Energy Systems Engineering

(Graduate Level Master of Engineering Programme)

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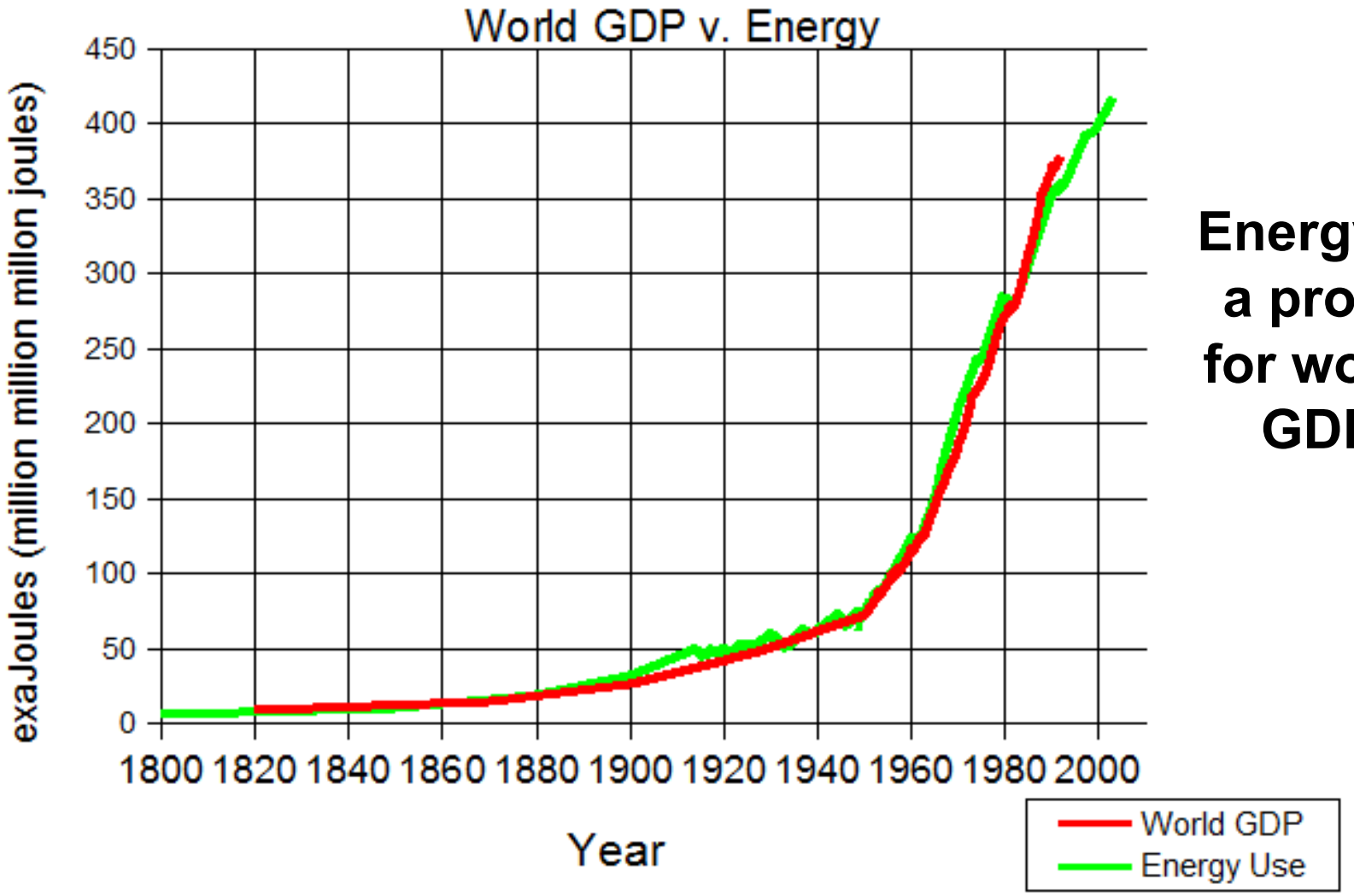
Master of Engineering (ME) in Energy Systems Engineering

- Prepares graduates to meet the engineering, economic and environmental challenges facing the energy systems of developed countries in the future.
- Will focus on the interdependence between;
  - **The electricity system,**
  - **Building energy systems,**
  - **The industrial production system,**
  - **The food supply chain, and**
  - **The transport system,**

- taking account of security of supply and climate impact / CO_2 emissions.

World Energy Use and World GDP 1800 - 2000

(scaled to fit)

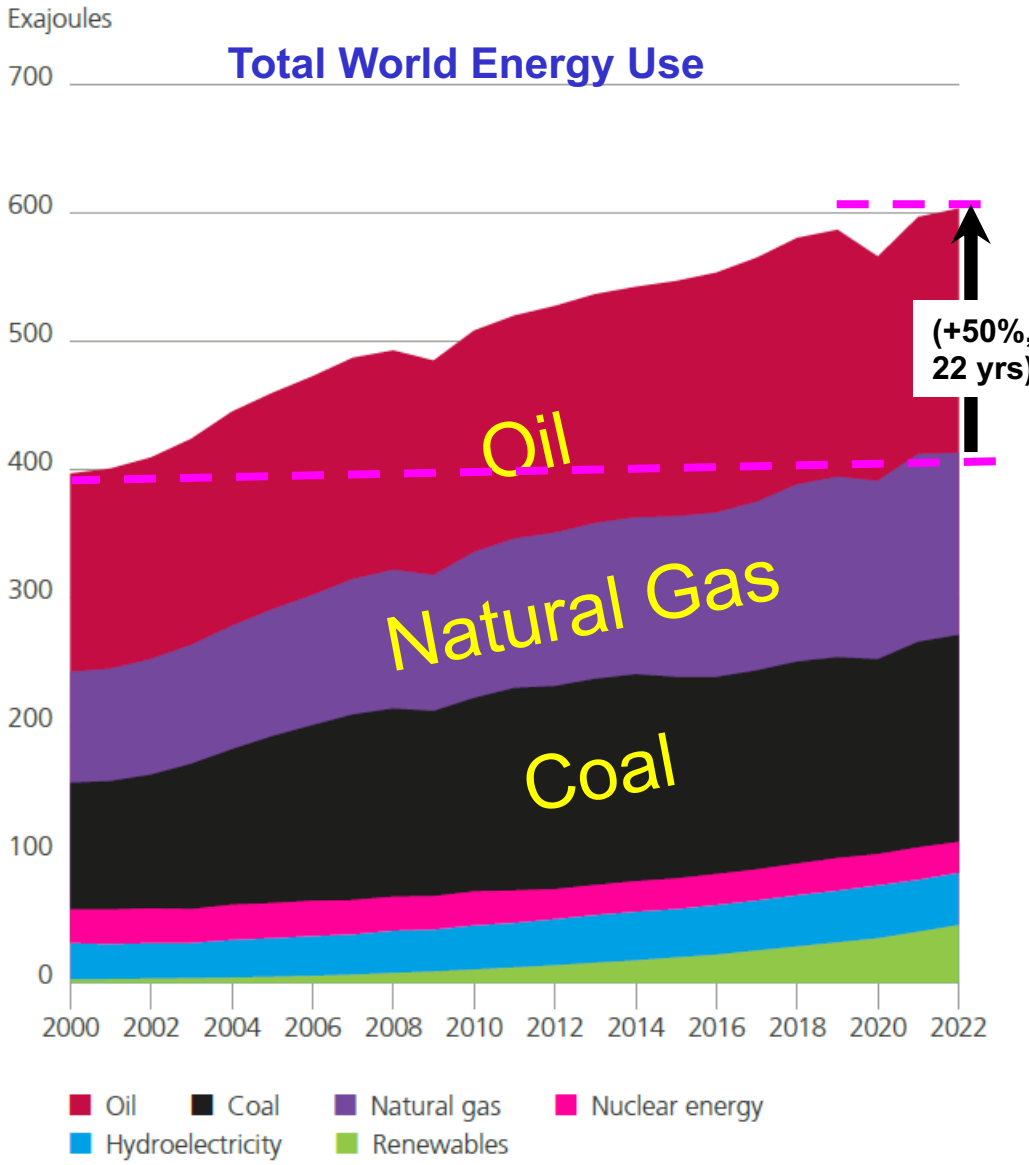


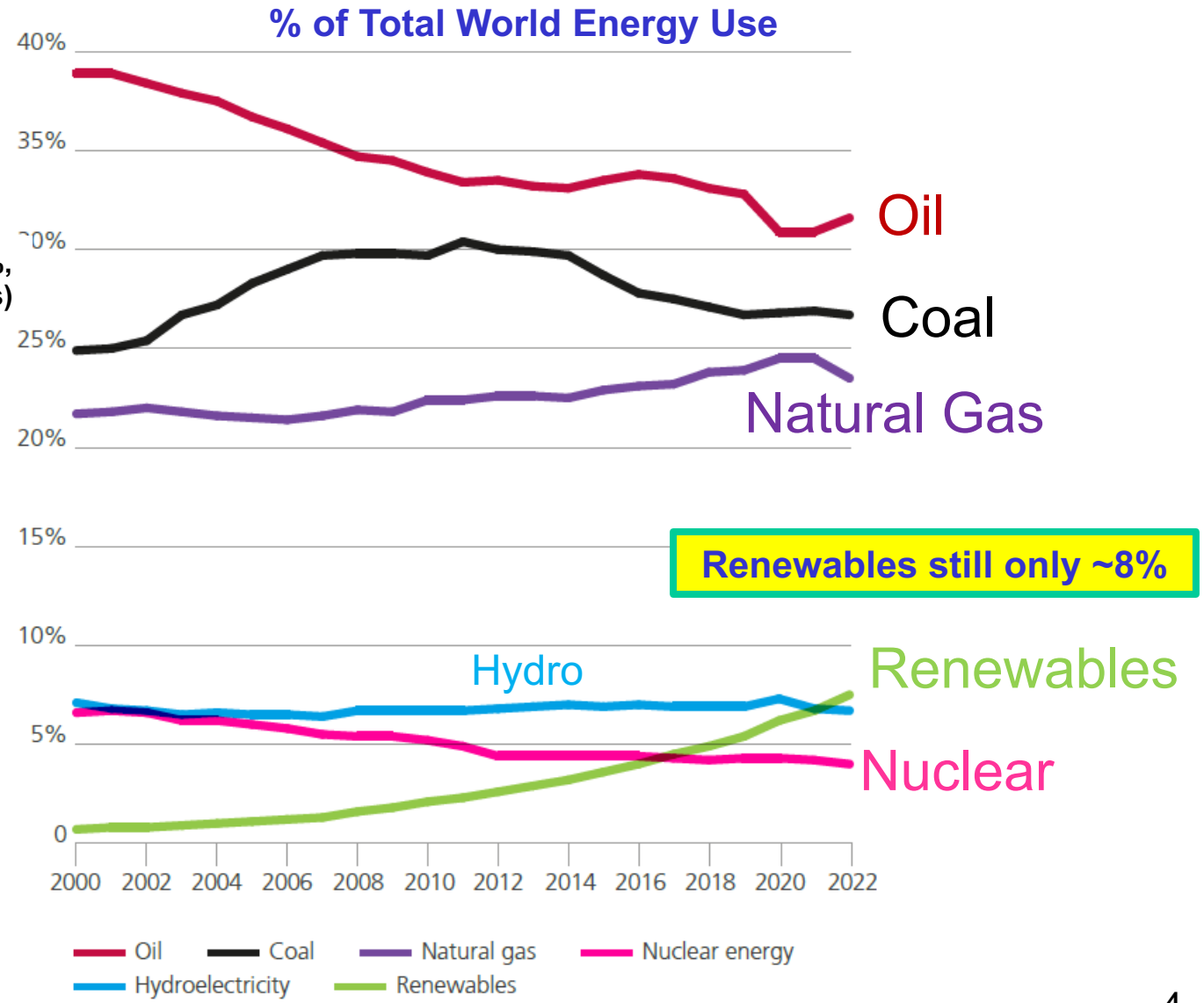
Energy is a proxy for world GDP

http://scottishsceptic.co.uk/2013/10/18/enerconics-the-relationship-between-energy-and-gdp/

