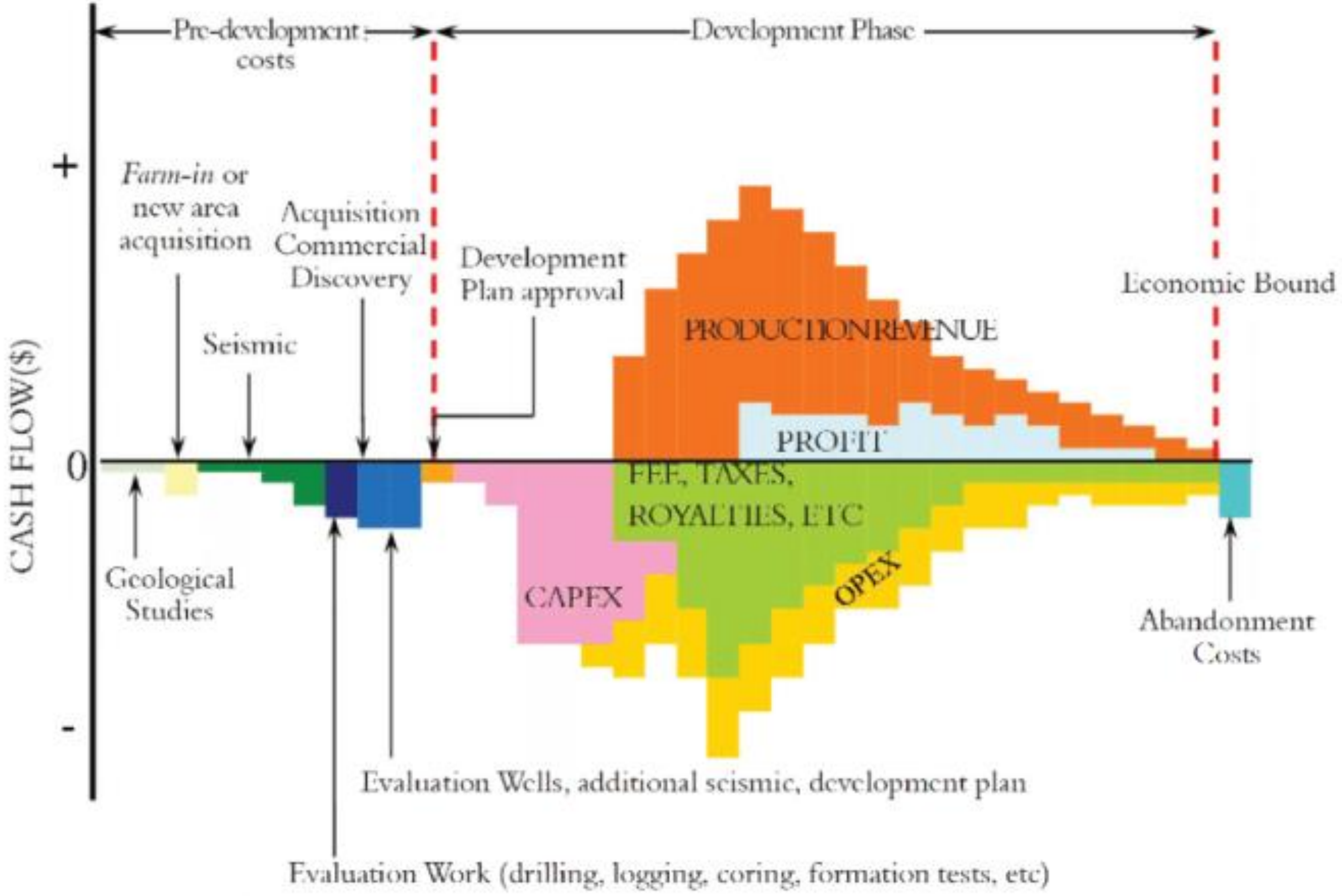
What does 10% **discount rate** mean? For instance, if you invest $100 today in a savings plan with a 10% interest rate, it will accumulate to $110.

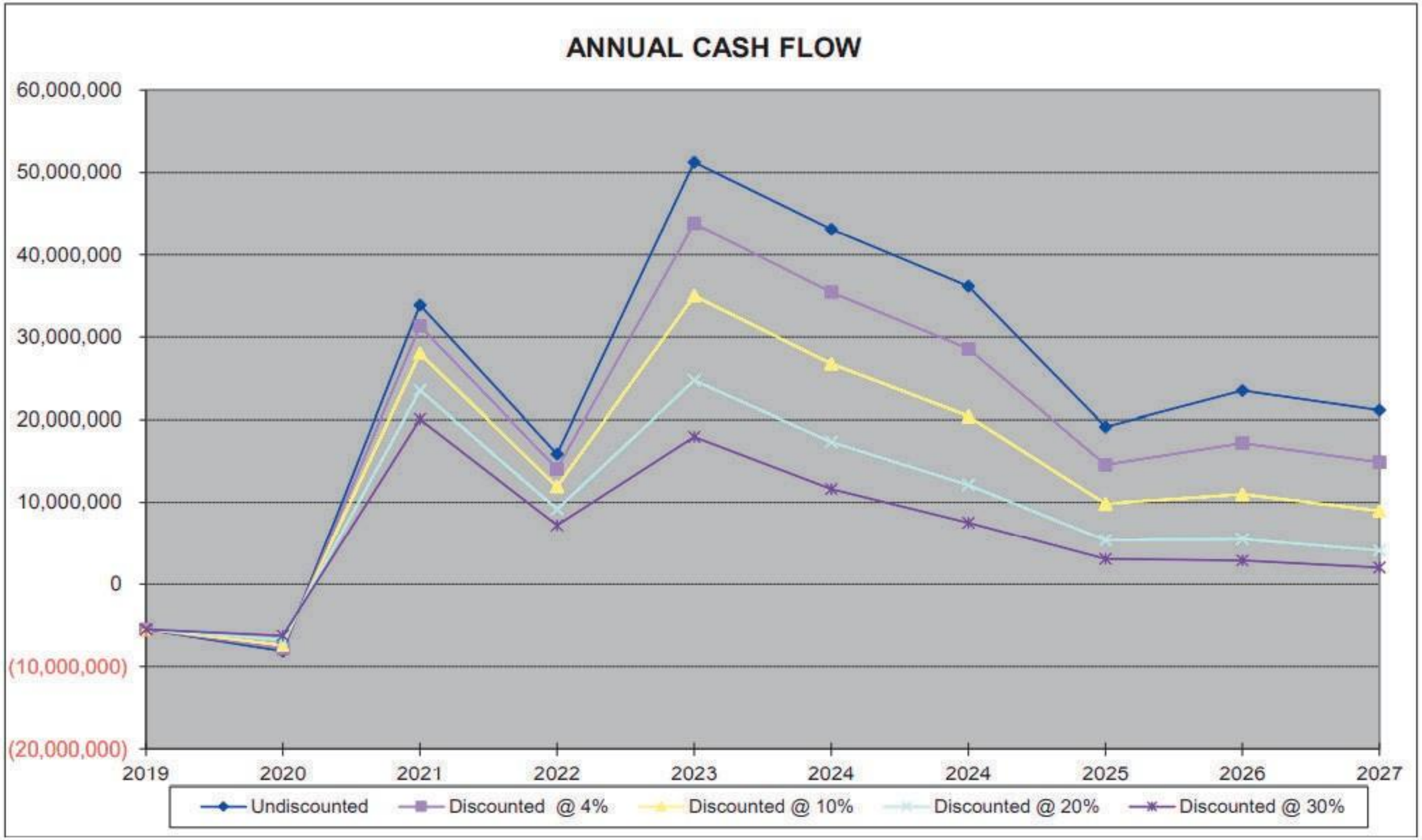


What is the **company's hurdle rate**? The hurdle rate refers to the lowest rate of return on an investment necessary to cover its expenses.

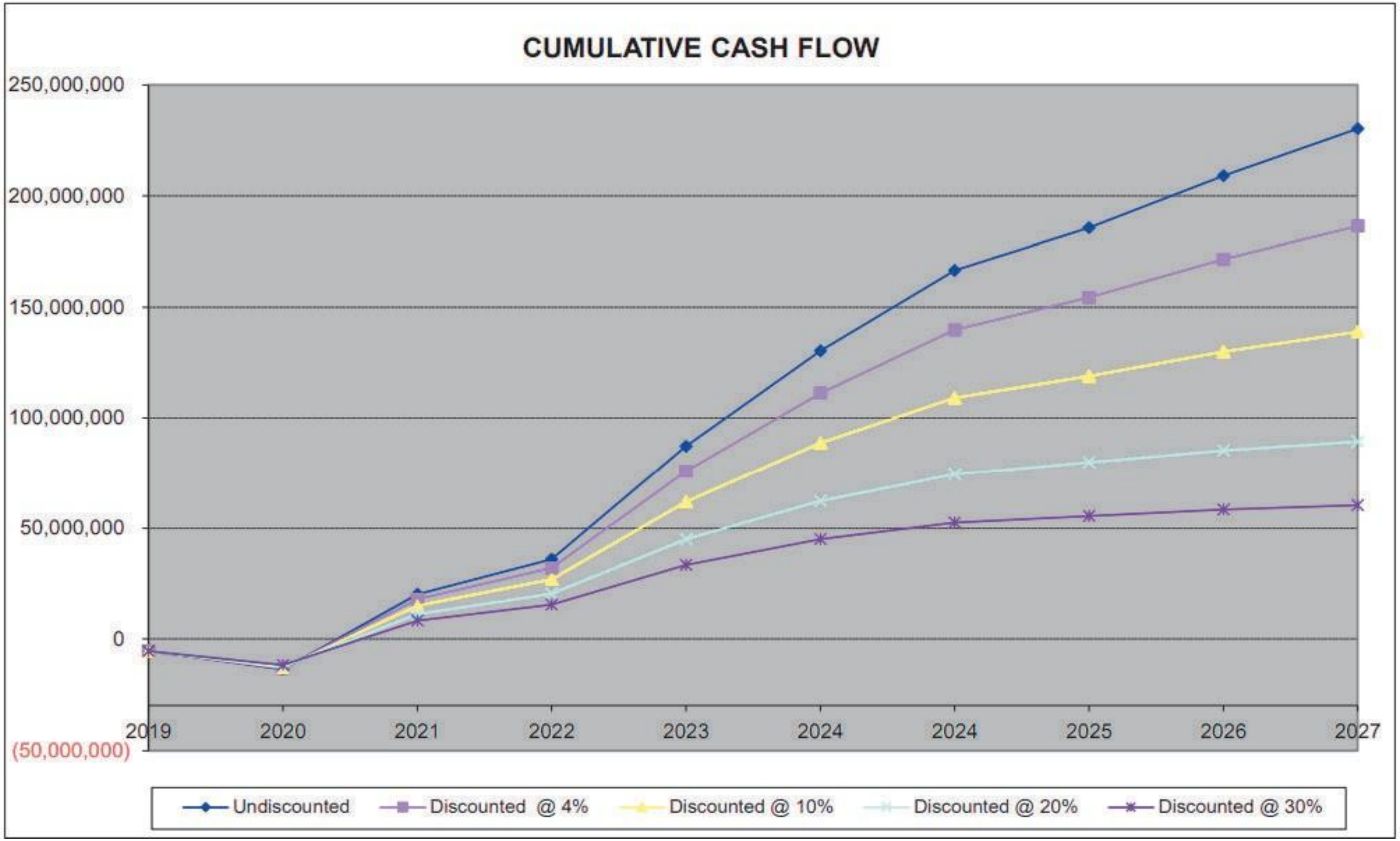
In simple terms, the weighted average cost of capital (**WACC**) indicates the expected return that both lenders and shareholders anticipate receiving for investing in a company. For instance, if lenders expect a 10% return and shareholders anticipate 20%, then the company's WACC would be 15%.

Figure 4–4. The cost of capital and discount rate


Pre-development costs
Development Phase
+
0
-
CASH FLOW($)
Farm-in or new area acquisition
Acquisition Commercial Discovery
Seismic
Development Plan approval
Economic Bound
PRODUCTION REVENUE
PROFIT
FEE, TAXES, ROYALTIES, ETC
CAPEX
OPEX
Geological Studies
Abandonment Costs
Evaluation Wells, additional seismic, development plan
Evaluation Work (drilling, logging, coring, formation tests, etc)



ANNUAL CASH FLOW
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
(10,000,000)
(20,000,000)
2019
2020
2021
2022
2023
2024
2024
2025
2026
2027
Undiscounted
Discounted @ 4%
Discounted @ 10%
Discounted @ 20%
Discounted @ 30%



CUMULATIVE CASH FLOW
250,000,000
200,000,000
150,000,000
100,000,000
50,000,000
0
(50,000,000)
2019
2020
2021
2022
2023
2024
2024
2025
2026
2027
Undiscounted
Discounted @ 4%
Discounted @ 10%
Discounted @ 20%
Discounted @ 30%

Macroeconomics of Oil & Natural Gas

Higher oil prices contribute to inflation directly and by increasing the cost of inputs. There was a strong correlation between inflation and oil prices during the 1970s. Oil's potential to stoke inflation has declined as the U.S. economy has become less dependent on it.

How does oil prices affect inflation?

Rising fuel prices increase the cost of transporting goods and services, and as a result worsen inflation by raising the end price that customers have to pay for all goods.

Q: What will happen with the discovery of large natural gas fields in our country?

A. We’ll all get rich & go to the Bahamas?

B. We’ll go bankrupt?

C. The country's manufacturing sector will decline

"Resource Curse" or the "Dutch disease"

<u>History repeats itself because no one was listening the first time</u>

With the conquest of the Aztec and Inca empires and supercharged by massive silver mines in modern-day Bolivia, Spain became the wealthiest nation in the world (Between the 16th and 17th centuries, over 180 tons of **gold** and 16,000 tons of **silver** were shipped to Spain). The Spanish Crown made a series of catastrophic financial decisions: 1) Wars with France, 2) Wars with the Ottoman Empire (the prize: The Mediterranean Sea), 3) The Dutch Revolt: to suppress a rebellion in the Netherlands, and 4) The Spanish Armada: A failed attempt to invade England in 1588)

Neglect of Domestic Economy + Massive Inflation

Why bother farming, manufacturing textiles, or building workshops when you can just wait for the next shipment of silver from across the ocean? Spain's domestic agriculture and industry stagnated and decayed

Spanish goods became too expensive to export, so they started importing everything from other European countries. The wealth flowed through Spain to its rivals.

When the fleets were delayed or captured by pirates, or when expenses exploded, the Spanish Crown simply declared **<u>Default</u>**. This happened in: 1557 (The first of many sovereign defaults in history), 1560, 1575, 1596, 1607, 1627, 1647, 1652, 1662

"Resource Curse" or the "Dutch disease"

<u>History repeats itself because no one was listening the first time</u>

The term "Dutch disease“ originated from the economic situation in the Netherlands after the discovery of large natural gas fields in 1959, which led to a decline in the country's manufacturing sector. The country experienced a large influx of foreign currency, from increased natural gas exports. This influx of wealth causes the domestic currency to appreciate in value.

