Sustainability and Energy Management

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Contents

BRIEF HISTORY OF POWER GENERATION

Brief history of power generation

Steam Engines

- 1680-1698: early steam engines by Denis Popin & Thomas Savery.
- 1712: Thomas Newcomen's first practical atmospheric steam engine.
- 1776: James Watt's separate condenser atmospheric engine.
- 1801: Richard Trevithick's high pressure steam engine.
- 1884: Charles Parson's steam turbine.

Combustion Engines

- 1860: Etienne Lenoir constructed the first usable gas engine.
- 1876: Nicolaus Otto 4-cycle Internal combustion engines.
- 1892: Hornsby runs first compression ignition engine.
- 1897: Rudolf Diesel files the first compression ignition engine patent.

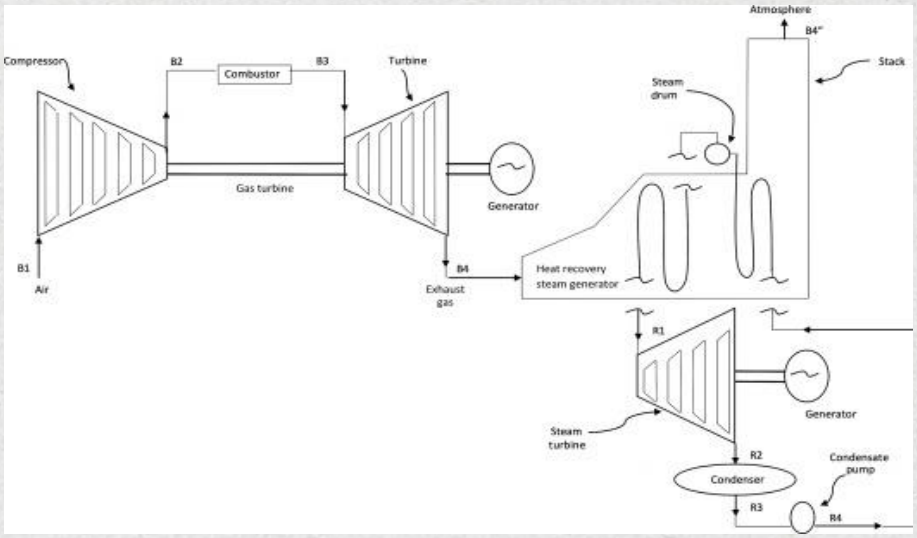
Gas turbines

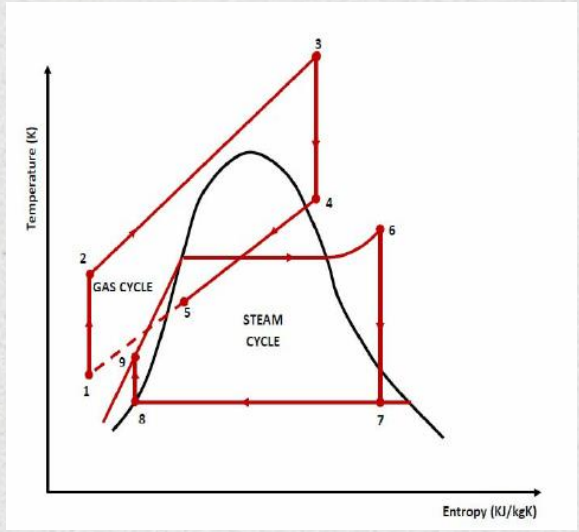
- 1791: John Barber patented the first gas turbine engine.
- 1872: Dr. F. Stolze designed the first proof of concept gas turbine.
- 1903: Aegidius Elling built the first running gas turbine engine.
- 1930-37: Frank Whittle patents and runs the first self-powered gas turbine engine.
- 1939: Hans Ohain's jet engine is the first to fly in the Heinkel 178.
- 1939: Brown Boveri & CIE, first utility power generation turbine.

https://www.deutsches-museum.de/en/collections/machines/power-engines/
https://www.aviationpros.com/engines-components/aircraft-engines/turbine-engines-parts/article/10383708/turbine-engine-history
https://www.Wikipedia.org

Open cycle power plant and combined cycle

- Rankine Cycle: Large steam turbine efficiency is 30-40%.
- Brayton Cycle: Open or simple cycle Gas Turbines efficiency is 35% - 40%.
- A combined cycle power plant combines both cycles to reach efficiencies of 60%





Combined cycle gas turbine generator.

https://www.sciencedirect.com/science/article/pii/B9780081019405000026

https://www.researchgate.net/figure/Temperature-Entropy-Diagram-for-Combined-Cycle-Power-Plant_fig2_281321697

The oil crisis and the energy revolution

- 1973: Major changes in global oil markets:
  - Arab members of OPEC raise oil prices by 70%
  - Restricted production.
  - Impact: Oil prices almost quadrupled to over $12 a barrel
  - Western energy crisis marked the end of the era of very cheap energy.
- Result: US Department of Energy starts Residential Conservation Service:
  - Promoted energy audits.
  - Asked consumers to weatherize their homes.
  - Promoted conservation behaviors amongst consumers.
  - Some states offered a price per kWh paid for verified energy savings.
  - In 1977 launched the Solar Energy Research Institute in Colorado.
- Result: UK Government creates the Department of Energy:
  - Launches Industrial Energy Thrift Scheme to gather information on energy use and advise on how to improve energy efficiency on site.
  - Scheme visits >6000 sites during the mid to late 1970s Energy efficiency data aggregated and published in industry sector guides.