2023 | 72nd edition Statistical Review of World Energy

https://www.energyinst.org/statistical-review



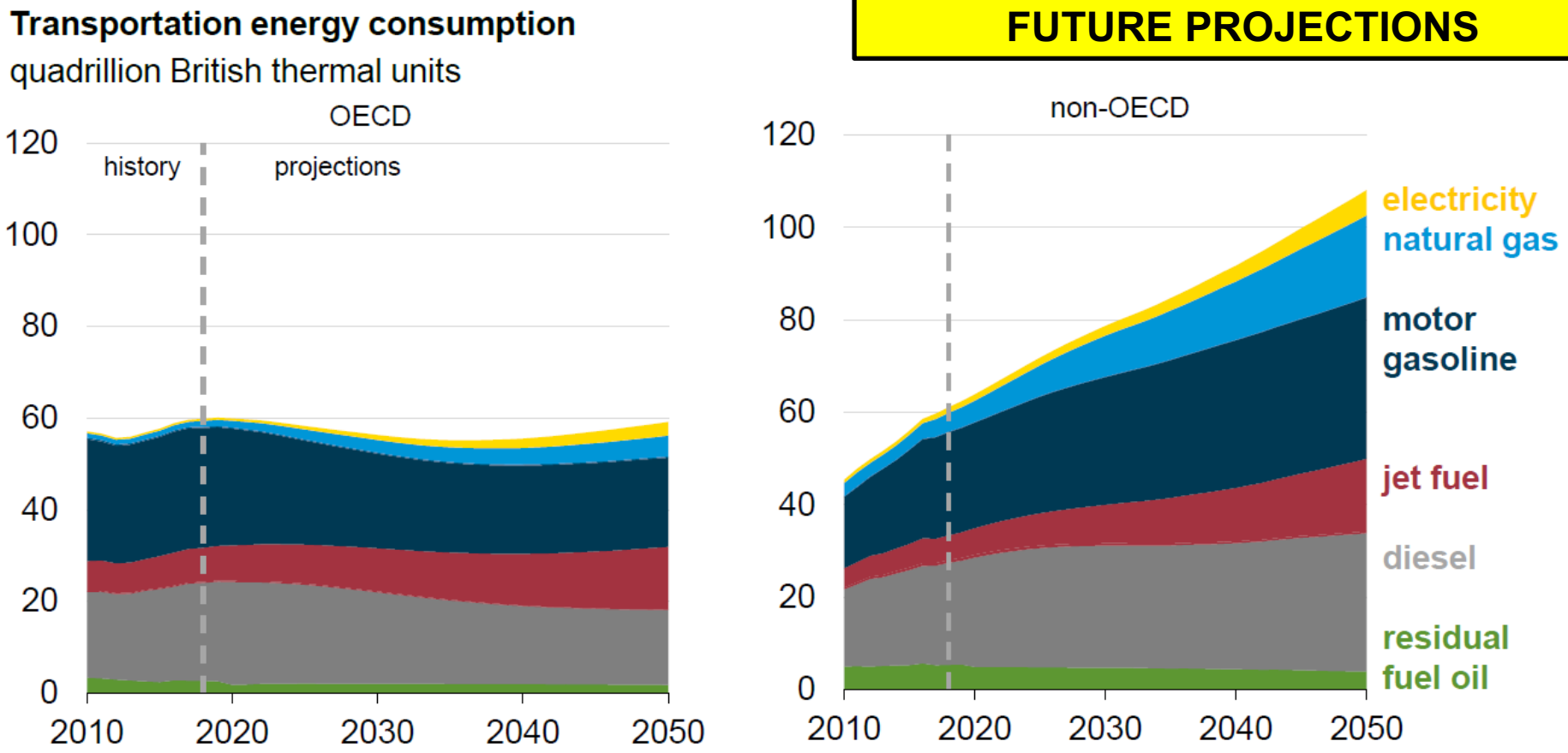


https://www.energyinst.org/__data/assets/pdf_file/0004/1055542/EI_Stat_Review_PDF_single_3.pdf

International Energy Outlook 2019 with projections to 2050

U.S. Energy Information Administration Office of Energy Analysis

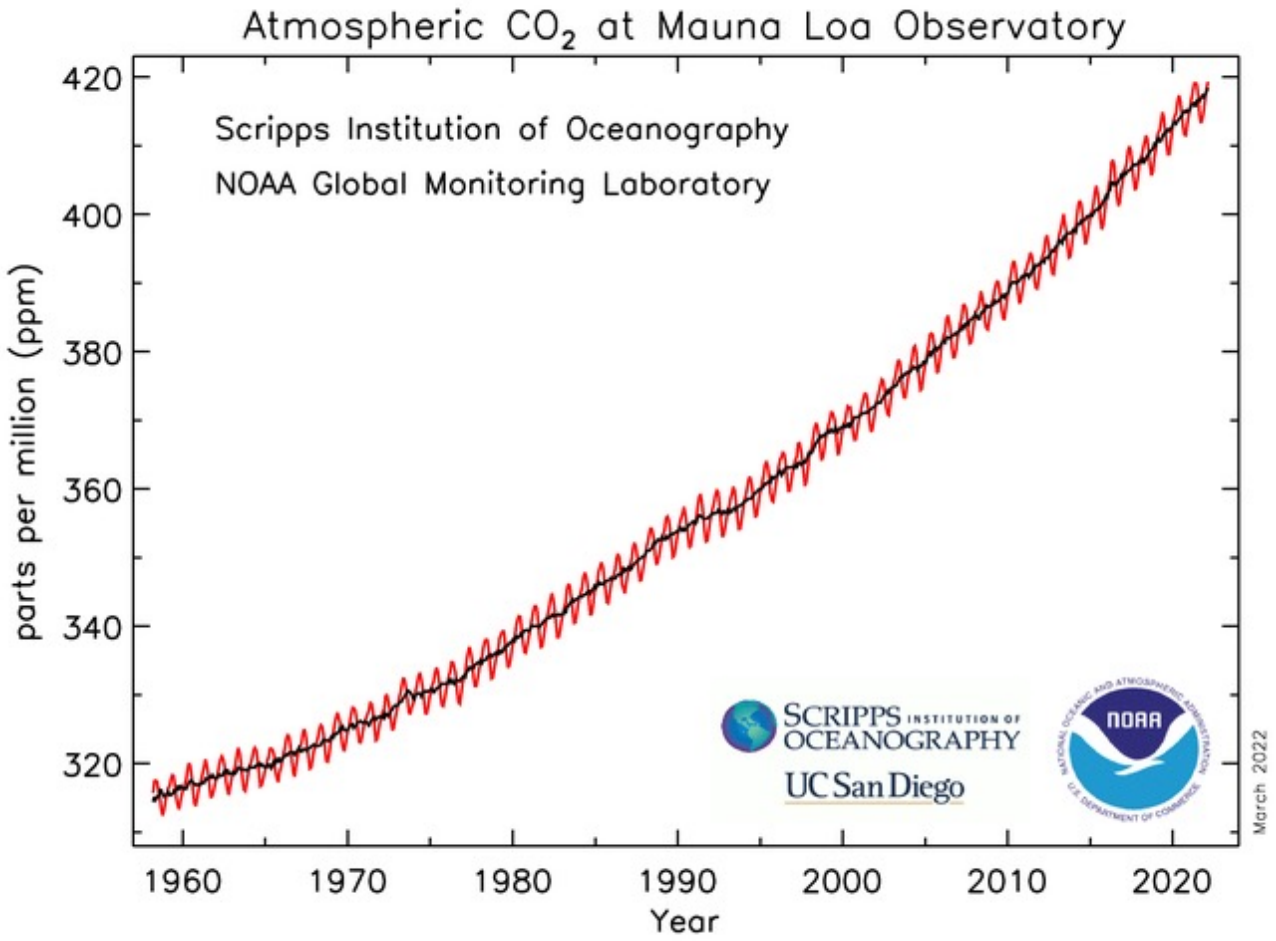
FUTURE PROJECTIONS



In the Reference case, the share of transportation fuel from alternative energy sources increases through 2050 but refined petroleum and other liquids remain dominant.

https://www.eia.gov/outlooks/ieo/pdf/ieo2019.pdf

Increasing Atmospheric CO_2 (1958 to 2022)