Decline in Other Sectors + Deindustrialization

The stronger currency makes it more expensive for foreign buyers to purchase the country's other manufactured or agricultural goods, reducing their export competitiveness. It also makes imports cheaper, which can hurt domestic industries

As a result, the manufacturing and other traditional export sectors shrink, leading to job losses and economic stagnation in these areas, sometimes referred to as premature de-industrialization.

energy mag

☰ Μενού

Αναζήτηση

ΠΕΤΡΕΛΑΙΟ | ΦΥΣΙΚΟ ΑΕΡΙΟ | ΤΡΑΜΠ | ΤΙΜΟΛΟΓΙΑ ΡΕΥΜΑΤΟΣ | ΦΩΤΟΒΟΛΤΑΙΚΑ | ΥΠΕΡΑΚΤΙΑ ΑΙΟΛΙΚΑ ΠΑΡΚΑ | ΔΑΣΜΟΙ

▪ ΕΝΕΡΓΕΙΑ | ▪ ΑΡΤΕΜΙΣ ΜΑΝΘΗ | 16.02.24 . 07:46

Cronos - 2: "Χρυσάφι" στο Κυπριακό οικόπεδο 6 - Τα επόμενα βήματα

ENGLISH EDITION

energypress

Δημοσιογραφικό ενημερωτικό portal για την ενέργεια

ΗΛΕΚΤΡΙΣΜΟΣ • ΠΕΤΡΕΛΑΙΟ • ΦΥΣΙΚΟ ΑΕΡΙΟ • ΑΝΑΝΕΩΣΙΜΕΣ • ΣΤΕΡΕΑ ΚΑΥΣΙΜΑ

ΑΦΙΕΡΩΜΑΤΑ | WEEKLY ISSUES | RENEWABLE & STORAGE FORUM | POWER & GAS FORUM | HYDROGEN FORUM | ΕΚΔ

"Το φυσικό αέριο θα κάνει την Κύπρο την πλουσιότερη ευρωπαϊκή χώρα"

ΟΙΚΟΝΟΜΙΑ 05/06/2019 10:04

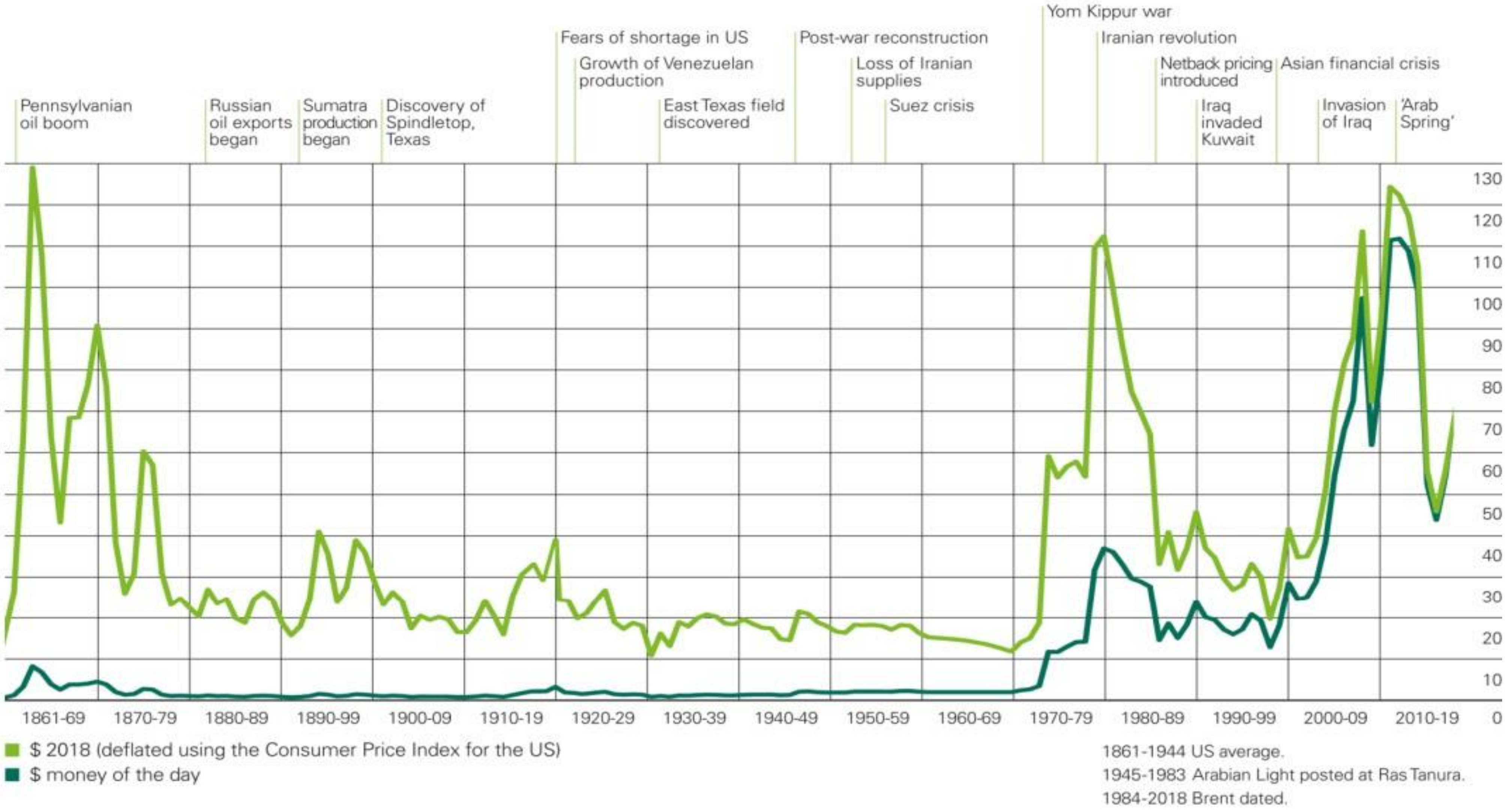
Ενα μικρό «Κατάρ» η Κύπρος: 9,5 δισ. δολάρια θα βάλει στα ταμεία της από το κοίτασμα «Αφροδίτη»

ΚΟΣΜΟΣ 17/12/2013 11:51

Κατάρ η Κύπρος: Στο οικόπεδο 12 εντοπίστηκε πετρέλαιο αξίας στα 60 δισ. ευρώ

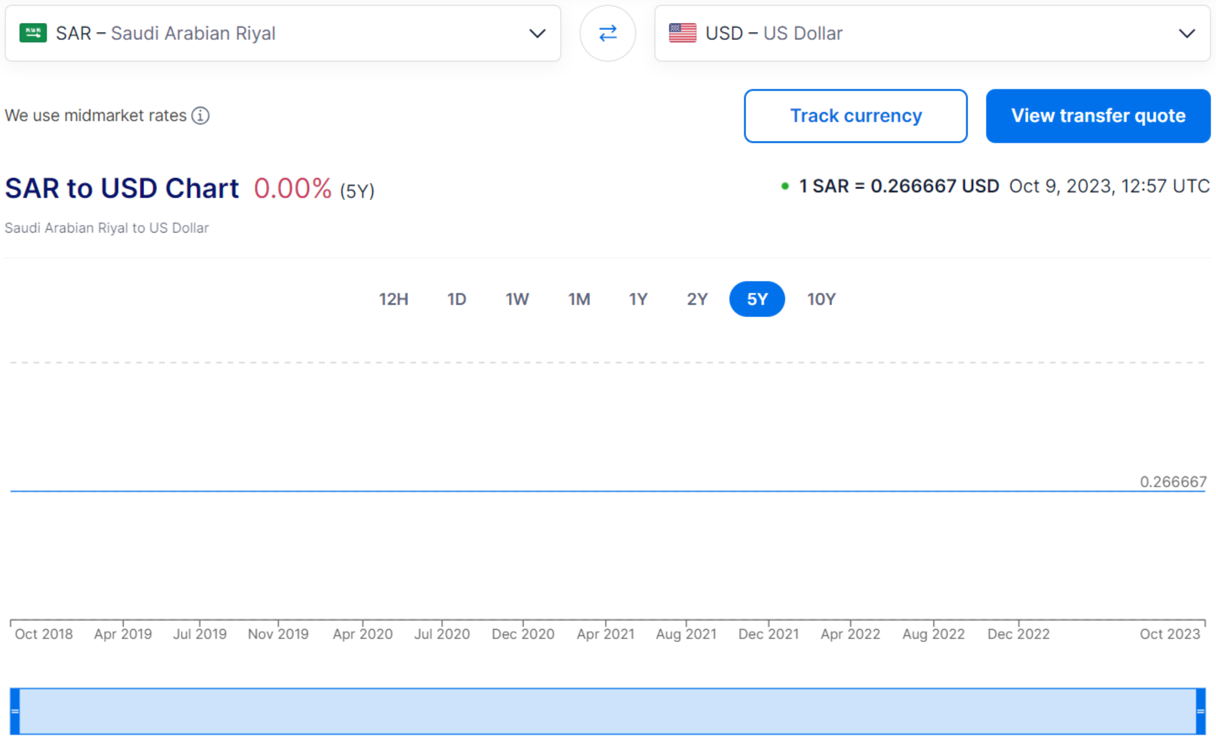
Crude oil prices 1861-2018

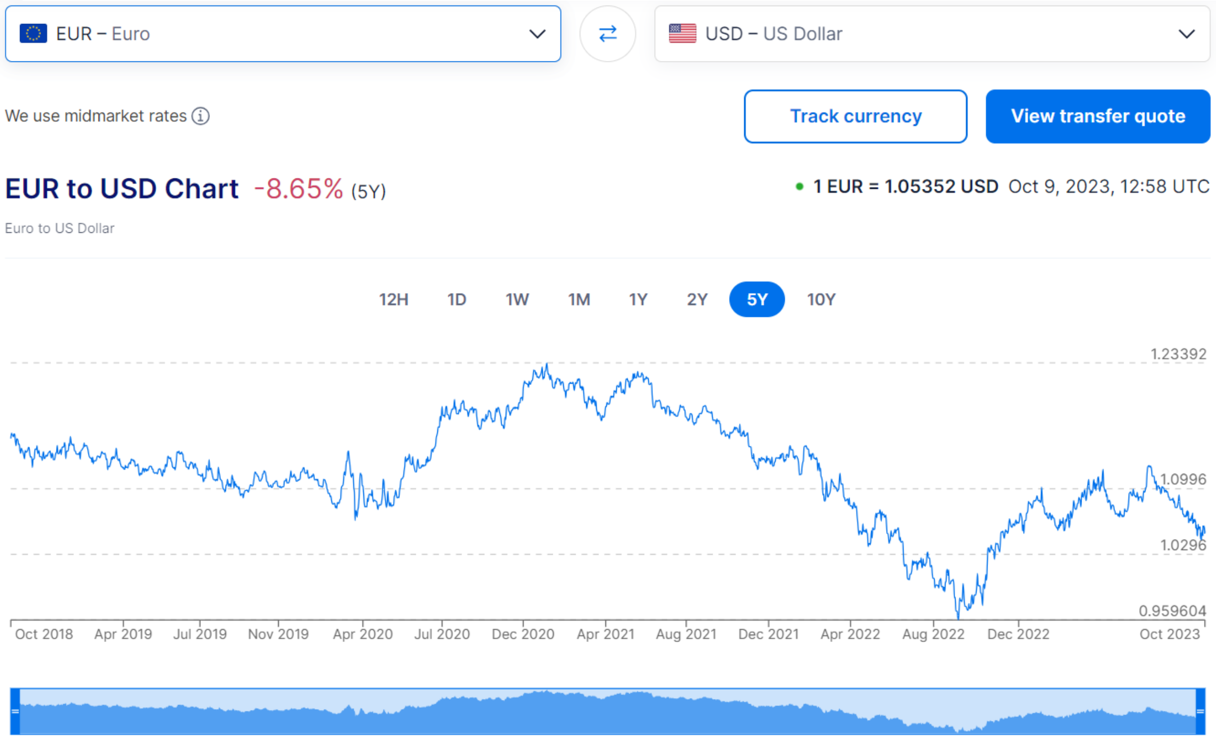
US dollars per barrel, world events



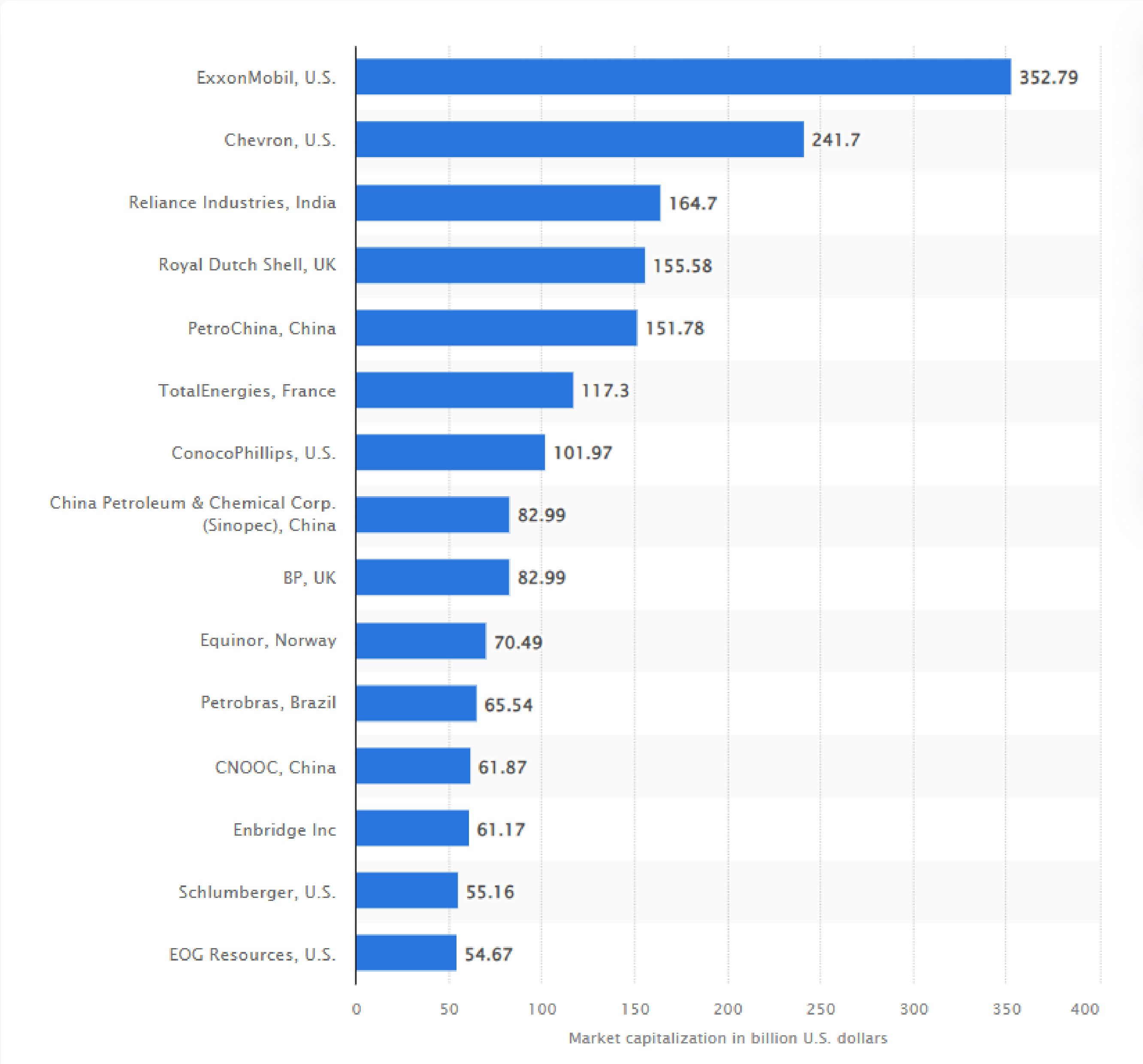
Source: BP Statistical Review of World Energy 2019

Do you see anything weird?