Mauna Loa data obtained at an altitude of 3400 m in the northern subtropics

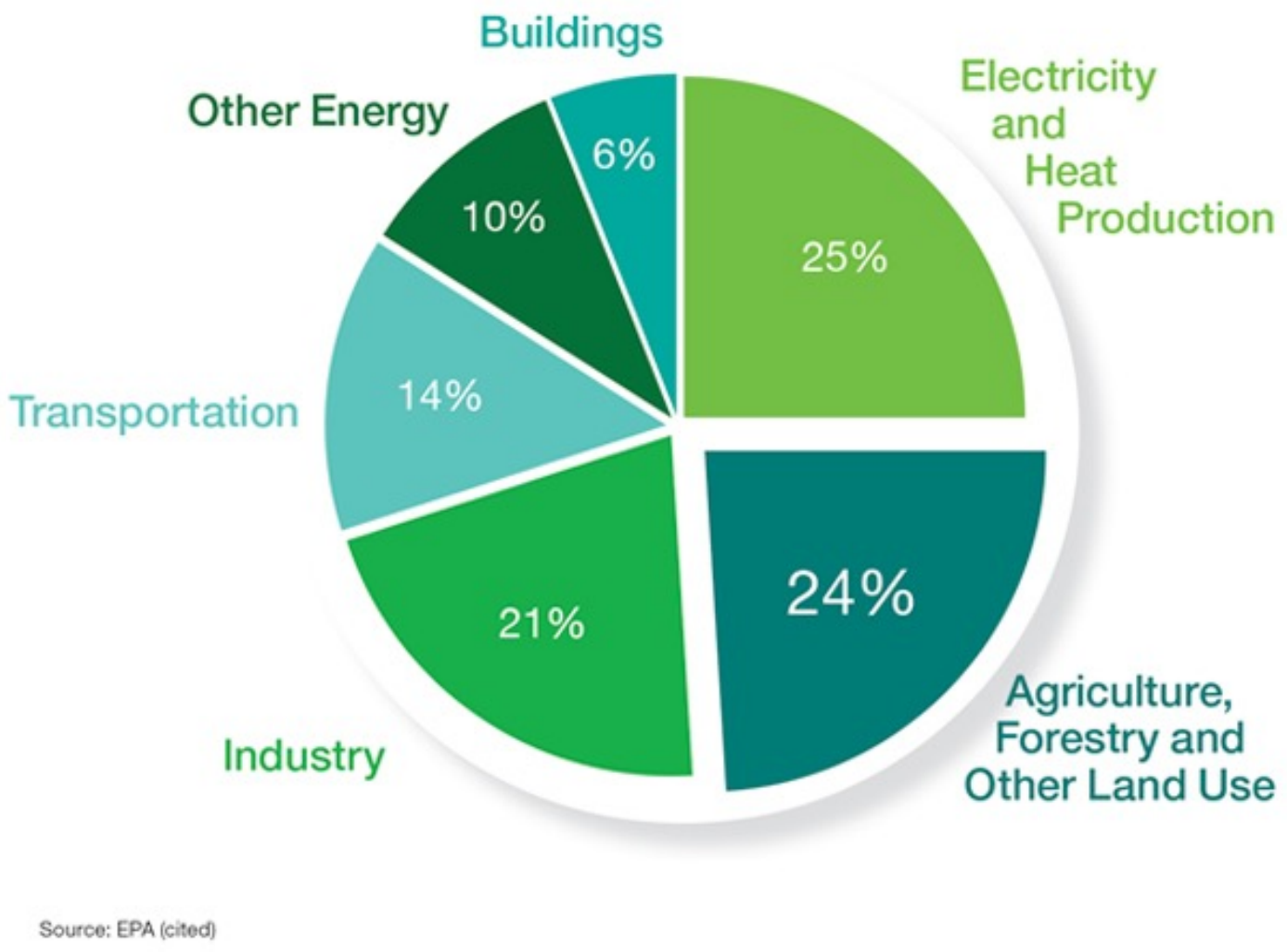
Average CO_2 increase = 2.3 ppm/year (Doubling every 178 years)

Recent Monthly CO_2 Averages @ Mauna Loa

January 2001: 370.8 ppm **January 2021: 415.5 ppm** **February 2024: 420.3 ppm (up 13%)**

https://www.esrl.noaa.gov/gmd/ccgg/trends/

Global Greenhouse Gas Emissions by Economic Sector



https://www.kynetec.com/news/510-how-cop26-methane-and-carbon-pledges-will-impact-agriculture

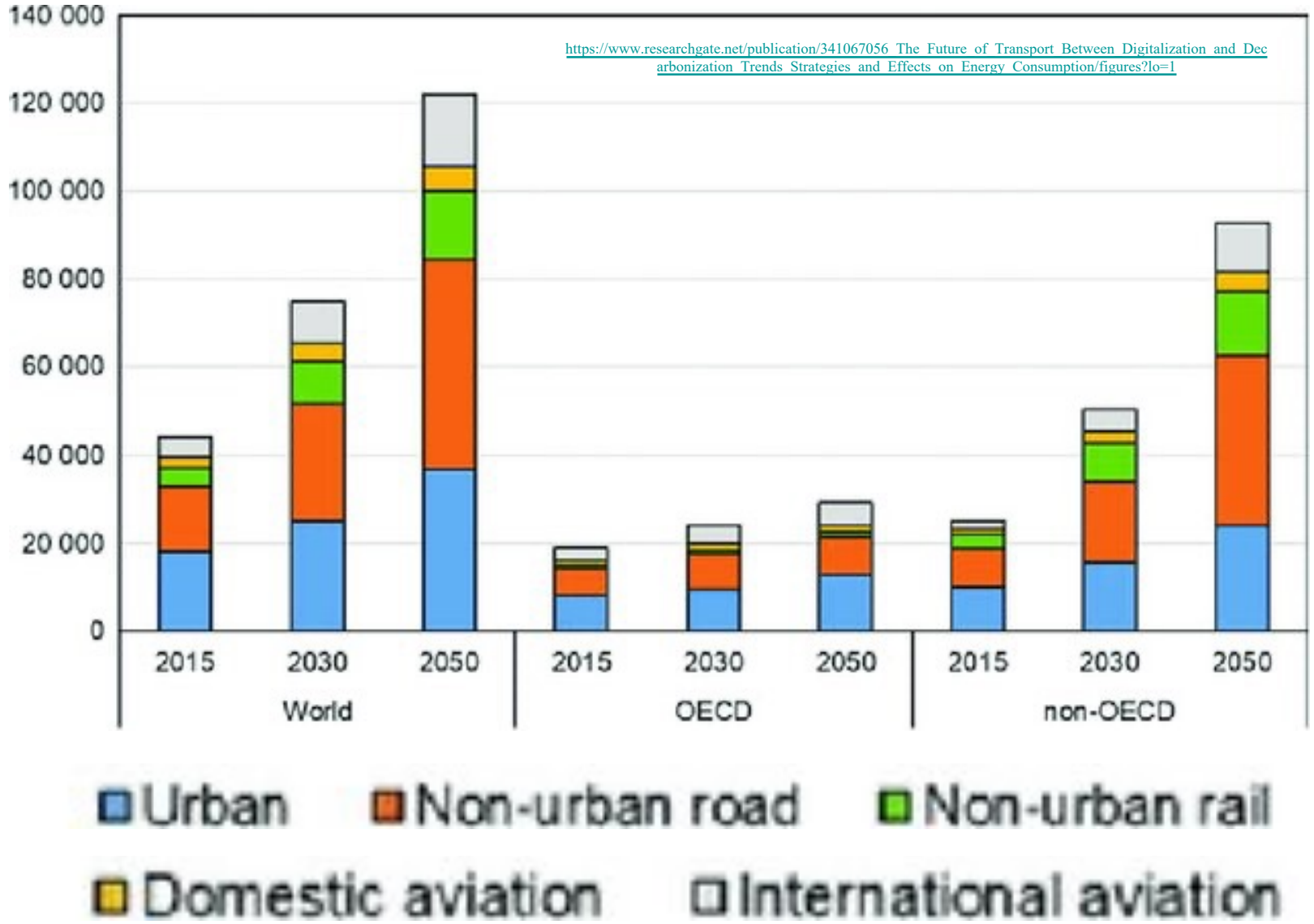
United Nations Framework Convention on Climate Change (UNFCCC) negotiations at the 21st Conference of the Parties (COP21) December 2015 -> **COP26** in December 2021

Paris Agreement: Ministers from 195 countries adopted by consensus a legally binding agreement to fight climate change.

Glasgow:
Countries agreed only to "phase down" and not "phase out" coal, due to a last-minute edit by China and India.

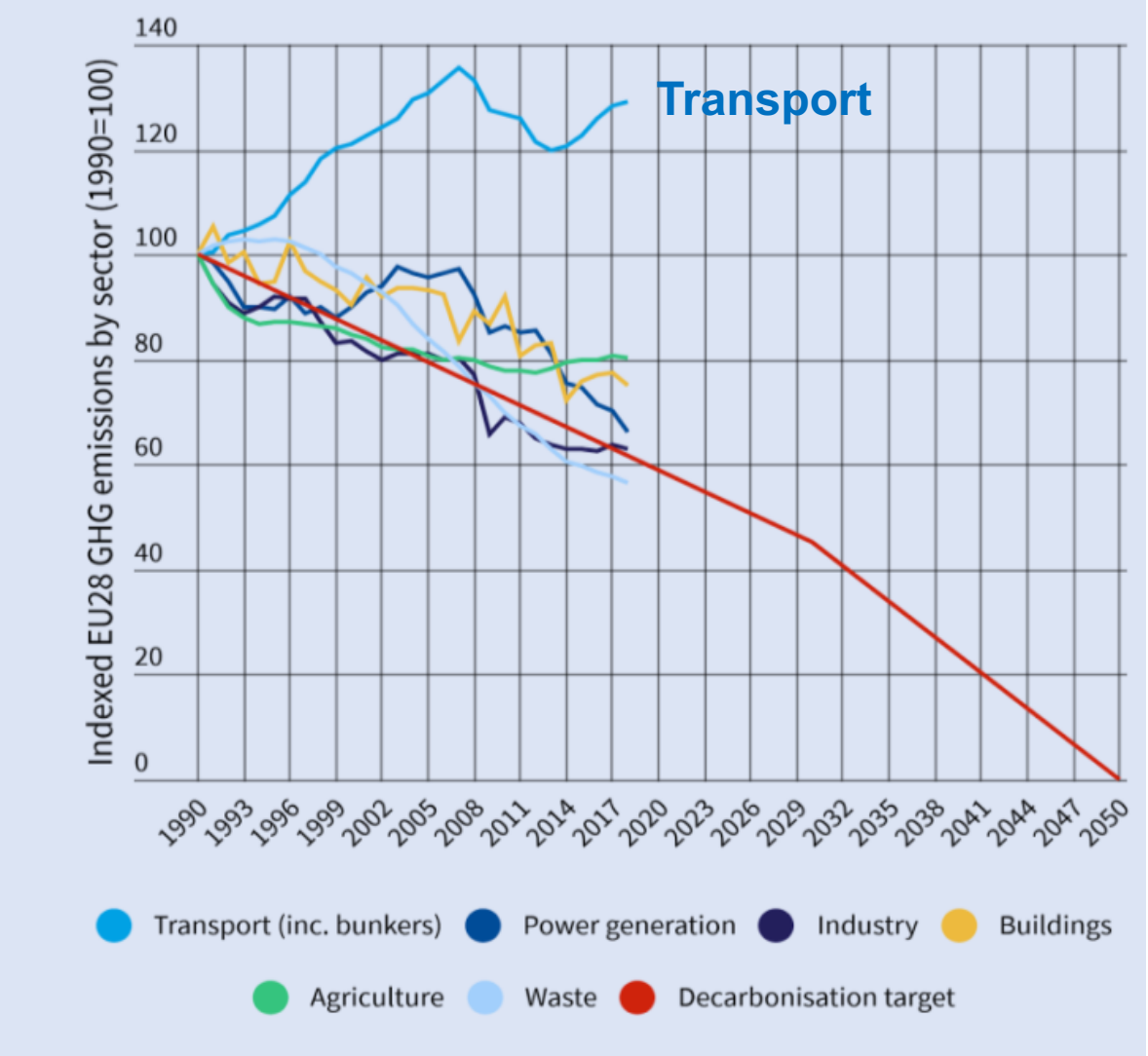
Key accomplishments from COP 28 Dubai:
included an agreement to *transition away* from fossil fuels,
the creation of a fund to help vulnerable countries pay for climate-related damage,
and the publication of landmark assessment of the world's progress in mitigating climate change

Demand for passenger travel is expected to grow strongly, especially non-OECD (billions of passenger km)



European Union Emission by Sector (1990-2050 projection)

The decarbonisation target line includes a 55% reduction in 2030 and assumes full decarbonisation by 2050.



EU – Trends & Projection to 2050

Transport (including international aviation and shipping) in 2018 was almost 30% above 1990 levels.

https://www.transportenvironment.org/sites/te/files/publications/2020_02_TE_EGD_vision_How_EU_transport_can_contribute_minus_55.pdf

ME in Energy Systems Engineering

- What do we do now?
- Who is going to re-arrange the world so as to maintain improving living standards for an ever increasing population?

Energy Systems Engineers!

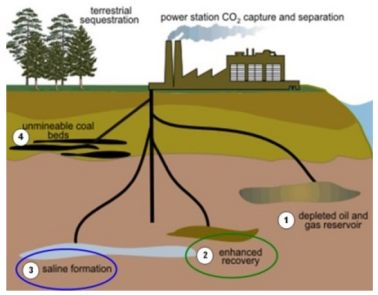
Why Energy Systems Engineering?

- Greenhouse Gas Emissions
- Climate Change
- Diminishing Fossil Fuels
- Increasing Demand for Energy
- Energy Security
- Stringent Carbon Emission Constraints
- Prepare for forthcoming hydrogen economy

MULTI-DISCIPLINARY ENGINEERING REQUIRED

ME (Energy Systems) Engineering

- Aims to prepare graduates to meet the **often conflicting** engineering, economic and environmental **challenges** facing the energy systems of developed countries in the future, taking account of security of supply and climate impact / CO_2 emissions.
- Inter-disciplinary approached needed because of the future interdependence between the electricity system, building energy systems, and transport systems.
- Inputs provided by Mechanical, Electrical, Civil & Chemical Engineering, and Geological (Earth) Sciences / Physics / Economics / Business.
- >250 graduates since 2010.
- Also available as 12-month, 90-credit ME.



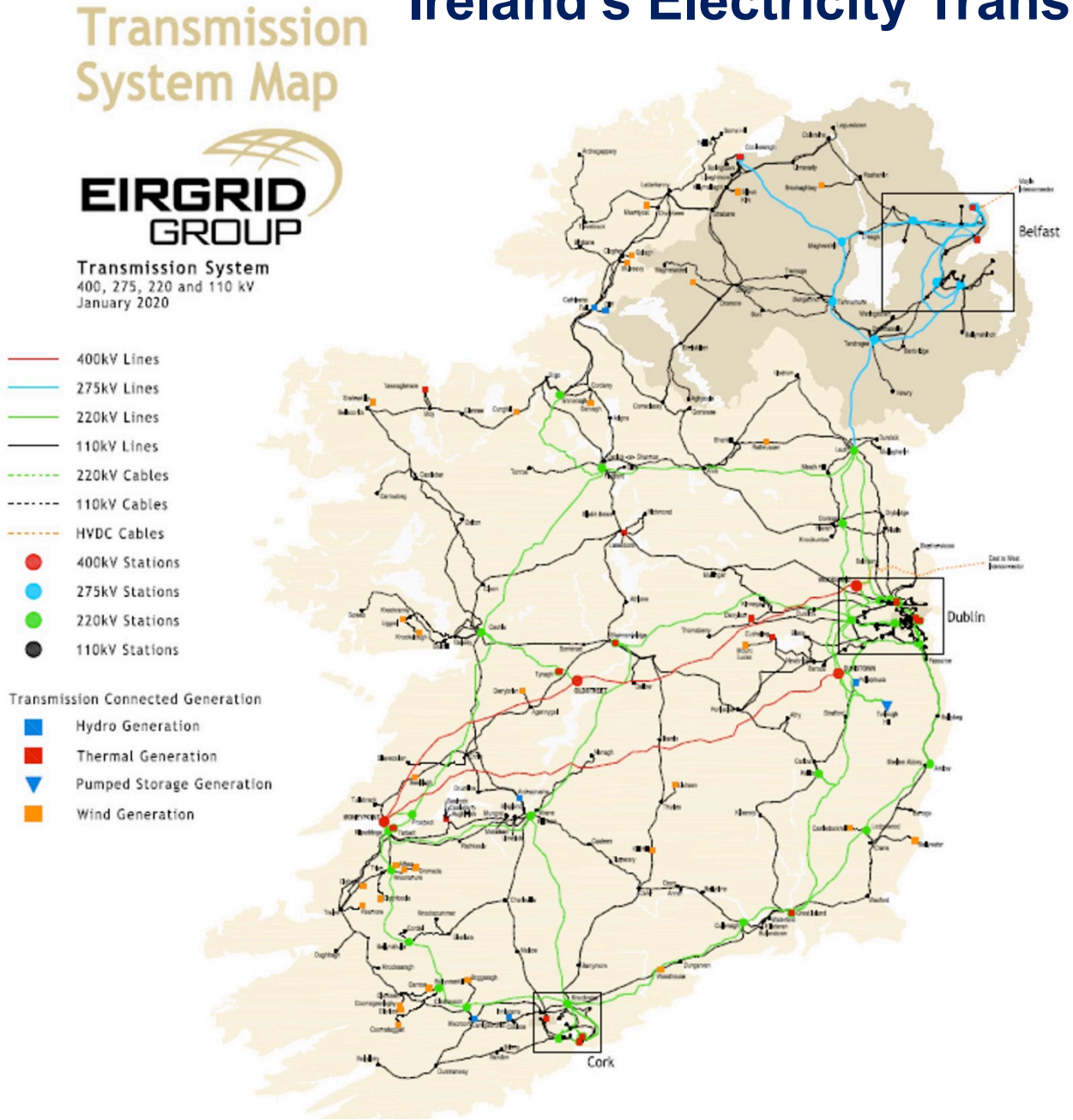
Energy Systems Engineering

Maintenance of current living standards in the developed world will require new ways to use energy more efficiently and greater contributions from:

- **solar energy,**
- **wind energy,**
- **wave / tidal energy,**
- **energy from crops / biomass / algae,**
- **nuclear energy, and**
- **from advanced fossil fuel technologies.**

- **Greater use of electrical energy in buildings and in transport is likely.**
- **"Smart Grid" and Energy Storage Technologies are needed.**

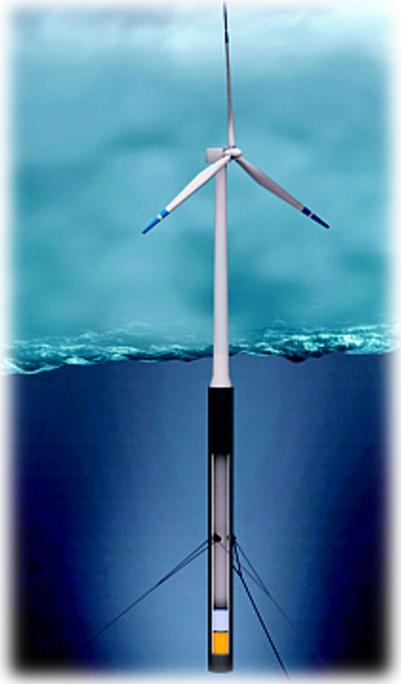
Ireland's Electricity Transmission System (National Grid)



Distribution System

Wind Energy

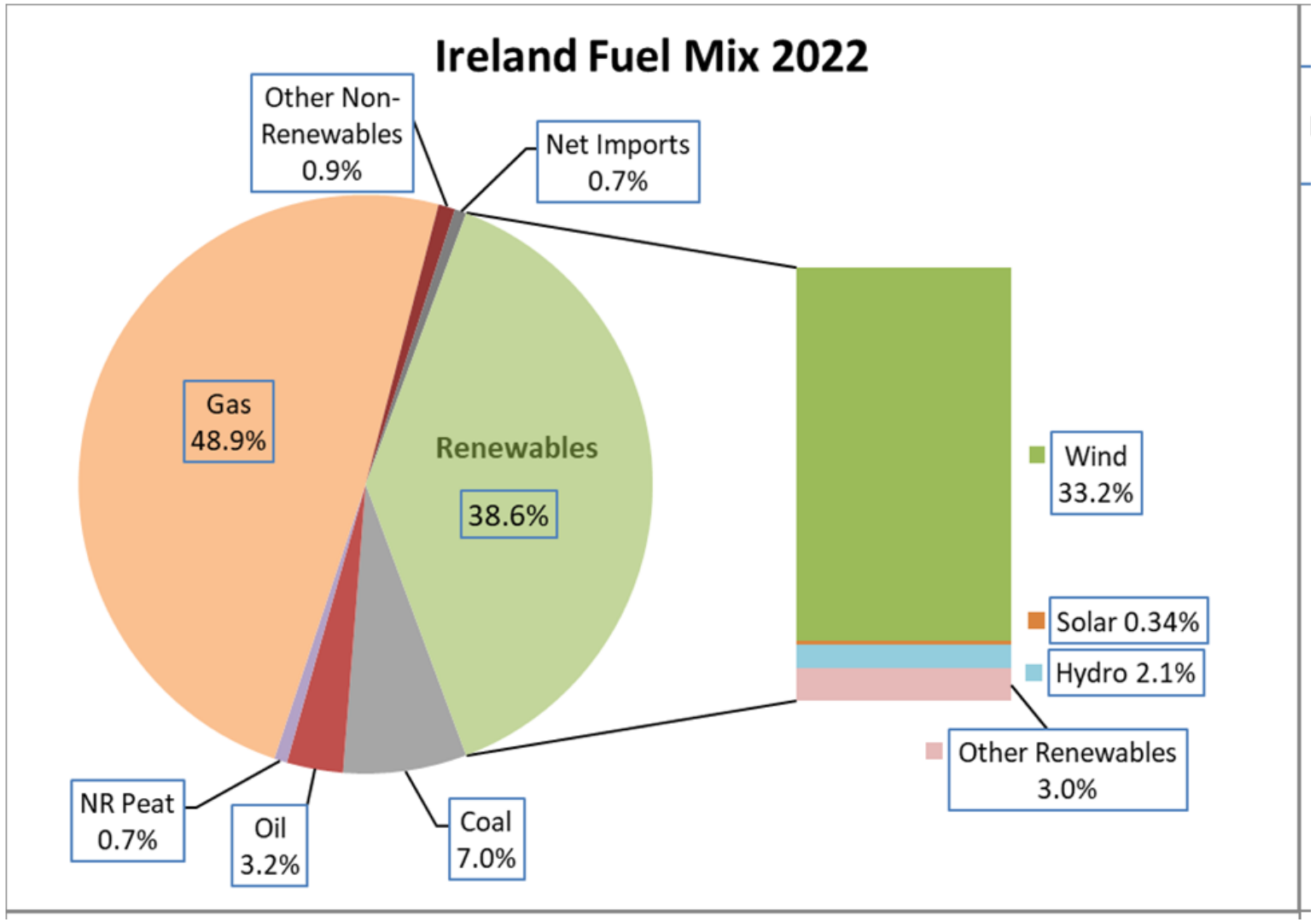
- Most mature of all new renewable energy technologies (excluding hydropower)
- Competitive with conventional fuels
- Continually evolving and improving
  - Offshore Wind Power
  - Floating Turbines
    - E.g. Hywind – Statoil, Ideol
- Electrical/Civil/Mechanical