Leading oil and gas companies worldwide based on market capitalization as of June 2023 *(in billion U.S. dollars)*

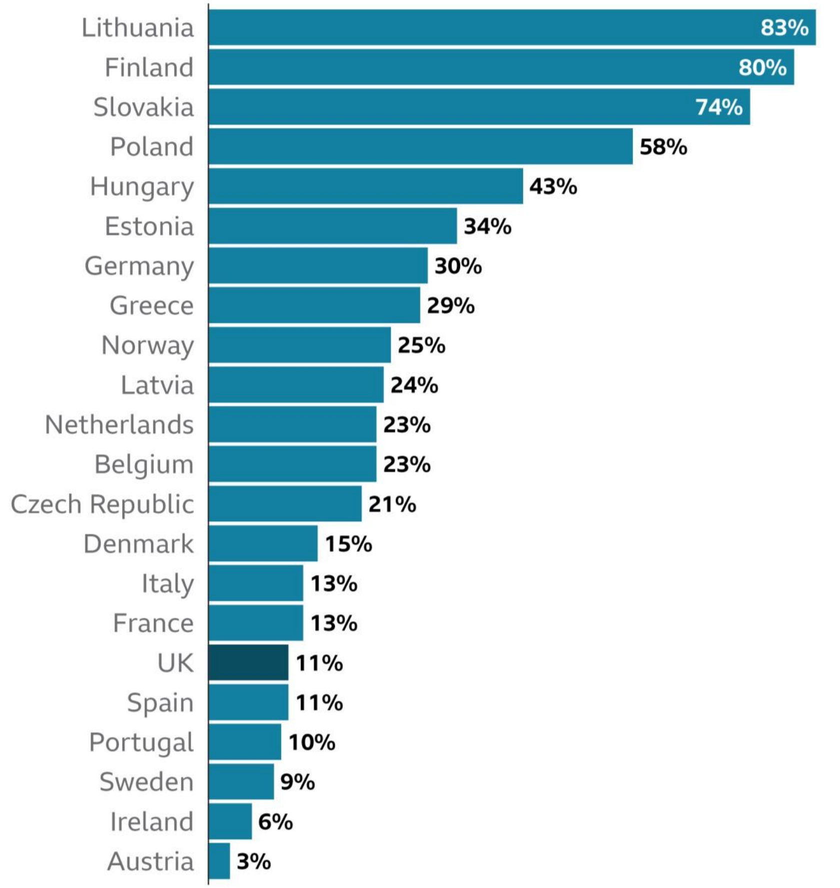


Natural Gas dead end – The relations with Russia

- … ''To sum up, Europe's goal of significantly diversifying away from Russian gas is challenging but not impossible in the short to medium term (through 2020-2025). Among the many challenges are the uncertainties regarding some of the most promising non-Russian gas supply options, such those from the Middle East and Caspian regions. The resolution of these uncertainties depends on the actions and political will of others (such as the US, Russia, and China) as well as Europe's ability to speak in its own voice. This latter would be significantly boosted by the introduction of a Special Envoy…''

COUNTRY	PROS	CONS
IRAN	Vast oil and gas resources E3+3 talks will create new possibilities?	International sactions still in place Infrastructural and transit problems
IRAQ	Oil and gas resources International companies are already present	Political instability
KURDISTAN	Rapprochement with Turkey would facilitate the transit to Europe	Disputes between Erbil and Baghdad over hydrocarbons, export strategies and revenue sharing
ALGERIA	In the past, it was Europe's second largest external gas supplier (after Russia)	Its potential is limited due to the difficulties to launch new projects
LIBYA	Could potentially supply up to 15bcm per year to Europe	Political instability Lack of export infrastructure
EGYPT	Traditional gas supplier to Europe	Political turmoil Growing domestic demand
ISRAEL	Discovery of the offshore Leviathan and Tamar gas fields	Its priority is to protect its national interests (60% of its reserves to the domestic market) and to export to its neighbours
AZERBAIJAN	Supplier best placed to respond to EU's needs Investments in TAP	/
TURKMENISTAN	Rich gas reserves	It shifted its export strategy towards China
TURKEY	Proximity and geopolitical importance	EU's energy security is treated as bargaining chip, not opportunity; Russian pressure

Natural Gas imports from Russia in 2021



Source: International Energy Agency, November 2021

BBC

The most important gas pipelines in Europe

Source: European Network of Transmission System Operators for Gas

BBC

NORWAY

Norway's supreme court in October 2021 ruled that two wind farms built at Fosen in central Norway, part of Europe's largest onshore wind farm, violated Sami rights under international conventions. But the turbines remain in operation today. 11 Sept 2023

REUTERS® World Business Markets Sustainability Legal Breakingviews Technology Inv

Sami activist sets up camp outside Norway parliament to protest wind turbines

By Gwladys Fouche

September 11, 2023 2:42 PM GMT+2 · Updated 19 days ago

Aa

WALL STREET JOURNAL

MARKETS

Qatar's Sovereign-Wealth Fund Opens Office in New York

Move will help QIA expand internationally and in the U.S., it said

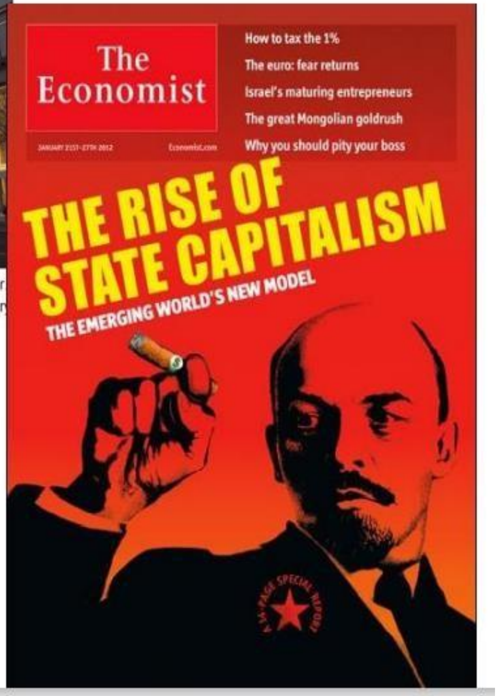
5th Avenue in New York earlier this year
J.S., including buying a stake in the luxur

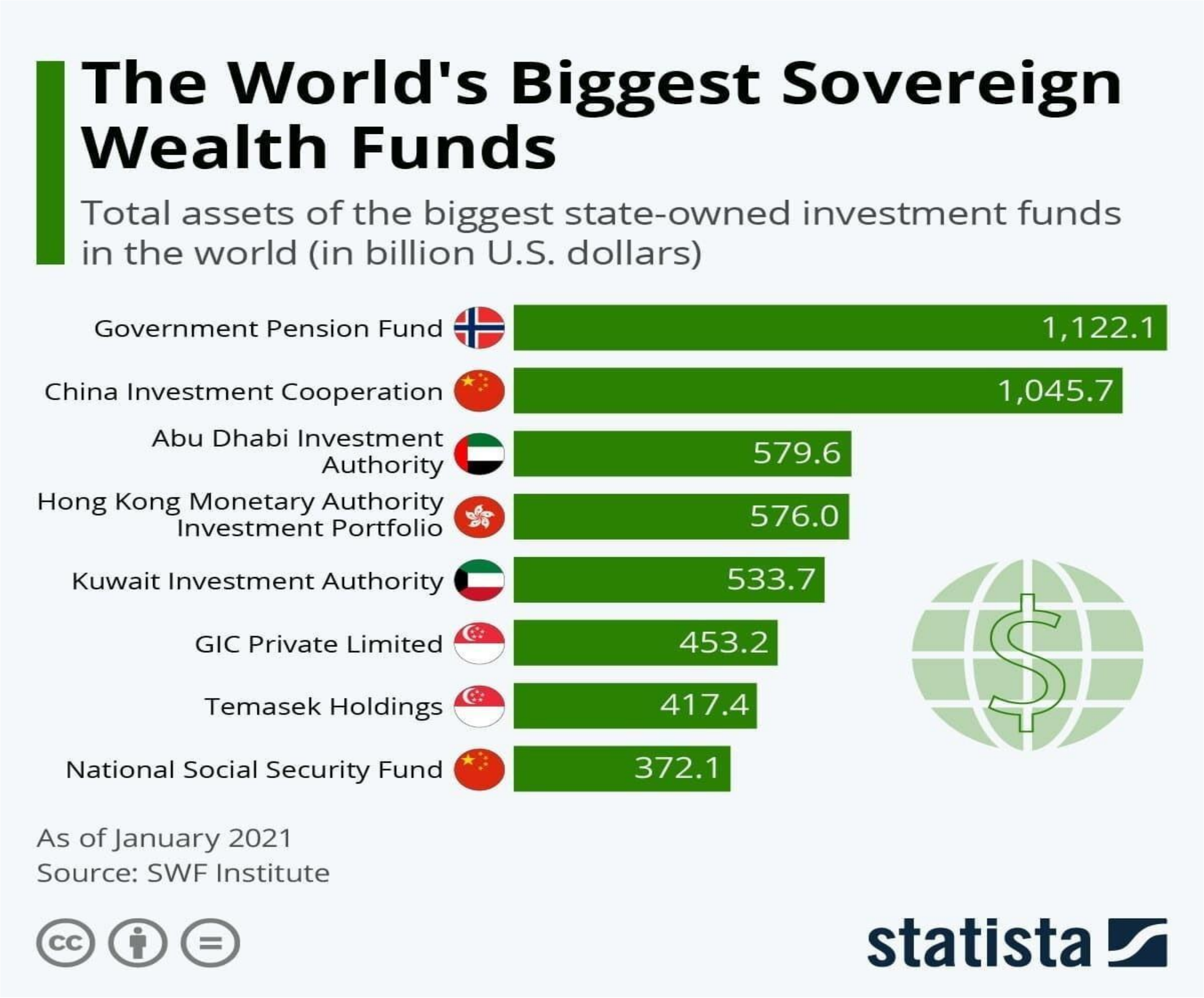
COMMISSION OF THE EUROPEAN COMMUNITIES

Brussels, 27.2.2008
COM(2008) 115 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

A common European approach to Sovereign Wealth Funds




The World's Biggest Sovereign Wealth Funds
Total assets of the biggest state-owned investment funds in the world (in billion U.S. dollars)
Government Pension Fund
1,122.1
China Investment Cooperation
1,045.7
Abu Dhabi Investment Authority
579.6
Hong Kong Monetary Authority Investment Portfolio
576.0
Kuwait Investment Authority
533.7
GIC Private Limited
453.2
Temasek Holdings
417.4
National Social Security Fund
372.1
As of January 2021
Source: SWF Institute
statista


Employment generation
Adoption of best practices by international standards
Local content policies
Stimulation of Research and Development
Knowledge transfer
Sectoral diversification

Current Trends

CURRENT TRENDS IN OIL AND GAS ECONOMICS

Exploring the shift towards sustainability and renewable energy investments

Investment in Renewables

There is a significant **increase** in investments towards **renewable technologies** like **solar** and **wind** energy.

Carbon-Neutral Strategies

Major oil companies are adopting **carbon-neutral strategies** to align with **sustainability** goals and reduce emissions.

Regulatory Pressures

Growing **regulatory pressures** and public demand are pushing the sector towards more **sustainable practices** and accountability.

DISRUPTION OF TRADITIONAL OIL AND GAS MARKETS BY RENEWABLE ENERGY

Exploring the effects of renewable energy on traditional market dynamics

Market Penetration

Renewables are increasingly capturing market share, especially in **electricity generation**.

Competitive Pressure

Increased **competition** from renewables pressures fossil fuel markets.

Market Reevaluation

Existing strategies within **oil and gas firms** must be reevaluated.

Pricing Dynamics

The influx of **renewables** has led to decreased **prices** for fossil fuels in some markets.

Strategic Shifts

Companies are compelled to adapt their **business models** to incorporate **renewables.**

Investment in Green Tech

The shift necessitates investments in **green technologies** by traditional firms.

BENCHMARKING METHODS FOR EVALUATING RENEWABLE ENERGY INVESTMENTS

Key metrics for assessing renewable energy investments in oil and gas economics

1. **Return on Investment**

   ROI assesses the financial return of renewable energy projects relative to their initial **investment**, helping firms determine profitability and viability.

2. **Levelized Cost**

   LCOE represents the average net present cost of electricity generation, allowing firms to compare costs across different energy projects effectively.

3. **Market Penetration**

   Understanding **market penetration rates** is crucial for evaluating how quickly renewable technologies are being adopted and their impact on the energy landscape.

4. **Informed Decisions**

   Utilizing these metrics enables firms to make **informed decisions** about their energy portfolios, optimizing investments and strategies in renewable sectors.

5. **Performance Benchmarking**

   Effective **performance benchmarking** against these metrics provides insights into project effectiveness and areas needing improvement in renewable investments.

6. **Investment Strategies**

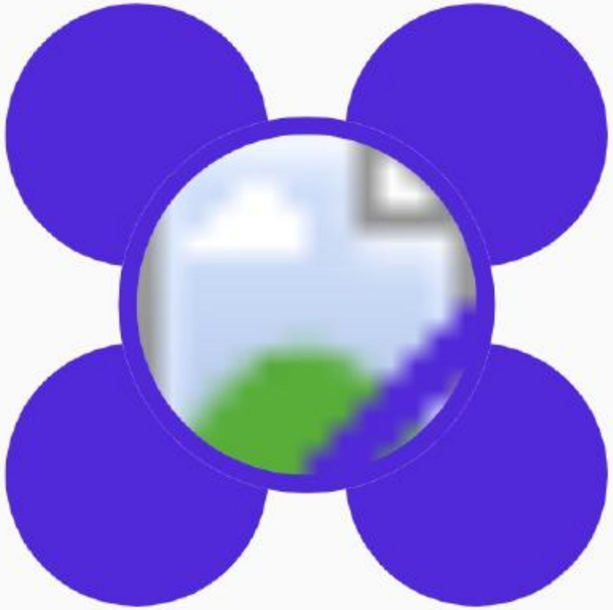
   Adopting these benchmarking methods helps in devising effective **investment strategies** that align with market trends and financial goals in the renewable sector.

OVERCOMING RENEWABLE INTEGRATION CHALLENGES IN OIL AND GAS

Exploring regulatory, financial, and technological barriers to renewable energy adoption

Regulatory Hurdles
Complex regulations vary by region.

Financial Constraints
High initial costs deter investments.



Critical Addressing
Essential for successful transitions.

Technological Limitations
Need for advanced technologies.

STRATEGIES FOR OVERCOMING FINANCIAL CONSTRAINTS IN RENEWABLE ENERGY

Innovative methods to navigate financial challenges in renewable energy investments

1. **Public-Private Partnerships (PPPs) are essential.**
   By collaborating with governments, PPPs allow renewable energy projects to share financial risks, thus enhancing project feasibility and attracting investors.

2. **Innovative Financing Models drive capital.**
   Utilizing instruments like **green bonds** can significantly raise capital for renewable energy projects, providing necessary funding while promoting sustainability.

3. **Long-term Contracts offer revenue stability.**
   Securing **Power Purchase Agreements (PPAs)** ensures a stable stream of income for renewable projects, thus making them more attractive to investors.

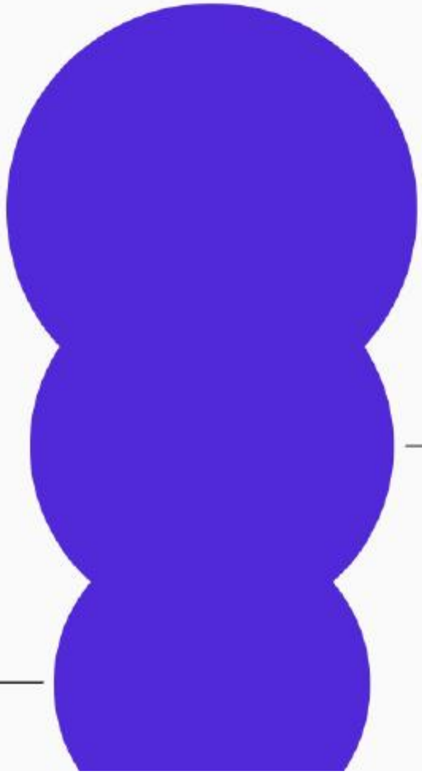
4. **Risk-sharing enhances investment appeal.**
   Strategies that involve shared financial risks between public and private sectors can make renewable energy projects more viable and appealing to investors.

5. **Capital raising through green initiatives.**
   Innovative financing models, particularly **green bonds**, focus on attracting environmentally-conscious investors to fund renewable energy projects.

6. **Stable revenue streams increase viability.**
   Long-term contracts, such as PPAs, provide the necessary revenue assurance that encourages further investment in renewable energy technologies.

KEY TECHNOLOGICAL INNOVATIONS IN RENEWABLE ENERGY FOR ECONOMIC BENCHMARKING

Exploring advancements that enhance renewable energy investments in the oil and gas sector



Advancements in Energy Storage Solutions

Recent developments in **battery technology** are essential for aligning energy supply with demand, improving overall grid reliability and efficiency.

The Role of Smart Grids in Energy Distribution

Implementing **advanced grid management systems** helps optimize energy distribution, ensuring greater efficiency and sustainability in renewable energy usage.

Enhancing Efficiency of Renewable Technologies

Ongoing research targets the **efficiency of solar panels** and **wind turbines**, making renewable projects more viable and appealing to investors.

ADAPTING OIL & GAS TO RENEWABLE ENERGY

Exploring strategic shifts in the oil and gas sector towards renewable energy investments

1

Diversification Strategies

Oil and gas companies are shifting towards **renewable sources** to broaden their portfolios and reduce risk.

2

Investment in R&D

Increased **funding** for research and development in **sustainable technologies** is essential for future growth and adaptation.

3

Collaborative Efforts

Partnerships between traditional energy firms and **renewable innovators** are becoming more common to foster innovation.

4

Sustainable Energy Transition

The oil and gas sector is crucial in the **transition** to a sustainable energy future, leveraging existing infrastructure.

5

Regulatory Adaptation

Companies must adapt to **regulatory changes** that favor renewable energy solutions over fossil fuels.

6

Market Demand Shift

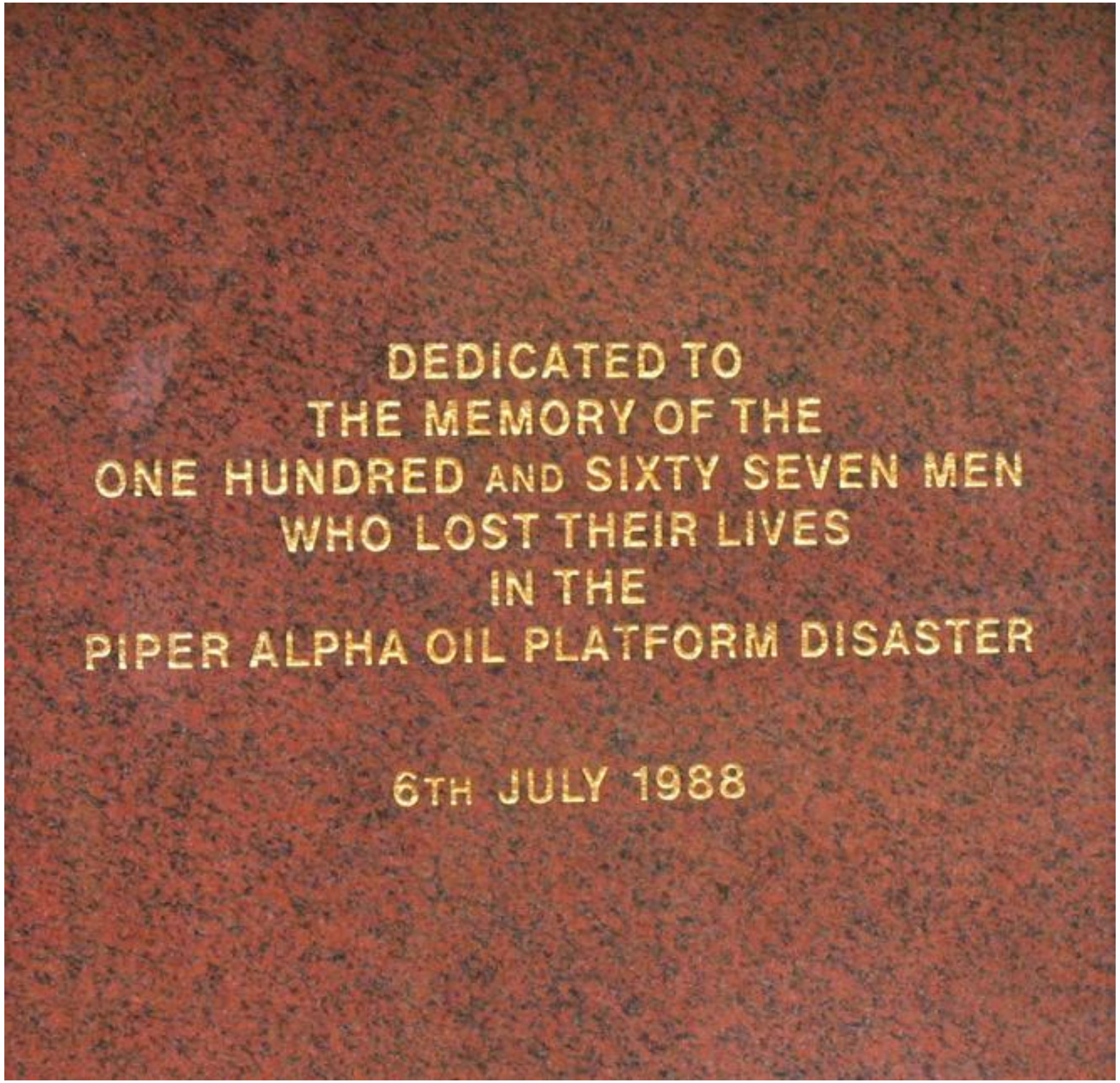
There is a noticeable shift in **market demand** towards cleaner energy, prompting strategic redirection in oil and gas firms.

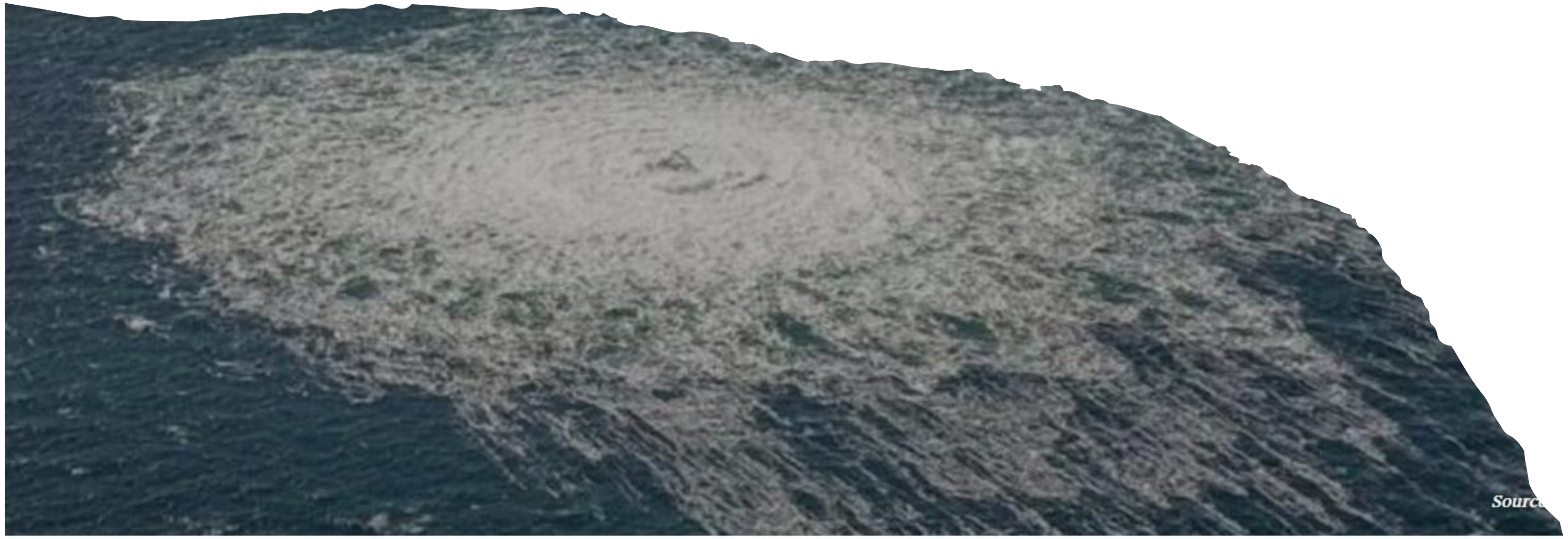
7

Technological Advancements

Investing in **innovative technologies** will be critical for oil and gas companies to remain competitive in a green economy.

Innovation & Technology
Health & Safety


DEDICATED TO
THE MEMORY OF THE
ONE HUNDRED AND SIXTY SEVEN MEN
WHO LOST THEIR LIVES
IN THE
PIPER ALPHA OIL PLATFORM DISASTER
6TH JULY 1988



CARNEGIE politika

Shock and Awe: Who Attacked the Nord Stream Pipelines?

30.09.2022

Sergey Vakulenko

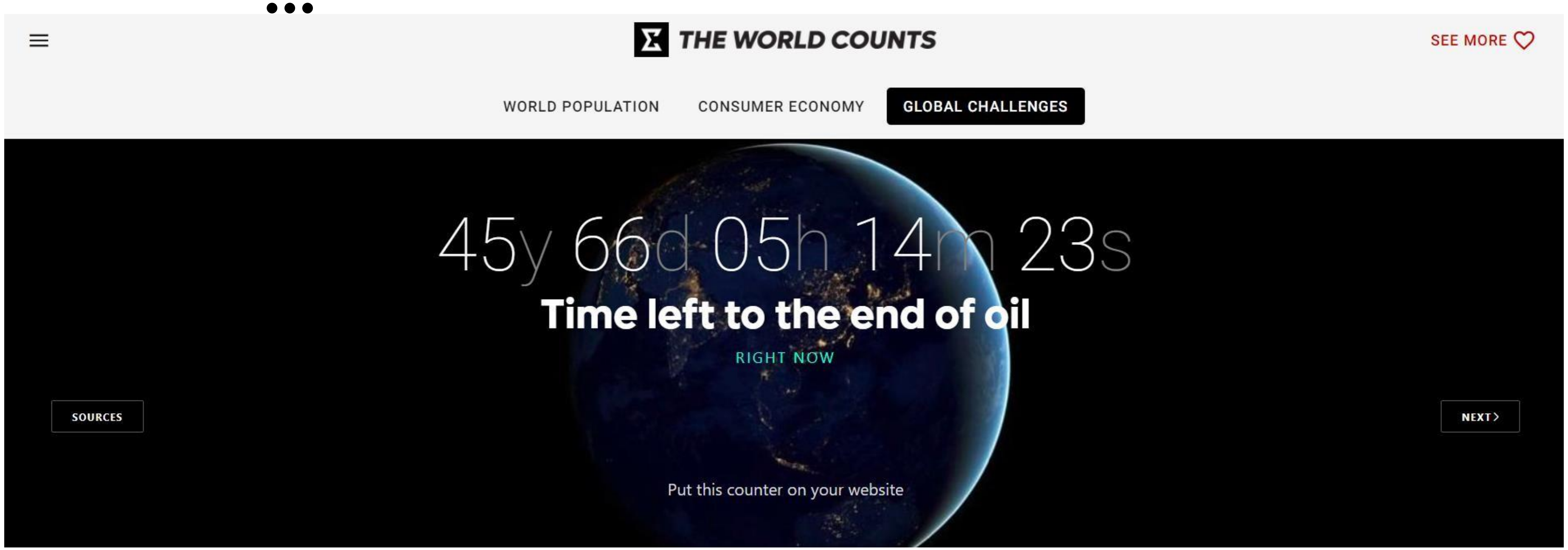
> If the perpetrator was Russia, the signaling value toward the West—which would certainly know Russia is behind the explosions—may be a threat to the rest of the marine energy infrastructure.

Follow Ca
Politik

Sign up for Ca
Politika

Reminder

...


THE WORLD COUNTS
SEE MORE
WORLD POPULATION
CONSUMER ECONOMY
GLOBAL CHALLENGES
45y 66d 05h 14m 23s
Time left to the end of oil
RIGHT NOW
SOURCES
NEXT
Put this counter on your website

THANK YOU

QUESTIONS?

[LCoE & Cash Flow Analysis]

[George Xydis]

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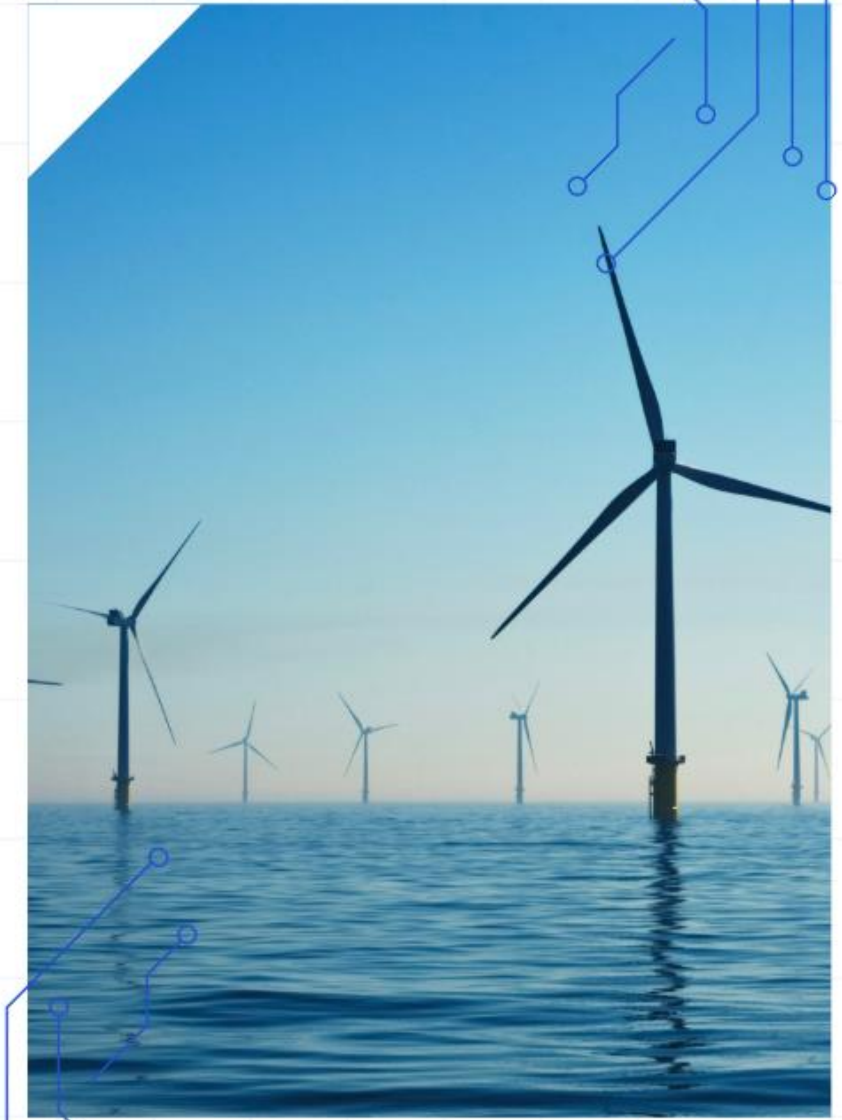
NEW ENERGY & ENVIRONMENTAL SOLUTIONS AND TECHNOLOGIES

AARHUS BSS

LCOE AND CASH FLOW ANALYSIS IN RENEWABLE ENERGY

This presentation delves into the financial analysis of floating wind turbines and hydrogen production, highlighting LCoE and cash flow management strategies.

GEORGE XYDIS
Aarhus University



TETHYS

WIND ENERGY ANALYSIS

LCOE & CASH FLOW ANALYSIS FOR WIND ENERGY

An in-depth evaluation of the Levelized Cost of Energy and cash flow dynamics in floating wind turbines and hydrogen production

TETHYS

INTRODUCTION TO LCOE AND CASH FLOW ANALYSIS

Exploring financial metrics for energy projects

UNDERSTANDING LCOE

LCoE represents the per-unit cost of energy over the lifetime of an energy project, crucial for evaluating cost-effectiveness.

IMPORTANCE OF CASH FLOW ANALYSIS

Cash flow analysis assesses timing and amounts of cash inflows and outflows to ensure project financial viability.

FOCUS ON INNOVATIVE ENERGY SYSTEMS

This presentation emphasizes floating wind turbines and hydrogen production systems, showcasing their financial dynamics.

LCOE CALCULATION TECHNIQUES

Understanding LCoE calculations is vital for comparing different energy projects and making informed investment decisions.

EVALUATING PROJECT VIABILITY

Combining LCoE and cash flow analysis provides a comprehensive view of project feasibility and potential returns.