Wind Turbine Design and Manufacturing

ENERCON

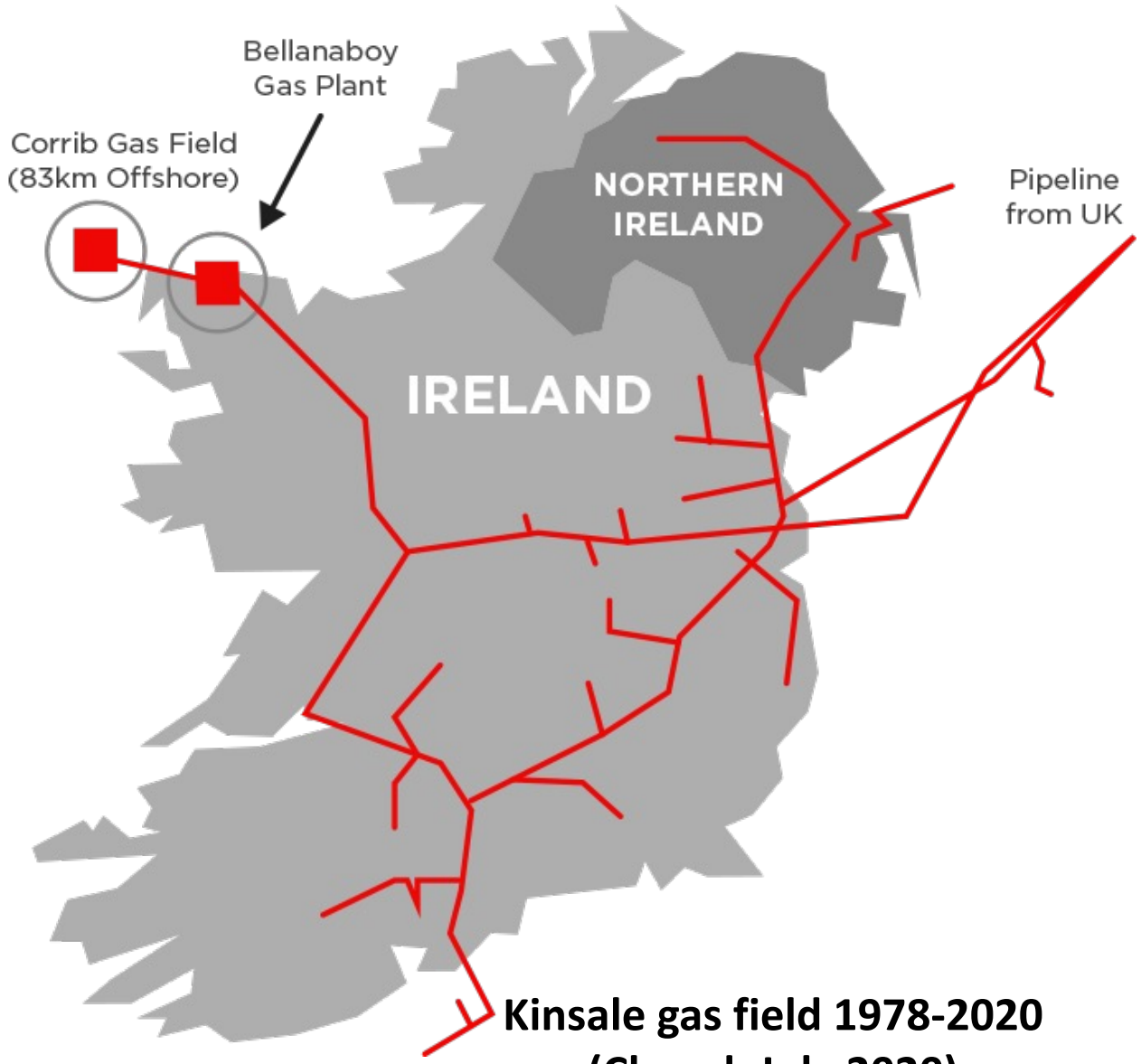
Energy Inputs to Irish Electricity System - 2022



38.6% of all the electrical energy (in kWh or MWh) produced in Ireland in 2019 was from **"Renewables"** (Wind, Hydroelectricity + other).

48.9% from natural gas

Irish Natural Gas Grid



Kinsale gas field 1978-2020
(Closed, July 2020)

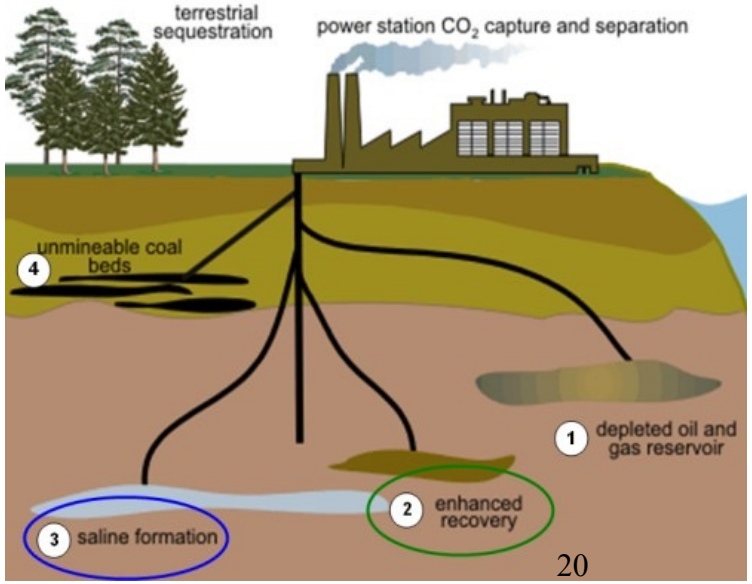
Corrib Gas Field flow has reduced by ~66% since Jan 2018.

Heavy dependence on pipelines from Scotland

Following the depletion of the Corrib gas field, Ireland is expected to be dependent on over 80% imports by the mid-2020s and over 90% by 2030.