TETHYS

OFFSHORE WIND FARM DEVELOPMENT

From Development to Execution to Operation of an offshore wind farm

Through the lens of an Independent Power Producer

TETHYS

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WIND FARM PHASES

Bid Submission

Screening

- Country assessment
- Greenfield assessment
- JV/partnerships
- Land grabbing

Development

- Environmental impact
- Technical assessment
- Business case analysis
- Bid preparation

Execution

- Contract preparation and signing
- Installation

Operation

- 25-35 years
- Maintenance
- Potential divestment

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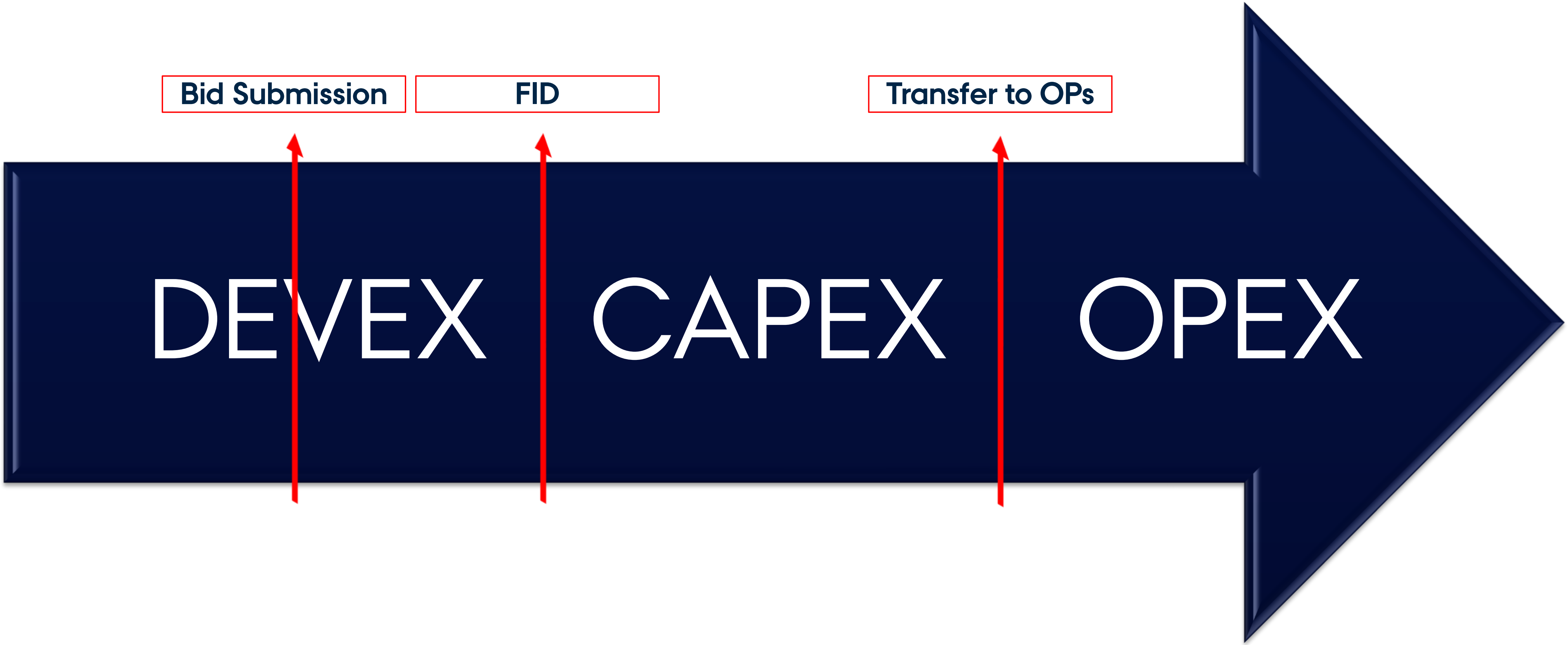
COST TIMELINE & LCOE



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LCOE

The **Levelized Cost of Energy (LCOE)** is a key metric used to compare the cost of different energy generation technologies over their lifetime. It is calculated using the formula:

$$LCOE = \frac{\text{Total Lifetime Costs}}{\text{Total Energy Produced Over Lifetime}}$$

$$LCOE = \frac{CAPEX + OPEX + DEVEX + ABEX}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

Where:

- **CAPEX (Capital Expenditure):** Upfront investment costs, including equipment, installation, and infrastructure.
- **OPEX (Operational Expenditure):** Ongoing costs like maintenance, fuel, and operational labor.
- **DEVEX (Development Expenditure):** Costs associated with project development, including permitting, feasibility studies, and environmental assessments.
- **ABEX (Abandonment Expenditure or Decommissioning Costs):** Costs for dismantling and restoring the site at the end of the project's life.
- E_t **(Energy Produced at Time t):** The amount of electricity generated in year t.
- r **(Discount Rate):** The weighted average cost of capital (WACC) or another appropriate discount factor.
- n: Project lifetime in years.

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LCOE

LCOE expresses the "levelized" unit cost of 1 MWh over the lifetime of the wind farm by taking the sum of the discounted lifetime costs relative to the sum of discounted energy production at the time of the financial investment decision.
LCOE can therefore be expressed as:

$$\boldsymbol{LCoE} = \frac{\boldsymbol{Present\ value}\ (\boldsymbol{Cost})}{\boldsymbol{Present\ value}\ (\boldsymbol{Production})}$$

The sum of discounted energy production (the denominator) is the present value of the energy production. The sum of discounted energy production is independent of perspective.

$$\boldsymbol{Production} \sum_{t=k}^{T} \frac{E_t}{(1+W_r)^t} = \frac{E_{year\ 0}}{(1+W_r)^0} + \frac{E_{year\ 1}}{(1+W_r)^1} + \cdots + \frac{E_{year\ T}}{(1+W_r)^T}$$

The discounted lifetime costs (the numerator) is the present value of all expenditures associated with the wind farm. The sum of discounted lifetime costs can be formulated as:

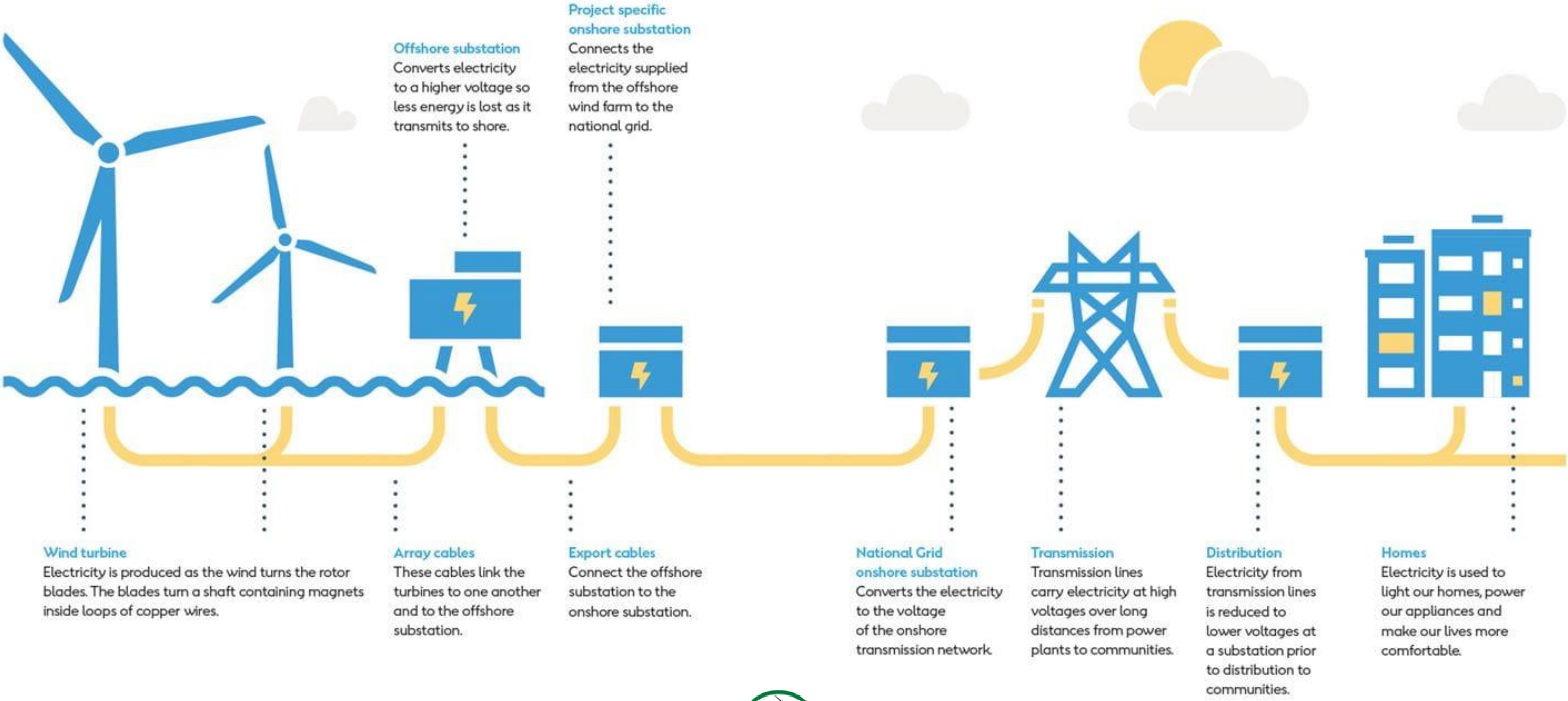
$$\boldsymbol{Cost} \sum_{t=k}^{T} \frac{I_t + O_t + A_t}{(1+W_n)^t} = \frac{I_{year\ 0} + O_{year\ 0} + A_{year\ 0}}{(1+W_n)^0} + \frac{I_{year\ 1} + O_{year\ 1} + A_{year\ 1}}{(1+W_n)^1} + \cdots + \frac{I_{year\ T} + O_{year\ T} + A_{year\ T}}{(1+W_n)^T}$$

Definition of variables:

t	Is the time period
k	Is the earliest period with cash flows or energy production; discount is applied to period 0
T	Is the latest period with cash flow
I_t	Is the cash flow at time t from invest at time t including both nominal DEVEX (development expenditures) and CAPEX (capital expenditures)
O_t	Is the cash flow at time t from nominal OPEX (operational expenditures)
A_t	Is the cash flow at time t from nominal ABEX (abandonment cost)
E_t	Is the electricity production at time t
W_r	Is the real WACC (weighted average cost of capital)
W_n	Is the nominal WACC

WIND FARM SCREENING AND DEVELOPMENT

TETHYS


Project specific onshore substation
Connects the electricity supplied from the offshore wind farm to the national grid.
Offshore substation
Converts electricity to a higher voltage so less energy is lost as it transmits to shore.
Wind turbine
Electricity is produced as the wind turns the rotor blades. The blades turn a shaft containing magnets inside loops of copper wires.
Array cables
These cables link the turbines to one another and to the offshore substation.
Export cables
Connect the offshore substation to the onshore substation.
National Grid onshore substation
Converts the electricity to the voltage of the onshore transmission network.
Transmission
Transmission lines carry electricity at high voltages over long distances from power plants to communities.
Distribution
Electricity from transmission lines is reduced to lower voltages at a substation prior to distribution to communities.
Homes
Electricity is used to light our homes, power our appliances and make our lives more comfortable.

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SCREENING OF SITES

Energy mix
Other renewables
Electrical grid
Electrical market

Political willingness

Country assessment

Overview of potential areas (technical analysis)

Regulatory and offshore wind framework

Market entry

- JV venture or independent entity
- Greenfield analysis
- Land grabbing
  - Lease area auction
  - Gaining site right in other means

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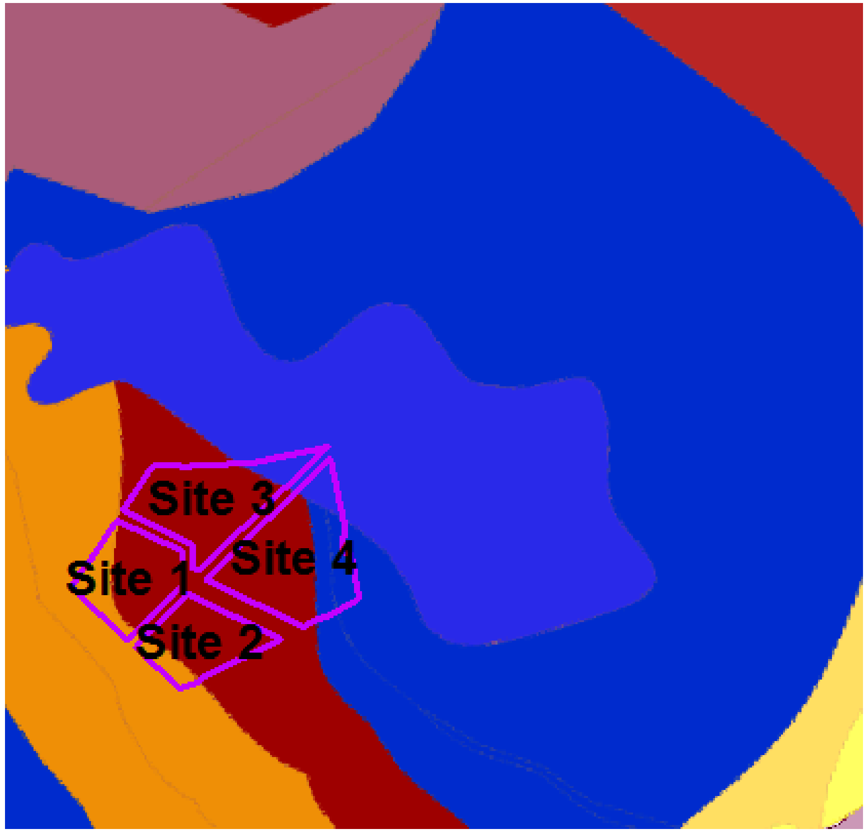
SITE SELECTION



- Soil conditions
- Wind speed and direction
- Bathymetry
- Distance from the shore (?)
- Grid connection
- Harbour vicinity
- Environmental protected areas
- Constraints like: shipping lanes, cables, Unexploded ordnance (UXOs)
- Fisheries

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WIND FARM COMPONENTS

Wind Turbine (WTG)

Foundation/Floaters

Array cable

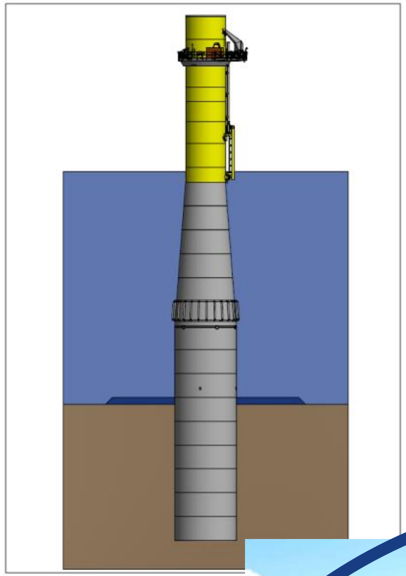
Offshore and Onshore Substation

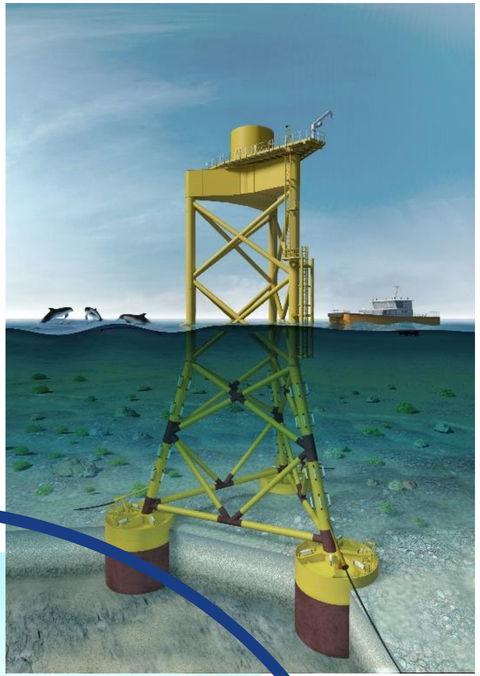
Export cable

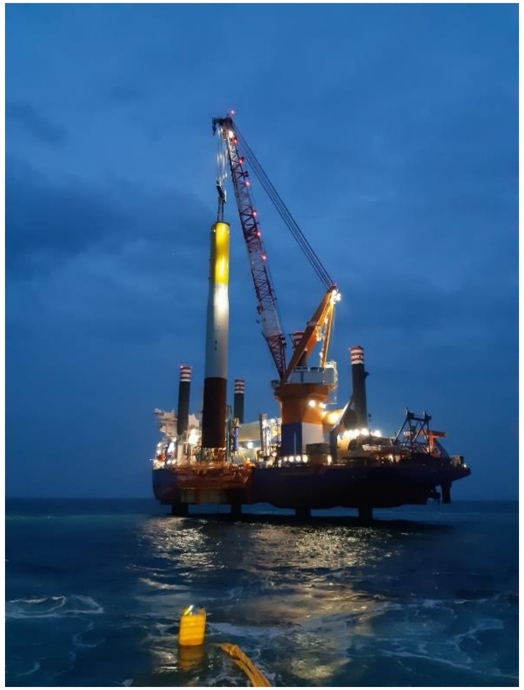
WTG TYPE

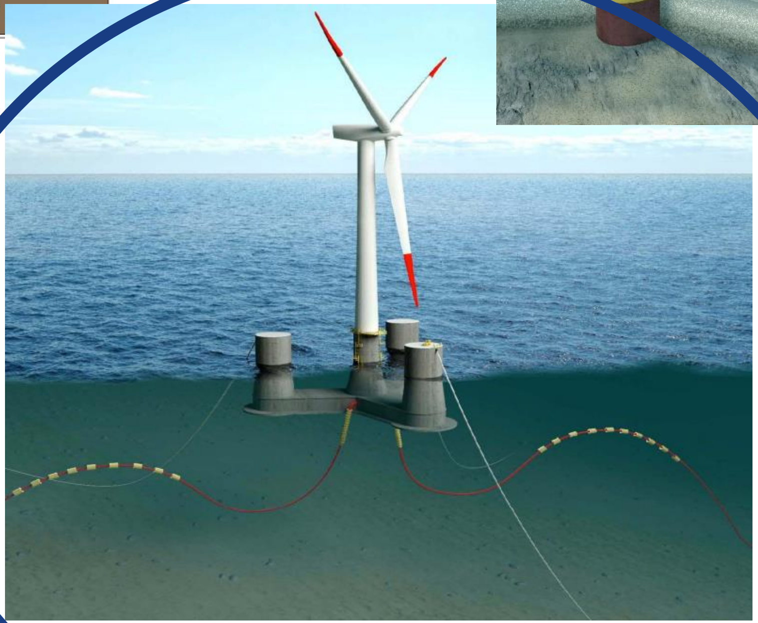
- Wind climate
- Rotor size
- Local content requirements

FOUNDATIONS SUPPLY AND INSTALLATION









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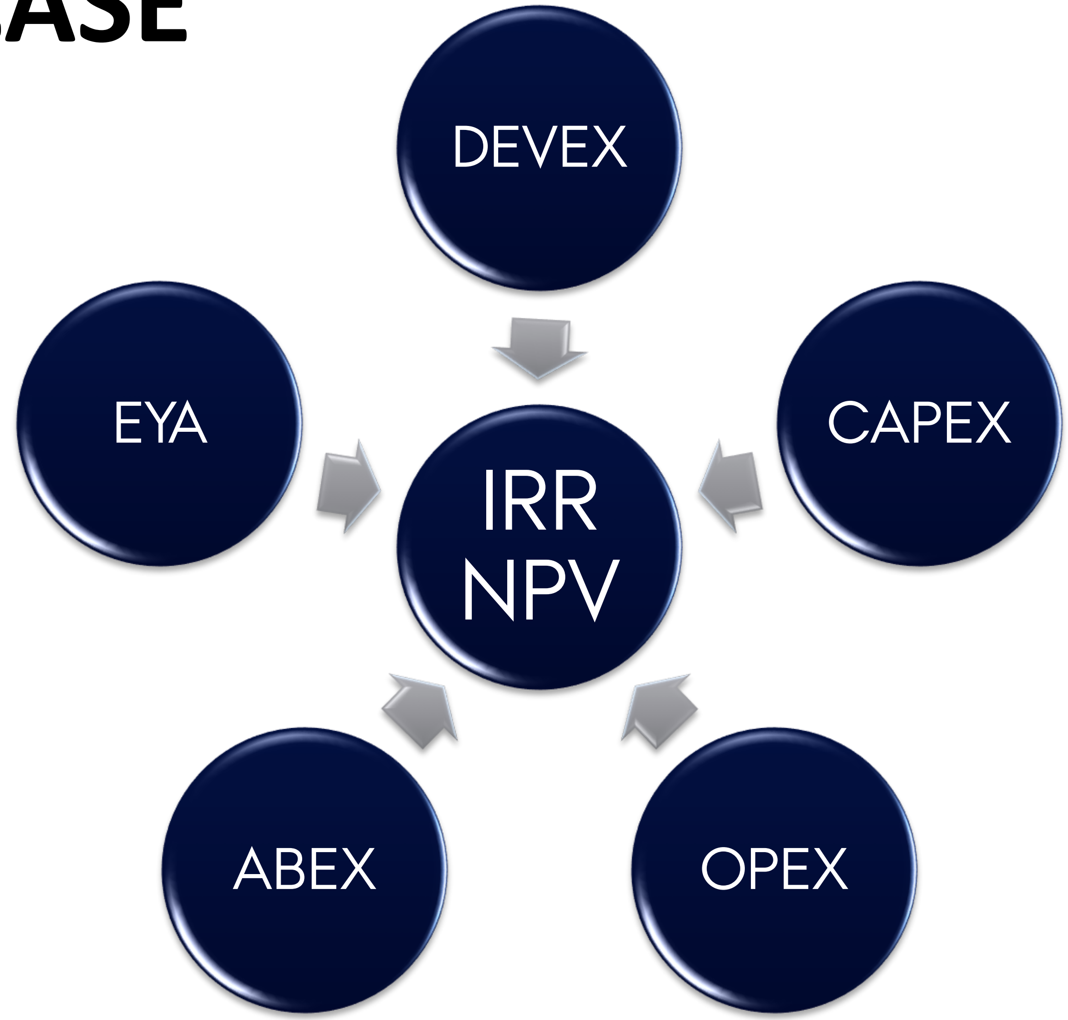
BUSINESS CASE

Important date: **FID**



- Payment plan
- Currency
- Inflation and Exchange rate forecast

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AUCTION REGIME

Combination

Beauty contest

- Technical and financial assessment of the developer
- Local content
- Extensive Bid documentation

- Environmental impact assessment
- Supply chain **pain** & Supply chain **plan**

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WIND FARM EXECUTION

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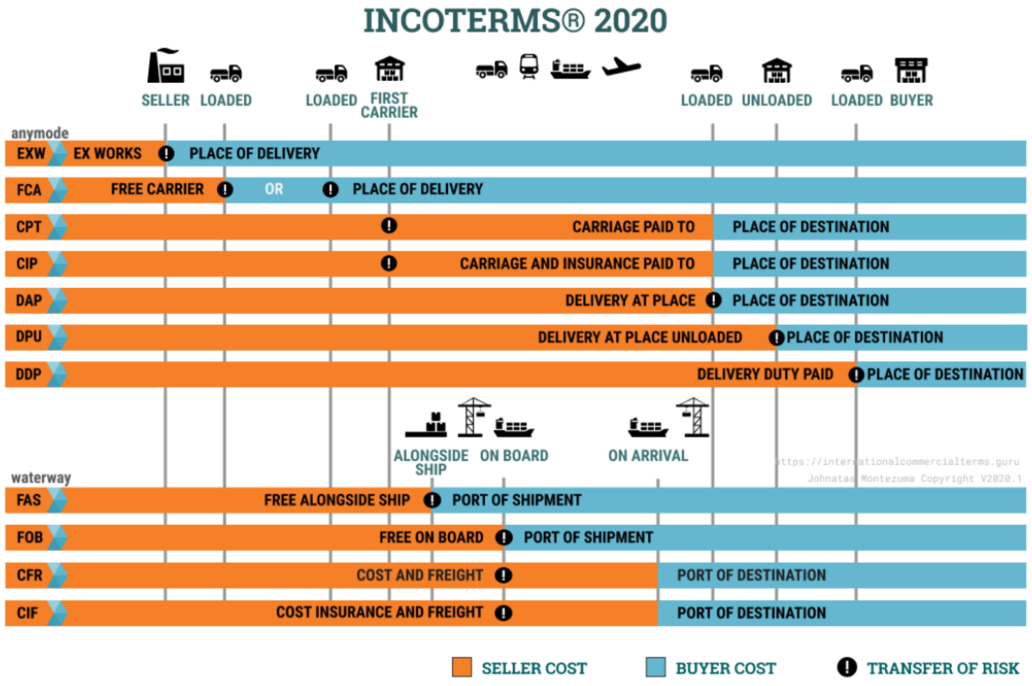
INSTALLATION

From the manufacturer → To the feeder port → To the site

Incoterms 2020



HANDOVER TO OPERATION

After complete installation of the entire wind farm and commissioning of the WTGs, it is handed over to operations for the rest of the wind farm lifetime

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AVAILABILITY AND MAINTENANCE

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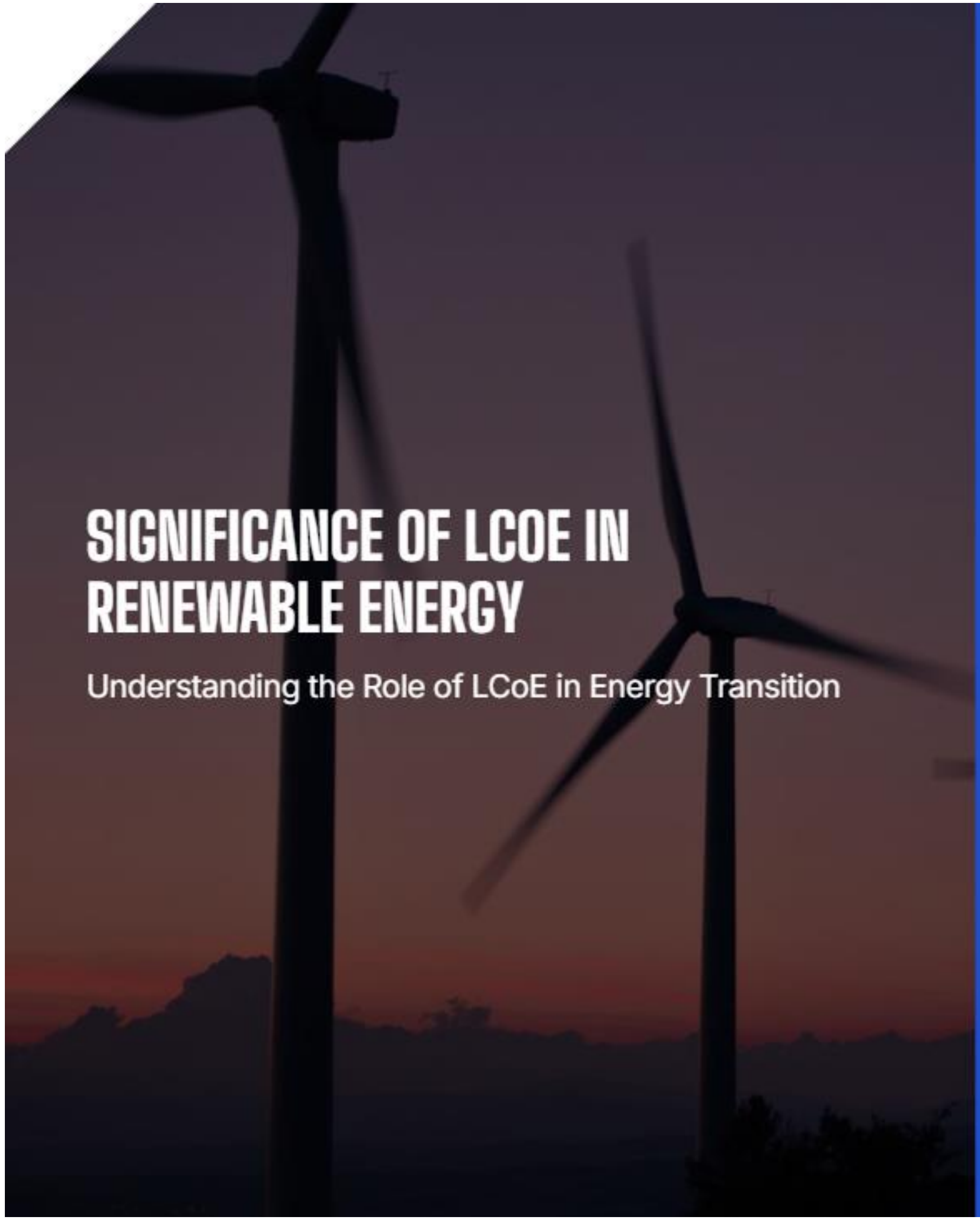


SIGNIFICANCE OF LCOE IN RENEWABLE ENERGY

Understanding the Role of LCoE in Energy Transition

COMPETITIVENESS OF RENEWABLE ENERGY

LCoE determines how competitive renewable sources are against fossil fuels.

INVESTMENT DECISIONS

LCoE aids in making informed investment decisions and shaping effective policy-making.

PROJECT FINANCING INFLUENCE

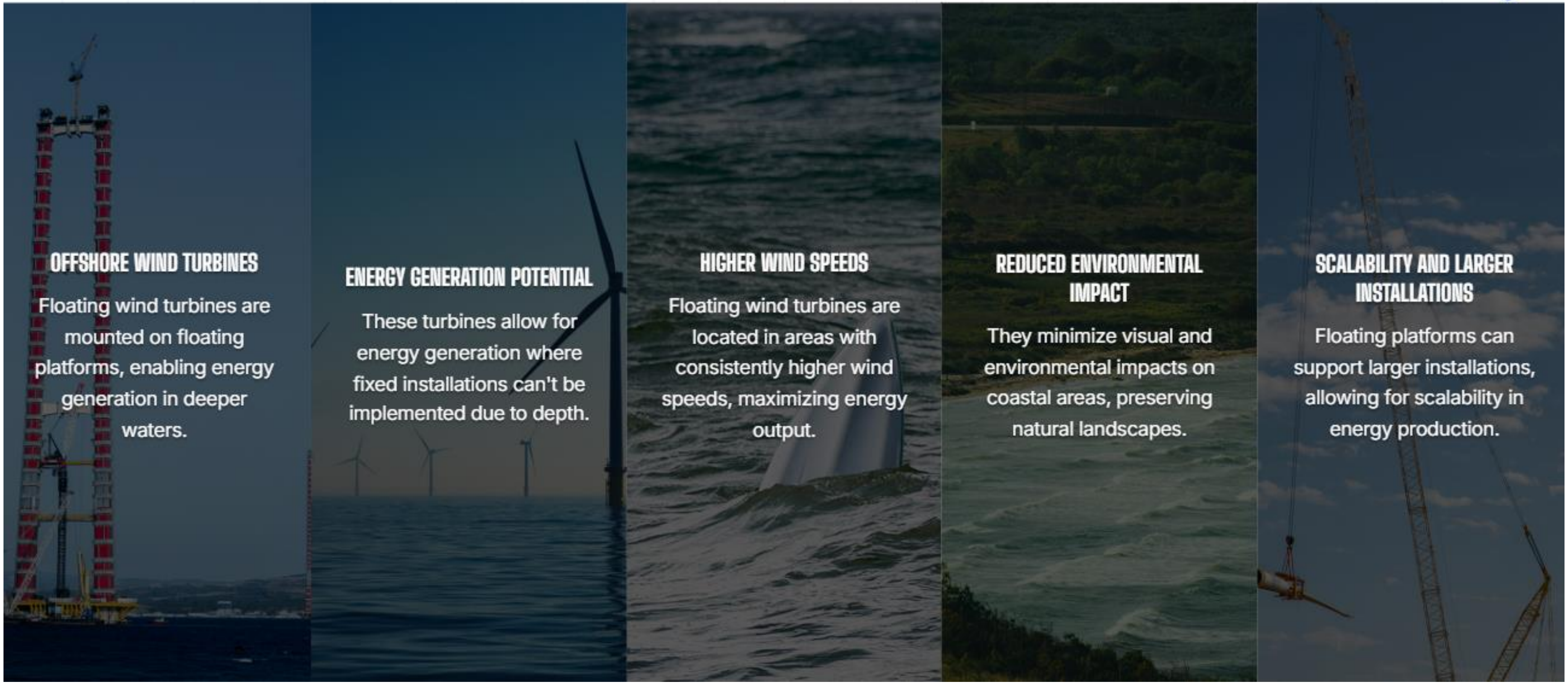
LCoE significantly influences project financing options and ensures long-term sustainability.