https://www.gov.ie/en/policy-information/f1ecf1-gas/#irelands-gas-system

Fossil Fuels and Geology

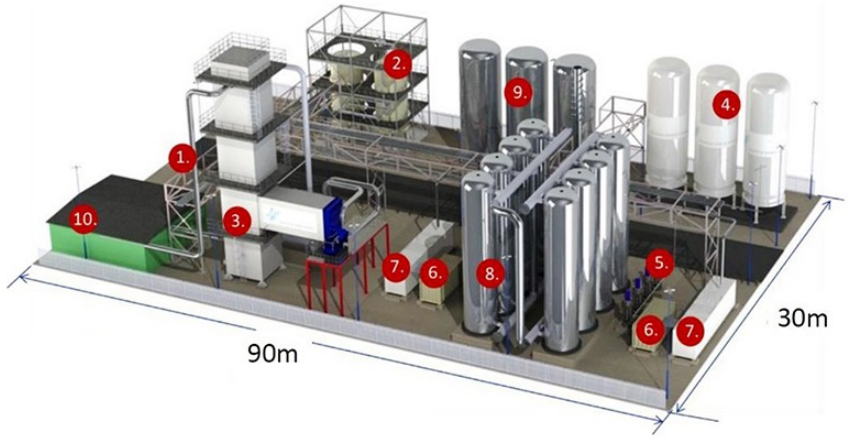


Energy Systems - many different technologies

Solar Farm

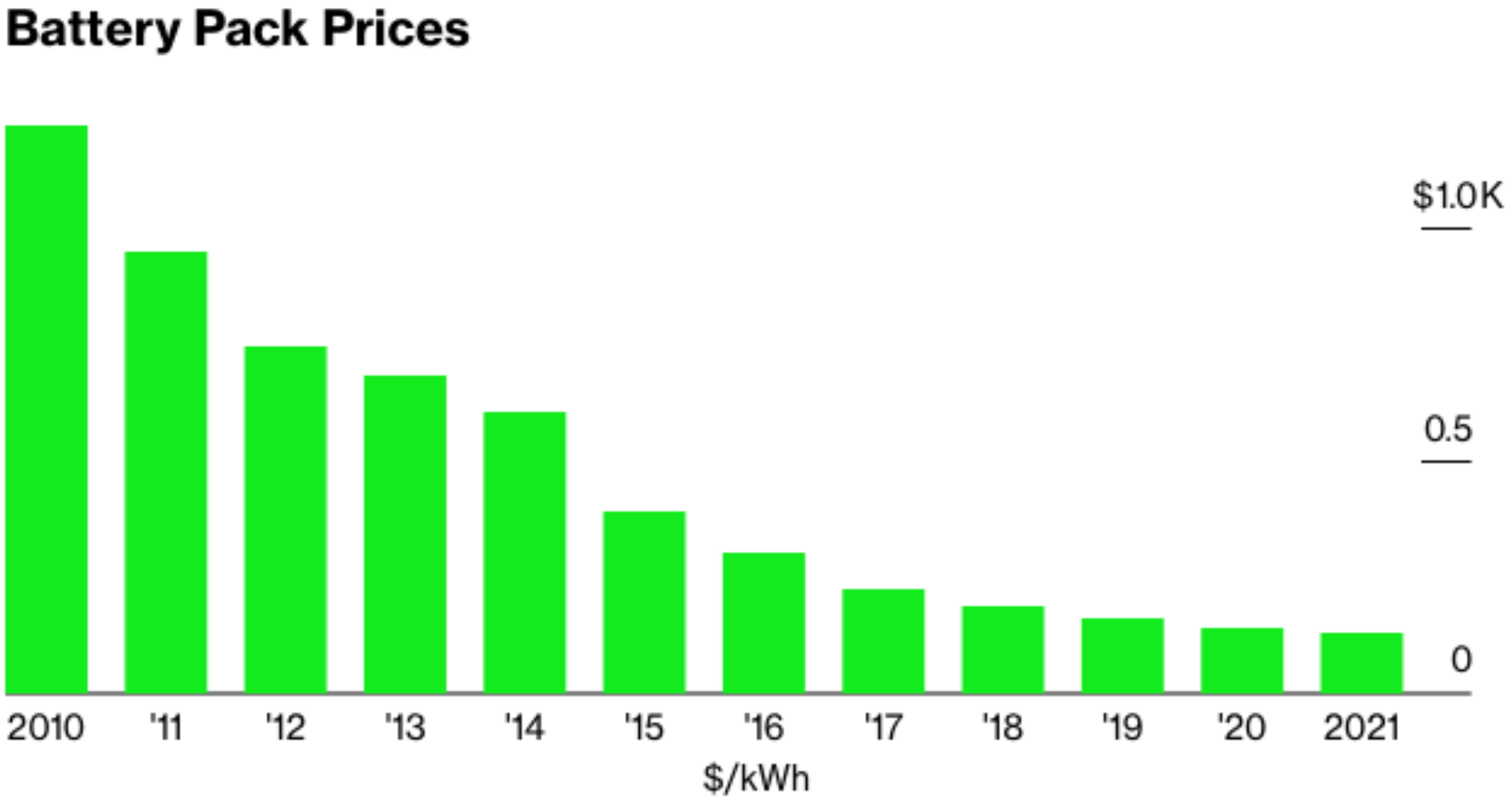
Volkswagen ID.3 Electric Car

Offshore Wind Farm



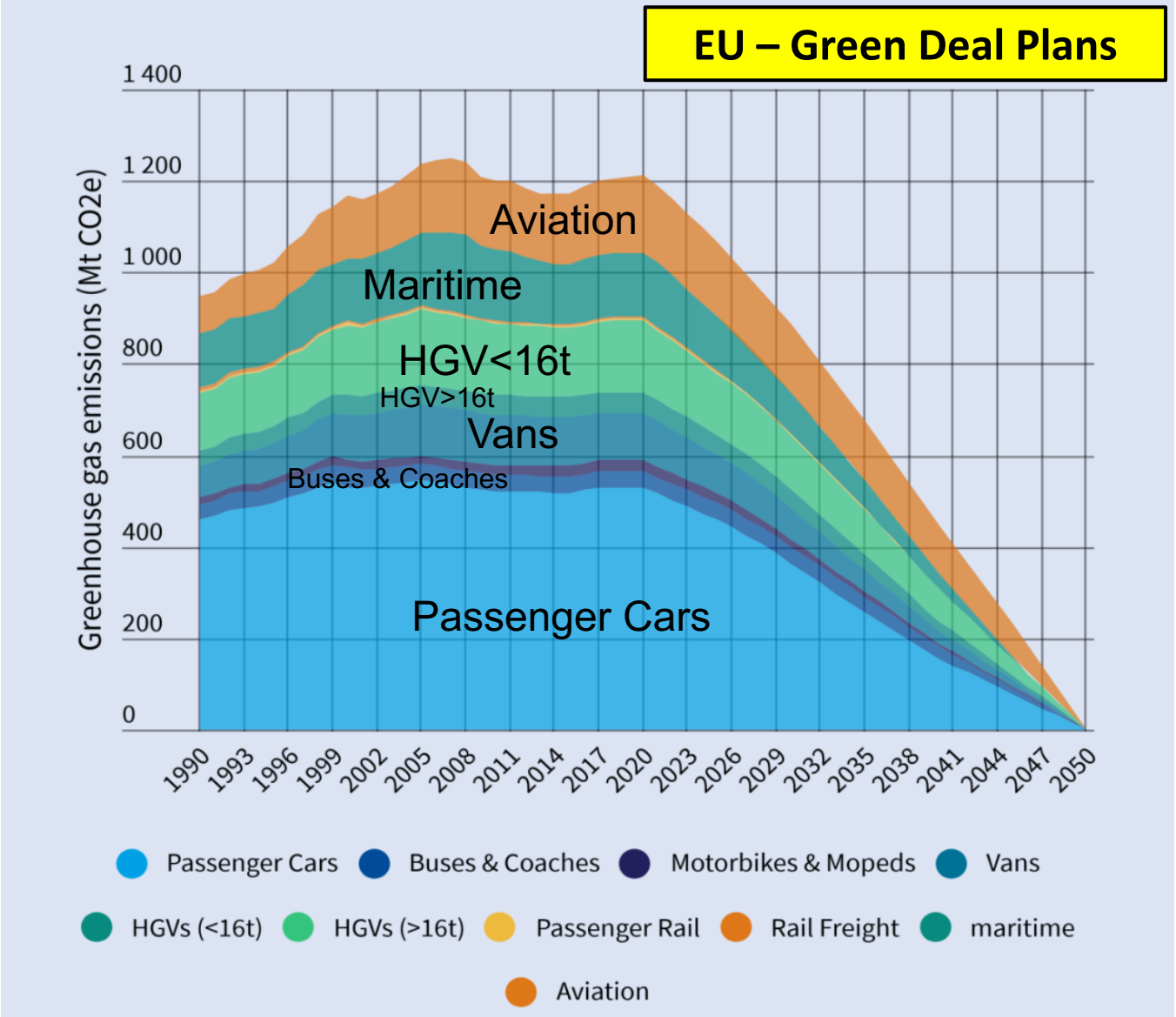
Liquid Air Energy Storage System

EV Battery Price Trend (US$/kWh)



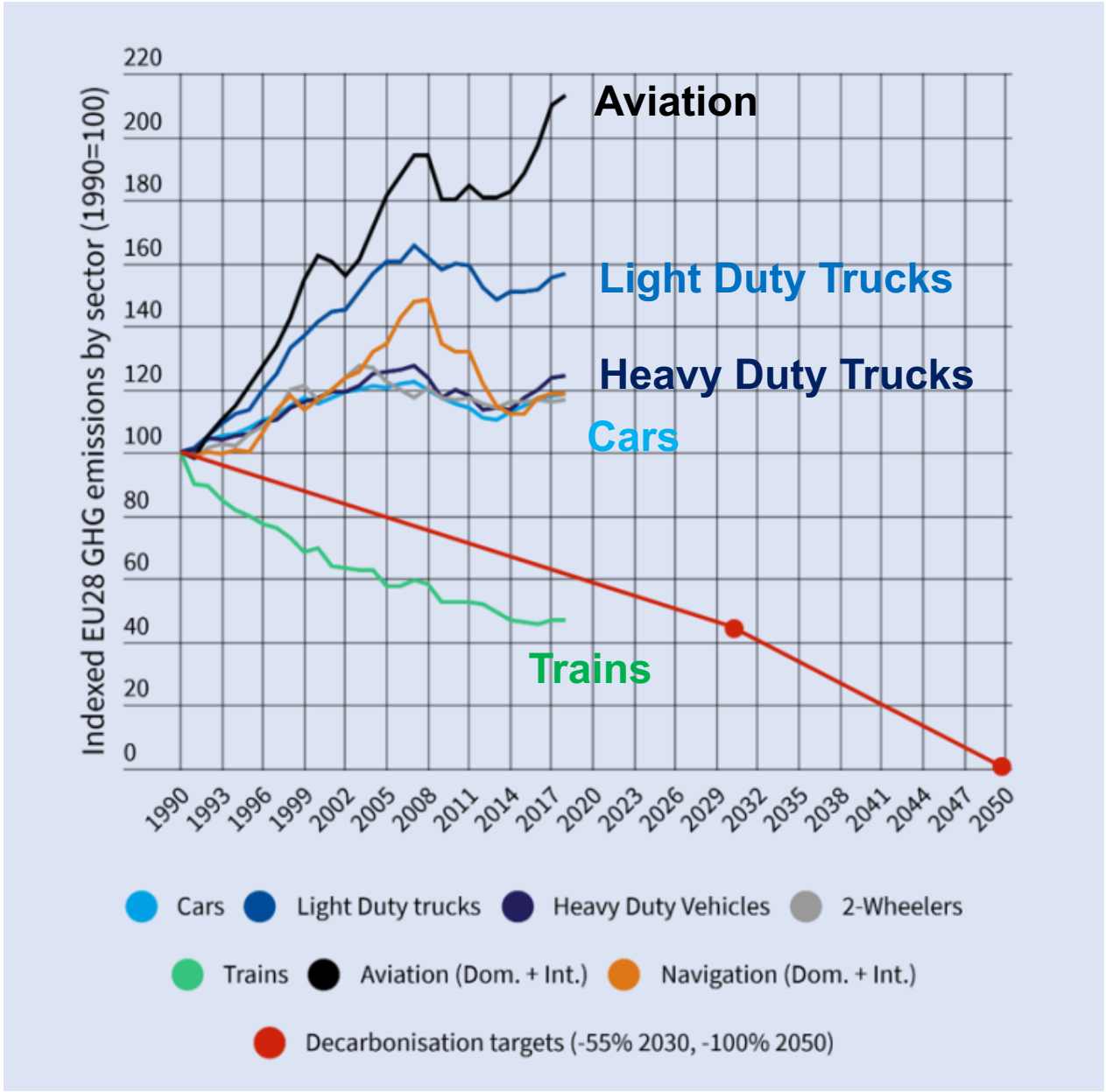
Data from BloombergNEF
https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/

EU Green Deal Agenda for Reducing GHG Emissions from Transport to 2050



https://www.transportenvironment.org/sites/te/files/publications/2020_02_TE_EGD_vision_How_EU_transport_can_contribute_minus_55.pdf

European Union Transport GHG Emissions Trends



EU

Only trains are on track to meeting a 55% reduction in emissions by 2030 compared to 1990.

https://www.transportenvironment.org/sites/te/files/publications/2020_02_TE_EGD_vision_How_EU_transport_can_contribute_minus_55.pdf