ATTRACTIVENESS OF INVESTMENT

A lower LCoE indicates a more viable and attractive opportunity for investors.

OVERVIEW OF FLOATING WIND TURBINES

Key Features and Advantages of Floating Wind Technology



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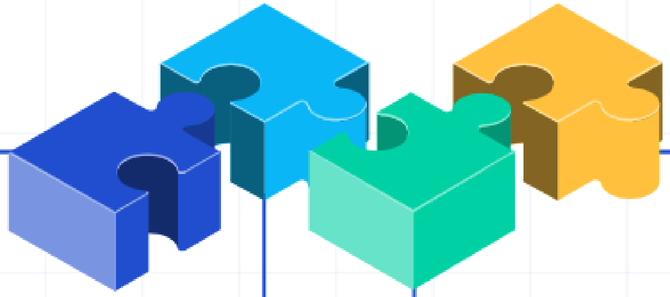
CASH FLOW DYNAMICS IN WIND PROJECTS

Understanding financial aspects of floating wind energy



01

SUBSTANTIAL INITIAL INVESTMENT

Floating wind projects require significant capital for construction and installation.

02

REVENUE GENERATION

Revenue is primarily generated through power purchase agreements (PPAs) alongside government incentives.

03

OPERATING EXPENSES OVERVIEW

Operating costs include maintenance, insurance, and staffing, impacting overall cash flow.

04

SEASONAL CASH FLOW MODELING

Cash flow modeling must consider seasonal variations in energy production and market prices.

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INTRODUCTION TO HYDROGEN PRODUCTION

Exploring hydrogen's role in energy sustainability

01 HYDROGEN AS A CLEAN ENERGY CARRIER

Hydrogen serves as a clean energy carrier, crucial for sustainable transportation and industrial applications.

02 PRODUCTION METHODS

Main hydrogen production methods include electrolysis with renewable energy and natural gas reforming.

03 ENHANCING SUSTAINABILITY

Integrating hydrogen production with renewable energy sources significantly boosts overall sustainability.

04 REVENUE STREAMS FOR WIND PROJECTS

Hydrogen production can create additional revenue opportunities for wind energy projects, enhancing profitability.

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CASH FLOW CONSIDERATIONS FOR HYDROGEN SYSTEMS

Understanding financial dynamics in hydrogen production

INITIAL INVESTMENT REQUIREMENTS

The upfront costs for electrolyzers and necessary infrastructure are significant.

REVENUE GENERATION POTENTIAL

Hydrogen sales to industries and transportation sectors can yield substantial revenue.

OPERATIONAL COST FACTORS

Ongoing expenses include energy, maintenance, and compliance with regulations.

ECONOMIC VIABILITY ASSESSMENT

The feasibility of hydrogen systems is affected by market prices and demand fluctuations.

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INTEGRATING WIND TURBINES AND HYDROGEN PRODUCTION

Exploring the Benefits of Dual Energy Systems

SYNERGISTIC BENEFITS

Pairing floating wind turbines with hydrogen production amplifies energy efficiency.

EXCESS ENERGY UTILIZATION

Wind energy can be converted to hydrogen, effectively balancing supply and demand.

REVENUE DIVERSIFICATION

Combining energy and hydrogen production enhances project financial resilience.

CASH FLOW ANALYSIS

Consider both energy sales and hydrogen revenue for comprehensive financial planning.

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KEY METRICS FOR LCOE EVALUATION

Understanding Financial and Operational Factors

Consider all initial investments required for the project.

TOTAL CAPITAL COSTS (CAPEX)

OPERATIONAL COSTS (OPEX)

Evaluate recurring costs necessary for operation over time.

Estimate the yearly energy output to assess project viability.

ANNUAL ENERGY PRODUCTION ESTIMATES

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METHODOLOGY STEPS FOR CASH FLOW ANALYSIS

IDENTIFY CASH INFLOWS

Recognize all sources of cash inflows, such as energy and hydrogen sales, vital for analysis.

ESTIMATE CASH OUTFLOWS

Assess all cash outflows including CAPEX and OPEX to understand total project costs.

DEVELOP CASH FLOW MODEL

Create a comprehensive cash flow model to project financial performance throughout the project lifecycle.

APPLY DISCOUNT RATES

Utilize appropriate discount rates to calculate the Net Present Value (NPV) for better investment appraisal.

CONDUCT SENSITIVITY ANALYSIS

Perform sensitivity analysis to evaluate the impact of various scenarios on cash flow and project viability.

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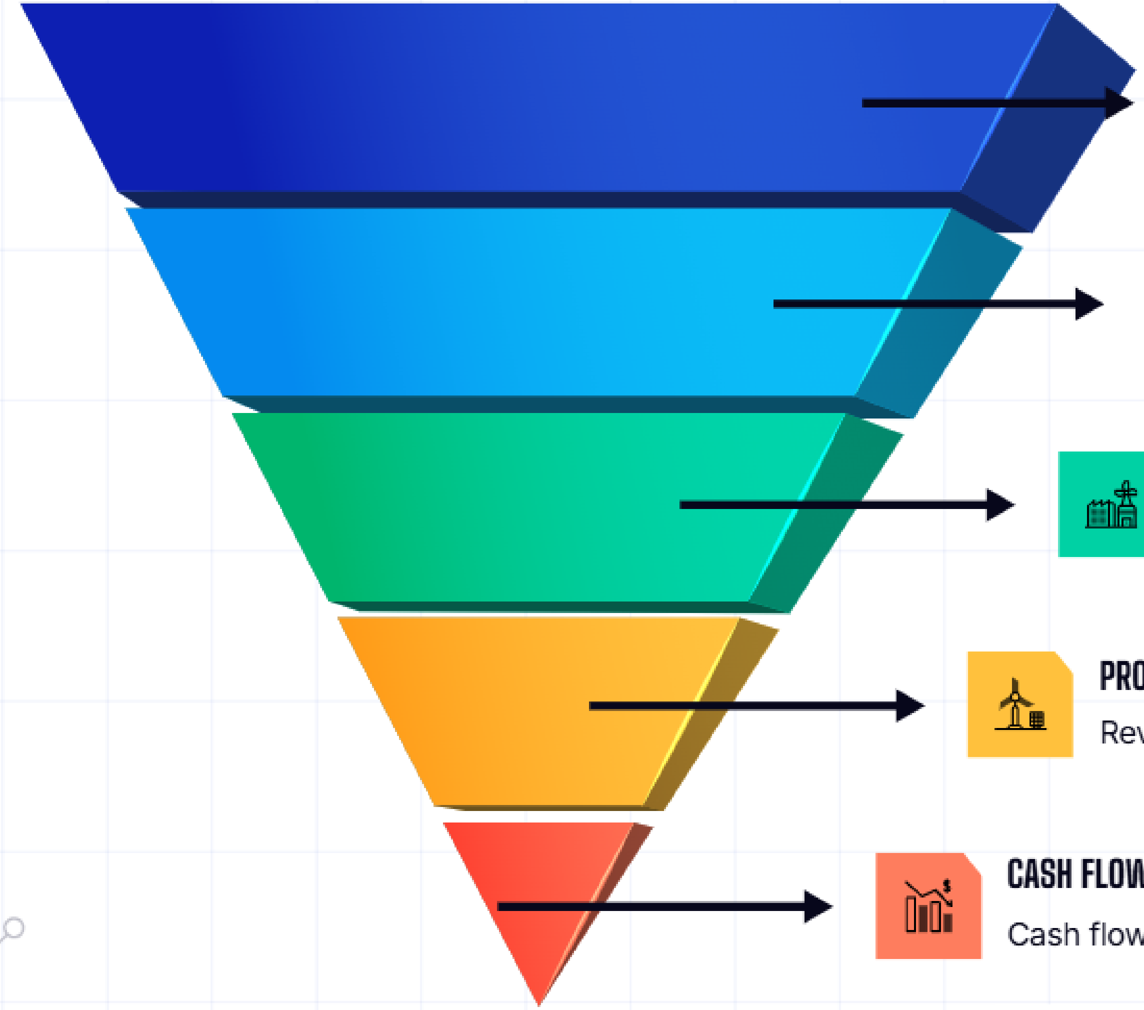
CASE STUDY: FLOATING WIND TURBINES

Overview and Financial Analysis



PROJECT OVERVIEW

This case study focuses on a pioneering floating wind turbine project.

INITIAL INVESTMENT

The initial investment for the project was $X million.

ANNUAL PRODUCTION

The project aims for an expected annual production of Y MWh.

PROJECTED REVENUE

Revenue from energy sales is projected to reach $Z million per year.

CASH FLOW TRENDS

Cash flow over the first decade shows positive trends post investment recovery.

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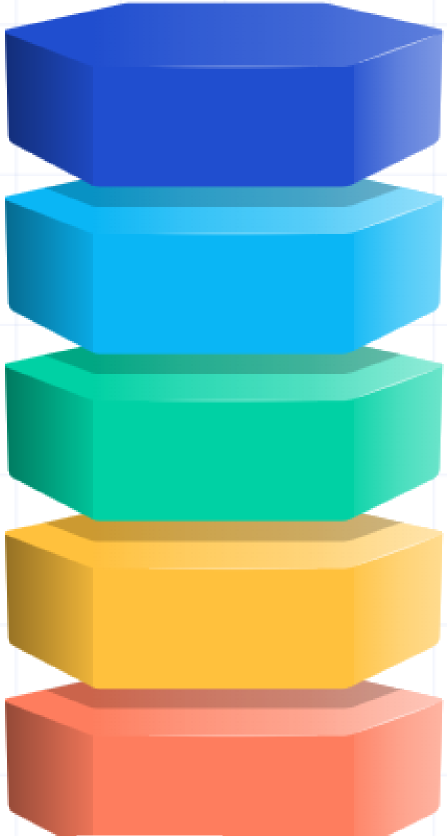
CASE STUDY: HYDROGEN PRODUCTION SYSTEMS

Exploring the financial viability of hydrogen systems



INTEGRATION WITH WIND ENERGY

This facility merges hydrogen production with wind energy, optimizing renewable resource use.

INITIAL INVESTMENT DETAILS

Initial costs are projected at $A million, a crucial factor for stakeholders.

PRODUCTION PROJECTIONS

The facility aims for a hydrogen output of B kg/year, showcasing its capacity.

SALES REVENUE ESTIMATES

Hydrogen sales are expected to generate $C million annually, indicating strong market demand.

PROFITABILITY TIMELINE

Projected cash flow suggests profitability within D years, appealing to investors.

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COMPARATIVE CASH FLOW ANALYSIS OF FLOATING WIND VS. HYDROGEN PRODUCTION

Key Metrics Comparison

METRIC	FLOATING WIND	HYDROGEN PRODUCTION
Initial Investment ($)	X	A
Annual Revenue ($)	Z	C
Payback Period (Years)	P	D
NPV ($)	N	M

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CHALLENGES AND RISKS IN ENERGY AND HYDROGEN SECTOR

MARKET VOLATILITY

Fluctuations in energy and hydrogen prices can disrupt cash flow stability.

REGULATORY CHANGES

Shifts in regulations can significantly impact profitability and operational strategies.

TECHNICAL RISKS

Floating wind technology and hydrogen production methods carry inherent technical challenges.

FORECASTING NEEDS

Accurate forecasting is essential for managing risks and ensuring financial health.

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CONCLUSION AND KEY FINDINGS

Insights on Floating Wind and Hydrogen Integration

01

LCOE AND CASH FLOW ANALYSIS

These analyses are crucial for evaluating the viability of floating wind turbines and hydrogen production systems.

02

SYNERGISTIC BENEFITS OF INTEGRATION

Combining floating wind turbines with hydrogen production enhances economic resilience and operational efficiency.

03

IMPORTANCE OF METHODOLOGIES

Employing comprehensive methodologies and sensitivity analyses is essential for informed decision-making in energy projects.

04

FUTURE RESEARCH DIRECTIONS

Research should aim to refine existing models and investigate policy implications for sustainable energy investments.

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THANK YOU

George Xydis

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Energy Investment Metrics: NPV, IRR, LCOE & LCOH

1st TETHYS summer school - Day 4

George Xydis

Funded by
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University of Cyprus
Università degli Studi Firenze
NEEST New Energy & Environmental Solutions and Technologies
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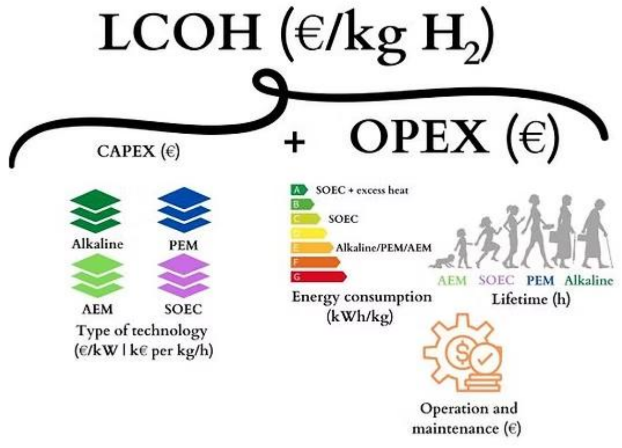
Continuing from LCOE…



Source: https://hydrogentechworld.com/

Similarly, LCOH is the Levelized Cost of Hydrogen

Meaning (again)…

The average cost to produce one kilogram of hydrogen over the entire economic life of a production facility

It helps compare different hydrogen projects, assess their economic viability, and identify key cost drivers like electricity prices and electrolyzer costs

Understanding LCOE and LCOH in Energy Investments

Exploring the metrics for evaluating energy generation costs and investment viability.

LCOE Definition

Levelized Cost of Energy is the per-unit cost of building and operating a generating plant, expressed in $/MWh.

LCOH Overview

Levelized Cost of Hydrogen measures the cost of producing hydrogen, similar to LCOE but focused on hydrogen production.

Importance for Stakeholders

Understanding LCOE and LCOH is vital for policymakers and investors when comparing renewable energy projects to conventional alternatives.

Understanding Challenges in LCOE and LCOH Calculations

Key complexities in energy investment metrics for accurate analysis

Complex Calculation Challenges

Calculating LCOE and LCOH can be complex due to several challenges.

Importance of Accurate Data

Accurate data collection is critical.

Assumption Variations Impact

Variations in assumptions about future costs, operational efficiency, and project lifespan can significantly impact the results.

Externalities Inclusion Issues

Inclusion of externalities such as environmental impact and subsidies can complicate calculations.

Essential Understanding for Practitioners

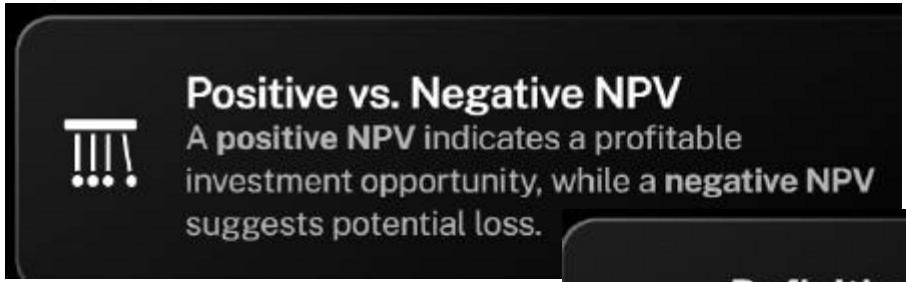
Understanding these challenges is essential for students and practitioners to improve the accuracy of their analyses.

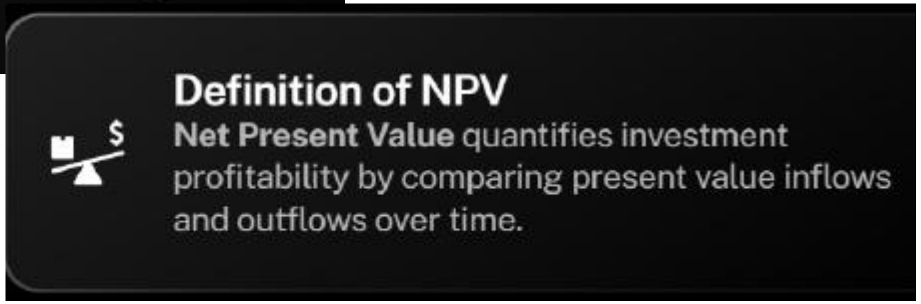
Is there any way to compare all investments?

ANS: yes, but there is no single "perfect" number.

A. Net Present Value (NPV)

The value of an investment today, after accounting for the cost of the investment and all future cash flows, discounted back to the present





B. Internal Rate of Return (IRR)

It's the discount rate that makes the NPV of all cash flows equal to zero.

How to use it: It gives you a percentage return.

NEXT PAGE

Is there any way to compare all investments?

ANS: yes, but there is no single "perfect" number.

B. Internal Rate of Return (IRR)

It's the discount rate that makes the NPV of all cash flows equal to zero. How to use it: It gives you a percentage return.

Understanding IRR: Investment Viability and Profitability

Exploring the significance of Internal Rate of Return in evaluating investment opportunities.

1. **Internal Rate of Return**
   The **IRR** is the discount rate that equates the **NPV** of all cash flows from an investment to zero, indicating its profitability.
2. **Comparison of Investments**
   IRR serves as a pivotal metric that allows investors to effectively compare the **profitability** of different investment opportunities.
3. **Calculation Methods**
   The formula for **IRR** is based on the **NPV** equation and is typically calculated through **iterative methods** or by using financial calculators.
4. **Investment Attractiveness**
   An investment is deemed attractive when its **IRR** surpasses the **required rate of return**, guiding investment decisions.

Evaluating Renewable Energy Projects with Investment Metrics

Key metrics for assessing wind, solar, and bioenergy projects effectively.

5% — **Typical IRR for projects**

Internal Rate of Return is often around 5% for renewable projects.

$50/MWh — **Average LCOE for solar**

Levelized Cost of Energy for solar is approximately $50 per megawatt-hour.

$60/MWh — **LCOE for wind energy**

Wind energy projects have an LCOE close to $60 per megawatt-hour.

20% — **NPV growth potential**

Net Present Value can demonstrate up to 20% growth potential.

30 years — **Typical project lifespan**

Most renewable energy projects have a lifespan of around 30 years.

50% — **Sustainability goal alignment**

Around 50% of investments align with sustainability goals.

Analyzing Solar Power Investment Metrics: NPV, IRR, LCOE, and LCOH

Understanding key energy investment metrics for informed decision-making in solar projects

$5million

Initial Investment

The project required a substantial upfront investment of **$5 million** to commence solar power generation.

$1.2million

Net Present Value

Over 20 years, the project achieved an **NPV of $1.2 million**, indicating profitability after accounting for the time value of money.

6%

Discount Rate

The analysis utilized a **discount rate of 6%**, reflecting the opportunity cost of capital for investors.

9%

Internal Rate of Return

With an **IRR of 9%**, the project demonstrates a solid return on investment, exceeding typical benchmarks.

$50/MWh

Levelized Cost of Energy

The **LCOE of $50/MWh** positions the project competitively against traditional energy sources.

20 years

Project Duration

The case study spans a **20-year period**, allowing for comprehensive evaluation of long-term financial metrics.

Understanding Key Investment Metrics in Energy Projects

Explore NPV, IRR, LCOE, and LCOH for informed energy investment decisions.

Projected NPV of a typical project

$10M

A Net Present Value of $10 million indicates a potentially profitable energy investment.

Average IRR in renewable projects

15%

An Internal Rate of Return of 15% is considered attractive for renewable energy initiatives.

Typical LCOE for solar energy

$50/MWh

Levelized Cost of Energy at $50 per megawatt-hour reflects competitive pricing in the solar sector.

LCOH for green hydrogen

$4/kg

A Levelized Cost of Hydrogen of $4 per kilogram demonstrates the growing feasibility of hydrogen projects.

Investment allocation in renewables

30%

Approximately 30% of total energy investments are directed towards renewable resources.

Average project payback period

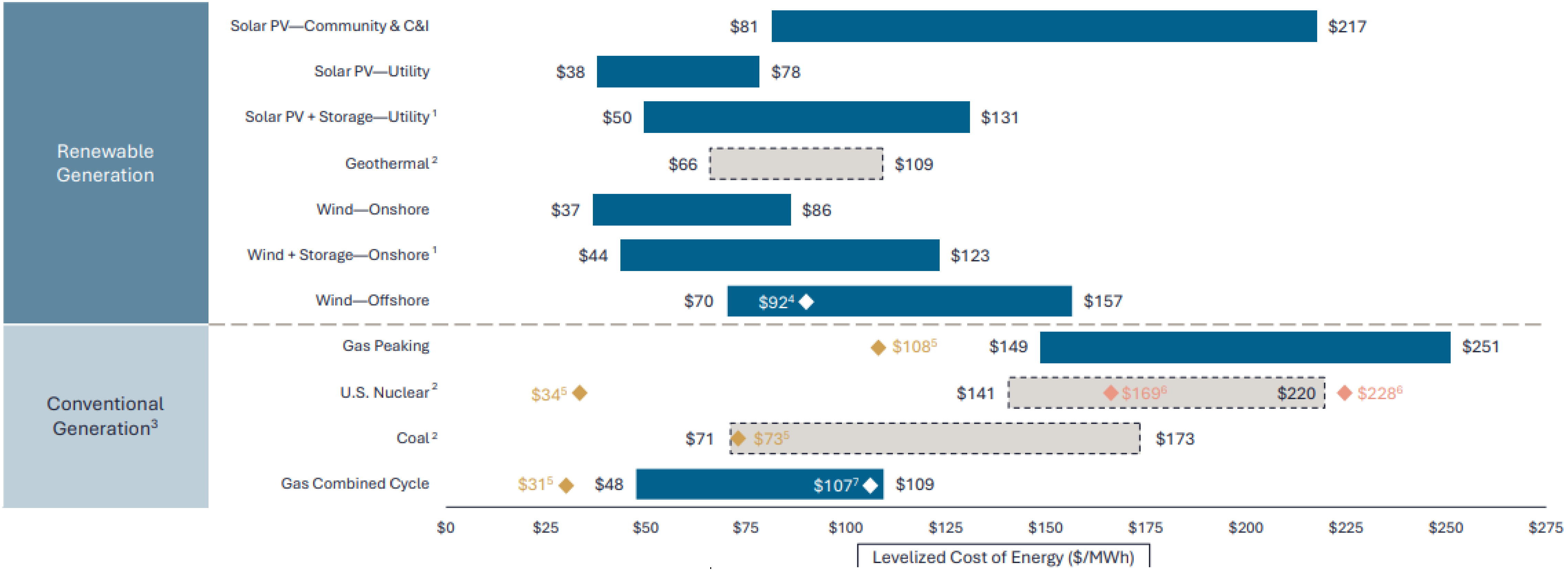
5 years

Energy projects typically have a payback period of around 5 years, enhancing financial attractiveness.

Is there any way to compare all investments?

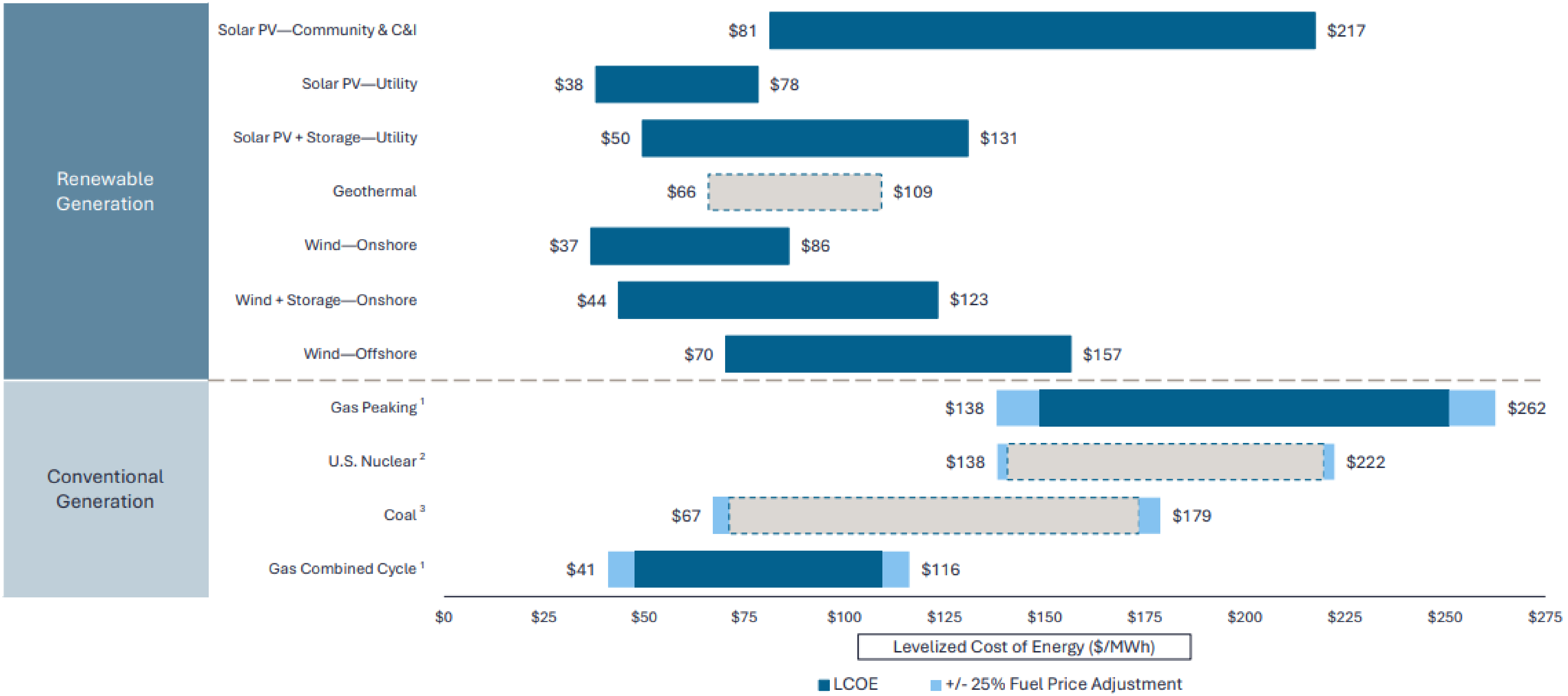
Levelized Cost of Energy Comparison—Version 18.0

Selected renewable energy generation technologies remain cost-competitive with conventional generation technologies under certain circumstances



Levelized Cost of Energy Comparison—Sensitivity to Fuel Prices

Variations in fuel prices can materially impact the LCOE of conventional generation technologies

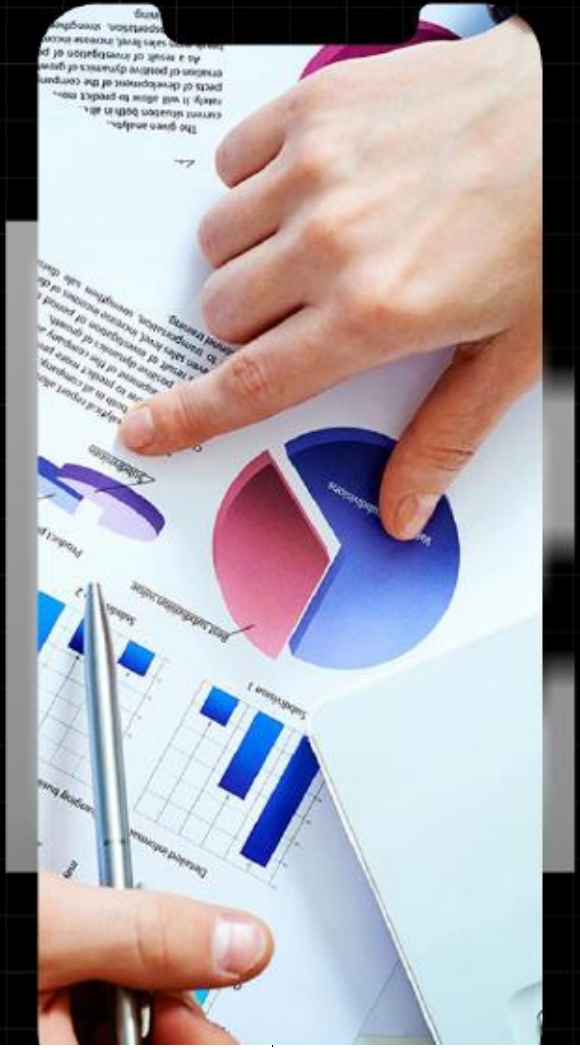


Comparative Advantages of NPV and IRR in Investment Analysis

Understanding the distinct roles of NPV and IRR for effective energy investment decisions

Net Present Value (NPV)

- Provides a **dollar value** for profitability.
- Allows comparisons between projects of **different scales**.
- Considered more **reliable** for mutually exclusive projects.
- Directly correlates with **financial value** established.
- Less susceptible to misleading results from cash flow variability.



Internal Rate of Return (IRR)

- Offers a **percentage return** for efficiency assessment.
- Easier to interpret for **investment efficiency**.
- Can be misleading in cases of **non-conventional cash flows**.
- Focuses on **rate of return**, not absolute value.
- May suggest multiple solutions in complex cash flow scenarios.

Integrating Sustainability in Energy Investment Metrics

Exploring the shift towards ESG factors in energy investments

1. **Sustainability is a key focus**

   The energy investment landscape is increasingly prioritizing **sustainability** alongside traditional financial metrics, reflecting a significant shift in investor priorities.

2. **Importance of ESG factors**

   Investors are now incorporating **environmental**, **social**, and **governance** (ESG) factors into their investment analyses, highlighting their growing importance in decision-making processes.

3. **Traditional metrics still relevant**

   While ESG factors gain traction, traditional financial metrics like **NPV** and **IRR** remain essential for evaluating investment viability and profitability.

4. **Meeting global climate goals**

   Incorporating sustainable practices in energy investments is crucial for meeting **global climate goals**, ensuring long-term viability and environmental stewardship.

5. **Investor recognition of impact**

   There is a broader recognition among investors that sustainable practices can lead to better long-term outcomes and **reduced risks** in energy investments.

6. **Impact on investment strategies**

   This trend is reshaping investment strategies, prompting a more comprehensive view that includes both financial returns and **social impact** metrics.

Integrating ESG Metrics in Investment Analysis for Energy Investments

Understanding the importance of ESG factors in evaluating energy projects' viability and performance

- **Importance of ESG Metrics**

  The integration of **Environmental**, **Social**, and **Governance** factors into investment analysis is crucial for assessing not only financial returns but also societal impact.

- **Performance Correlation**

  Studies indicate that projects with high **ESG ratings** generally outperform their peers on traditional financial metrics, showcasing the value of these assessments.

- **Holistic Investment View**

  Incorporating ESG factors alongside traditional metrics like **NPV** and **IRR** provides a more comprehensive view of project viability and long-term sustainability.

- **Investor Shift in Focus**

  There is a growing trend among investors to prioritize **sustainable** and responsible investment practices, reflecting a shift towards a broader evaluation of potential investments.

Best Practices for Using Investment Metrics in Energy Projects

Key strategies for effective energy project analysis using NPV, IRR, LCOE, and LCOH

1. **Ensure accurate data collection for reliable analysis.**
   Critical for valid investment assessments.
2. **Regularly update assumptions to reflect market changes.**
   Maintains relevance and accuracy in evaluations.
3. **Utilize sensitivity analysis to assess impacts of variables.**
   Helps understand risks and uncertainties.
4. **Combine different metrics for comprehensive insights.**
   Provides a holistic view of project viability.

https://people.uop.gr/~gxydis/_CASHFLOW_MODELGX.xls

THANK YOU

QUESTIONS?