Solar Power

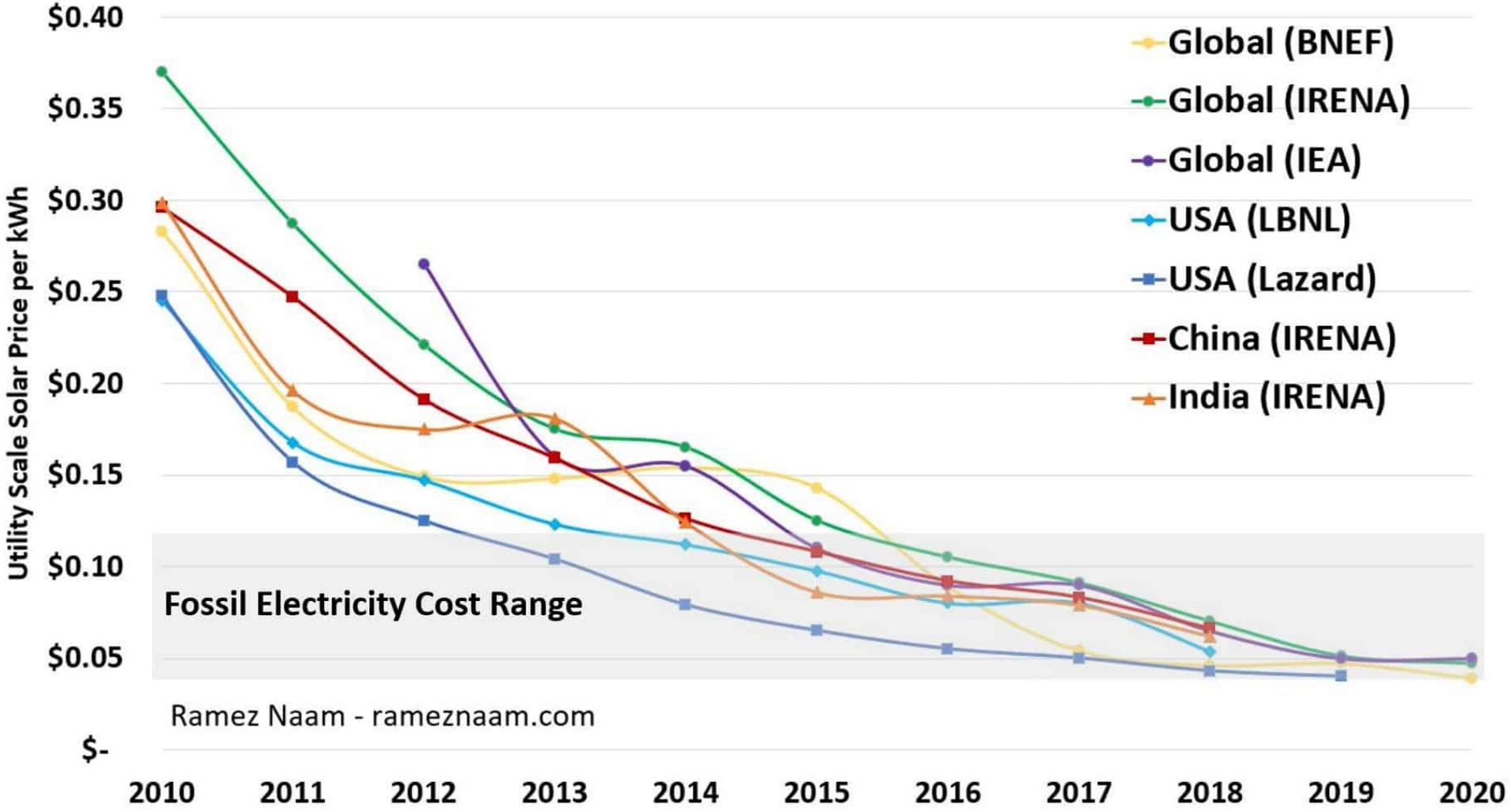
- Solar Photovoltaic - second most mature technology after wind.

Solar Farm

Individual Roof

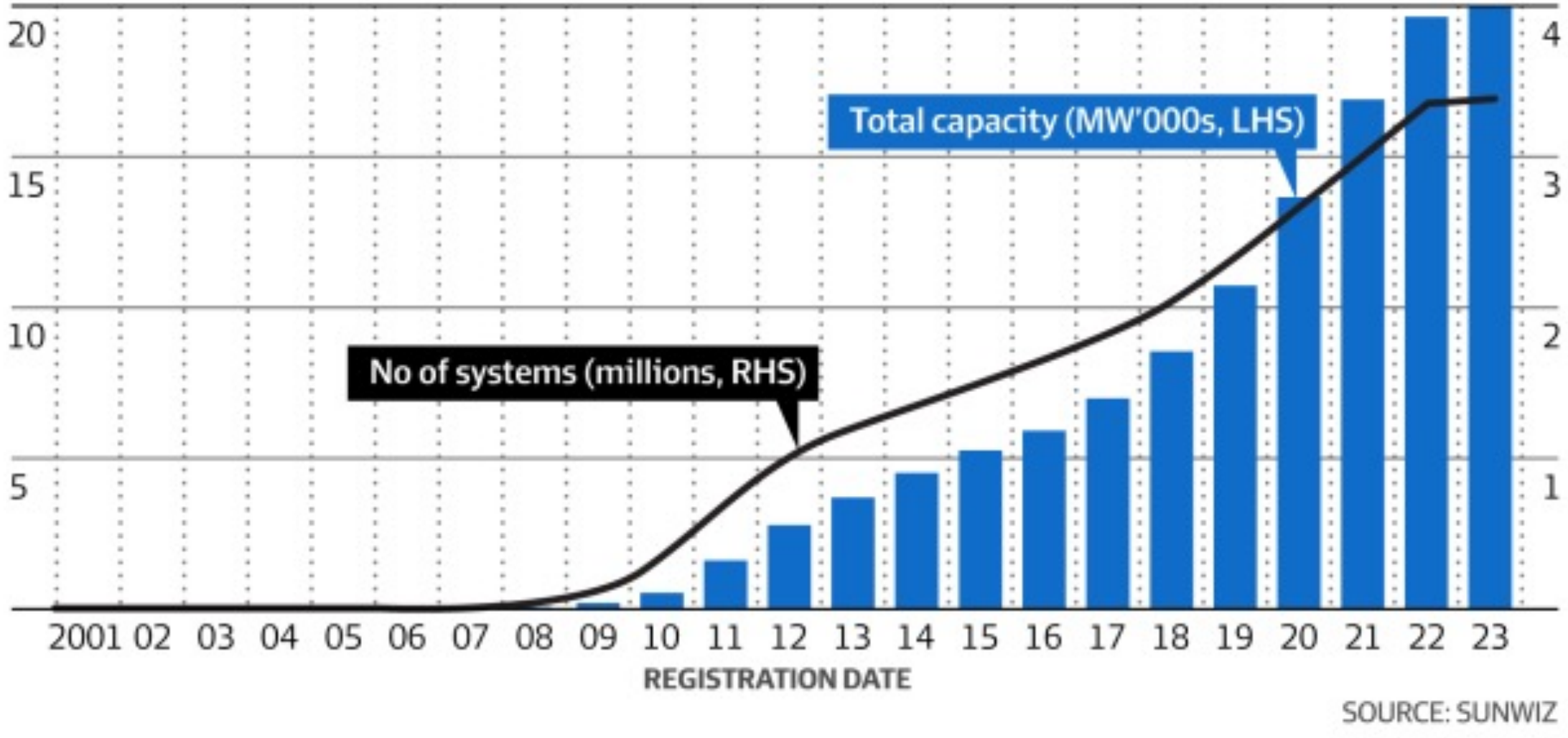
Solar Photovoltaic Electricity Costs / kWh

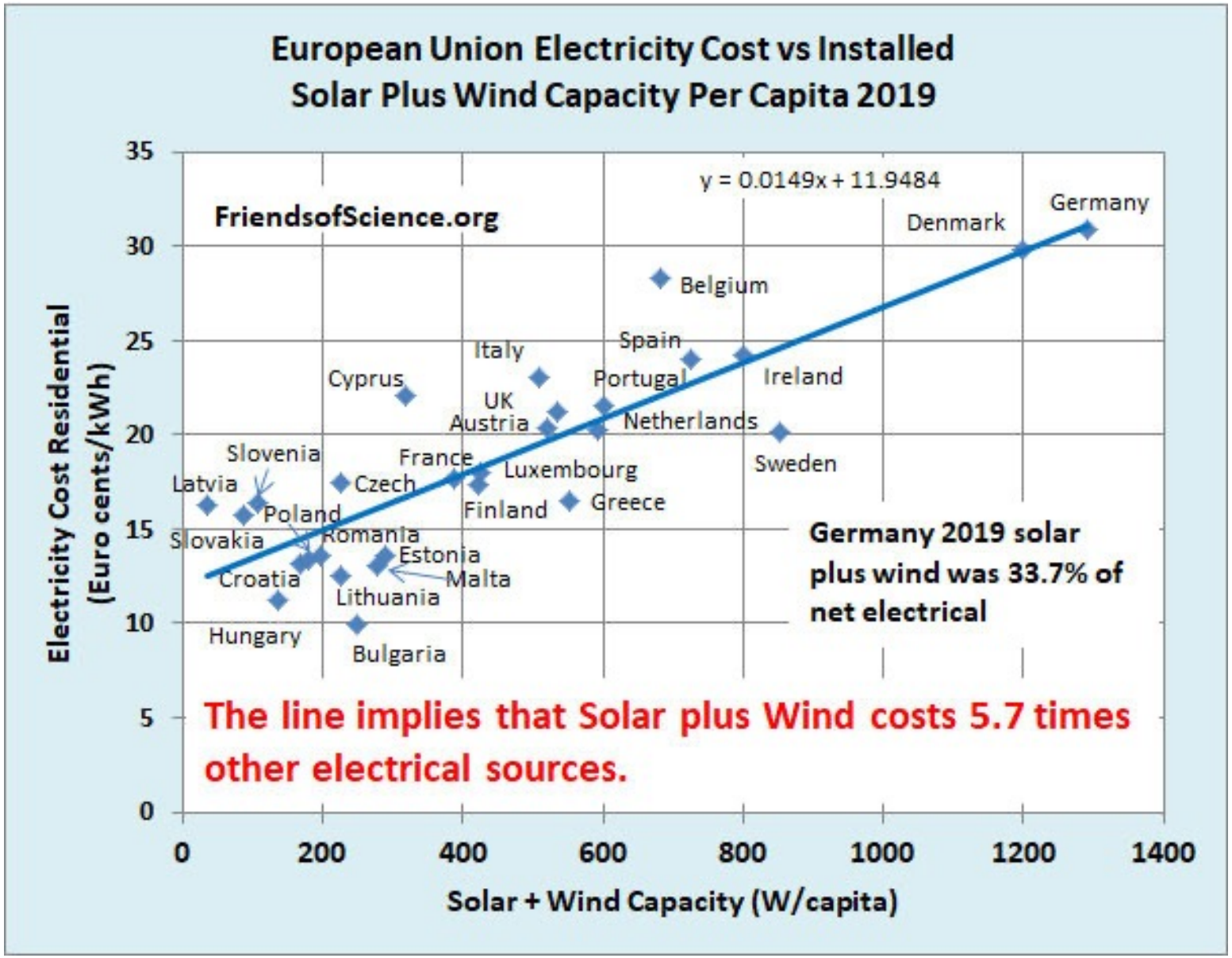
Solar Costs Dropped by a Factor of 5 Since 2010



https://rameznaam.com/wp-content/uploads/2020/05/Solar-Costs-2010-2020-vs-Fossil-Fuel-Cost-Range.jpg

Rooftop solar installations in Australia





https://www.friendsofscience.org/index.php?id=2550

ME in Energy Systems Engineering

Not restricted to renewable energy systems - aims to take a holistic or full-systems view. Includes modules dealing with nuclear power, with fossil fuel extraction, processing, combustion and carbon sequestration and storage.

Inputs to the programme are provided from UCD Schools of;

1. **Mechanical & Materials Engineering**
2. **Electrical & Electronic Engineering**
3. **Chemical & Bioprocess Engineering**
4. **Earth (Geological) Sciences**
5. **Civil Engineering**
6. **Biosystems & Food Engineering**
7. **Physics**
8. **Economics**
9. **Business**

ME Energy Systems Engineering FT (T164)

Educational Background Required

Incoming students should have a strong understanding of fundamental principles in the discipline of their “First Cycle” degree, typically in Mechanical, Electrical / Electronic or Chemical engineering, or in a strongly mathematical science-based discipline.

Participation in this programme ensures that they broaden their education to develop a grasp of fundamental principles from across a range of other disciplines in order to equip them to tackle the complex multi-disciplinary and often conflicting issues that arise in the search for effective solutions to the energy challenges facing mankind.

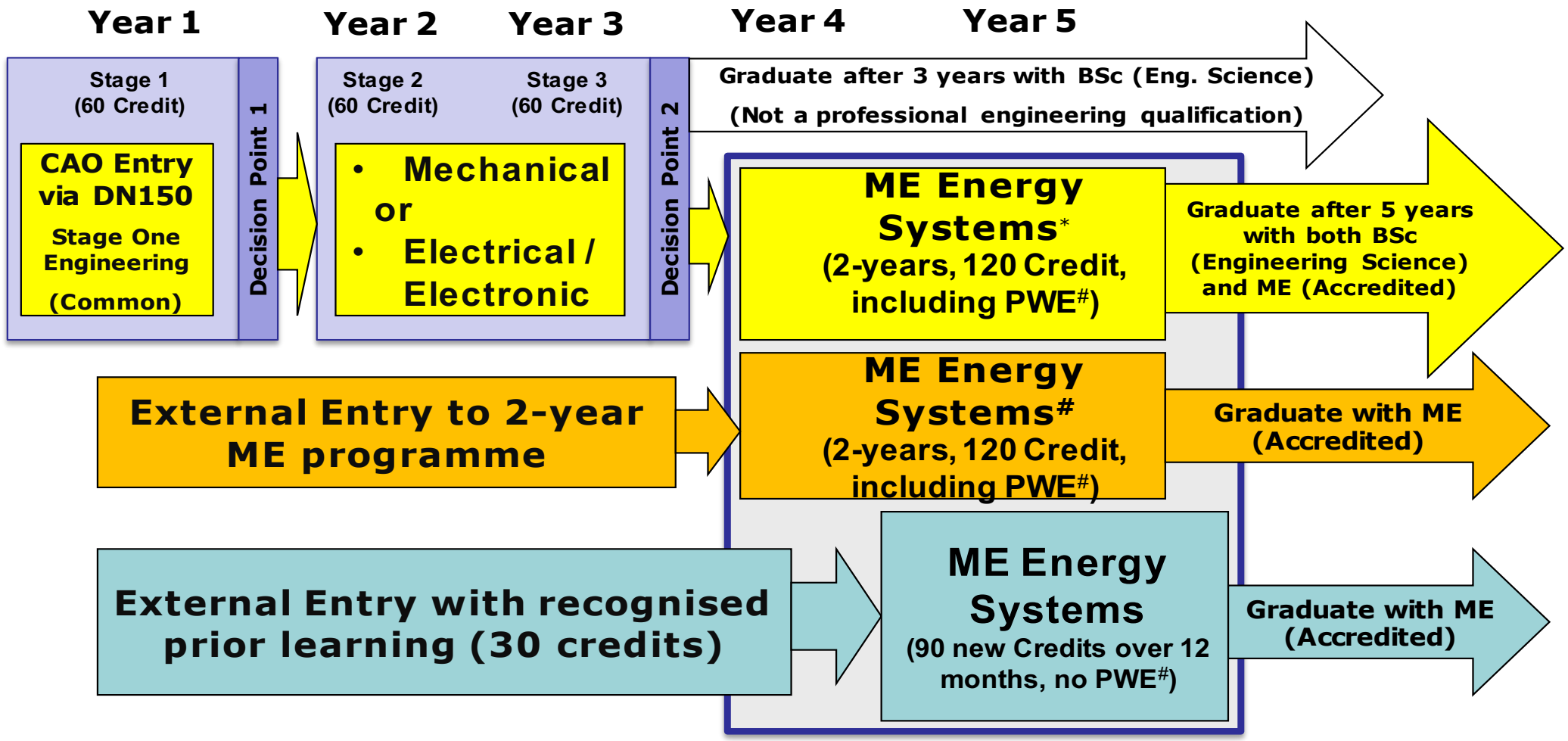
ME in Energy Systems Engineering (Master of Engineering Degree)

- A 2-year 120 ECTS Credit programme built on 3 or 4 years of foundation studies in a traditional engineering specialisation, normally based on either
  - **Mechanical Engineering,**

    or
  - **Electronic & Electrical Engineering.**

- Includes a 6-8 month industry-based "Professional Work Experience" (Internship) programme from January to September, taken after completion of Autumn Trimester in Year One.

ME (Energy Systems) Pathways



Minimum GPA = 2.80 required for entry

#PWE = Professional Work Experience (10 or 30 credits), taken during the penultimate year.

ME (Energy Systems) Engineering

- **Core** Modules (after Stage 3)
  - Energy Systems & Climate Change
  - *Eng. Thermodynamics II*
  - Fossil fuels, carbon capture and storage
  - Chemical Processes in Sust. & Renewable Energy
  - Energy Systems in Buildings
  - Power System Operation*
  - Renewable Energy Systems (Wind & Solar)
  - Research Skills & Tech.
  - ME Research Project (20 credits)
  - Professional Eng. (Mgt.)
  - Work Placement (30 credits)
- + 5 option modules

- **Option** Modules
  - Energy in Transport
  - Eng. Thermodynamics III
  - Mechanics of Fluids II & III
  - CCM I & II
  - Process Control
  - Environmental Eng. Fundamentals
  - Air Pollution
  - Technical Communication
  - Entrepreneurship in Action
  - Entrepreneurship in Engineering
  - Energy Economics & Policy
  - Nuclear Physics
  - Optimisation Techniques for Engineers
  - **Data science for Engineers (NEW 2023 onwards)**

. . .

*the equivalent of EEEN30070 Power System Engineering), is strongly recommended but is not essential.

ME (Energy Systems) Engineering

Work Placement Employers

- ESB International
- CES Energy, Dublin
- Energia
- Eirgrid
- Mainstream Renewable Power
- Enernoc
- Endeco Technologies / GridBeyond
- Electroroute
- Supernode
- RPS Group, Dun Laoghaire
- Arup, Dublin
- Aecom
- Murex Advanced Technologies
- Dublin Port Company
- Irish Water (Úisce Éireann)
- Jones Engineering
- Fingleton White
- Glanbia
- Meinhardt (UK) Ltd.
- Dennison Trailers
- Precision Heating, Dublin
- Accenture, Dublin
- T.E. Laboratories, Carlow
- IBM Smarter Cities Technology Center, Mulhuddart
- Lawrence Berkeley National Laboratory, Berkeley, USA
- Glen Dimplex, Dunleer, Co. Louth
- Fehily-Timoney Consultants, Cork
- Isle of Man Power Company
- AbbVie Pharmaceuticals
- Integrated Environmental Solutions, Dublin
- Veolia
- Eaton Corporation
- PM Group

New agreement pending to formalise relationships between this programme and the UCD Energy Institute & associated industry partners

ME (Energy Systems)
Numbers Graduating: 2010 to 2023

Year	Total No. Graduating	No. UCD “3+2” Grads
2010	27	0
2011	30	0
2012	21	1
2013	21	1
2014	15	2
2015	21	1
2016	14	4
2017	17	11
2018	30	24
2019	10	8
2020	22	21
2021	13	12
2022	22	21
2023	15	14
TOTALS:	**256**	**99**

ME (Energy Systems) Graduates

Jonathan Ruddy (2013), Greenlink Interconnector Technology Manager | HVDC | Offshore Wind | Renewables Integration

David Foley (2020), Trader in European short-term power markets at ElectroRoute, London.

Noel Cunniffe (2012) CEO at Wind Energy Ireland

Mussa Alamri (2013), Industrial Energy Engineer at Aramco, Saudi Arabia

ME (Energy Systems) Graduates

Síofra Herr (2020) , Solar Array and Battery Engineer, SpaceX, Seattle

Nessa McNamara (2020) , Power Systems Engineer, Eirgrid, Dublin,

James Egan (2015) , Senior Financial Software Consultant at Murex, Dublin

Johnny Cochrane (2012) Engineering Professional in Energy Storage and Sustainability I Technical Project Manager at EKU Energy, London

ME (Energy Systems) Graduates

Brónagh Sherlock (2013), Energy Management Systems Specialist at Irish Water, Dublin

Ed Healy (2013), Technical Program Manager at Google - Environmental Compliance (Data Centers), Dublin

Mostafa Bakhtvar, Ph.D. (2012), Expert in Power System Technical Studies and Automation, Eirgrid, Dublin

Olivier Neu PhD (2011), Senior Research Consultant (Product Innovation Team), IES Ltd, Dublin

Thank you.

Any questions?