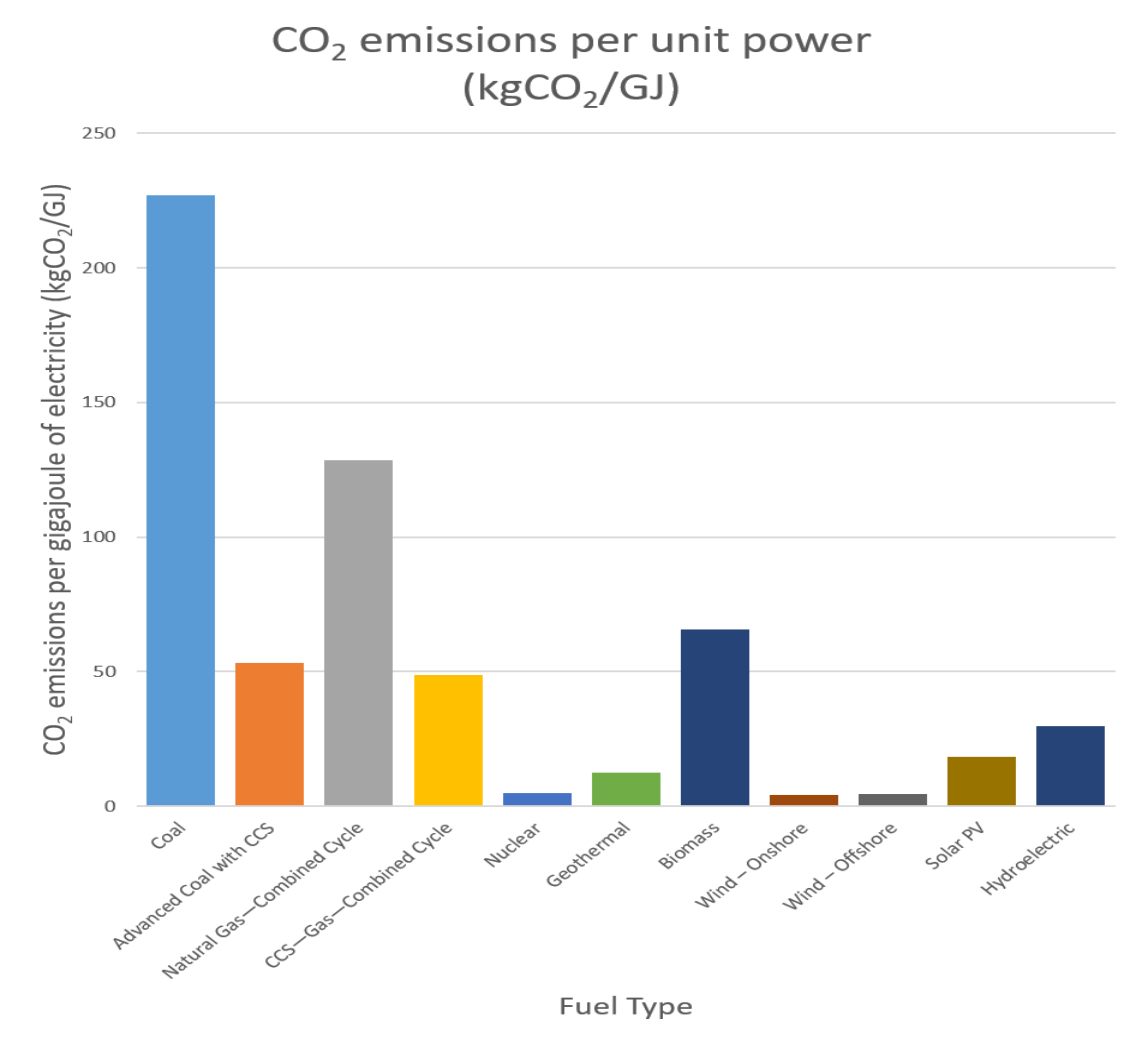
https://www.resilience.org/stories/2019-04-17/from-oil-crisis-to-energy-revolution-how-nations-once-before-planned-to-kick-the-oil-habit/

Cost comparison of energy sources in 2019

Power Plant Type	Levelised Cost $/KWh
Coal with CCS	$0.12-0.13
Solar Thermal	$0.165
Wind offshore	$0.106
Nuclear	$0.093
Biomass	$0.092
CC Natural gas with CCS	$0.075
CC Natural gas	$0.043
Hydro	$0.039
Wind onshore	$0.037
Geothermal	$0.037
Solar PV	$0.038

Adapted from US DOE http://www.renewable-energysources.com/

CO_2 emissions per unit of power



http://large.stanford.edu/courses/2016/ph240/kountz1/

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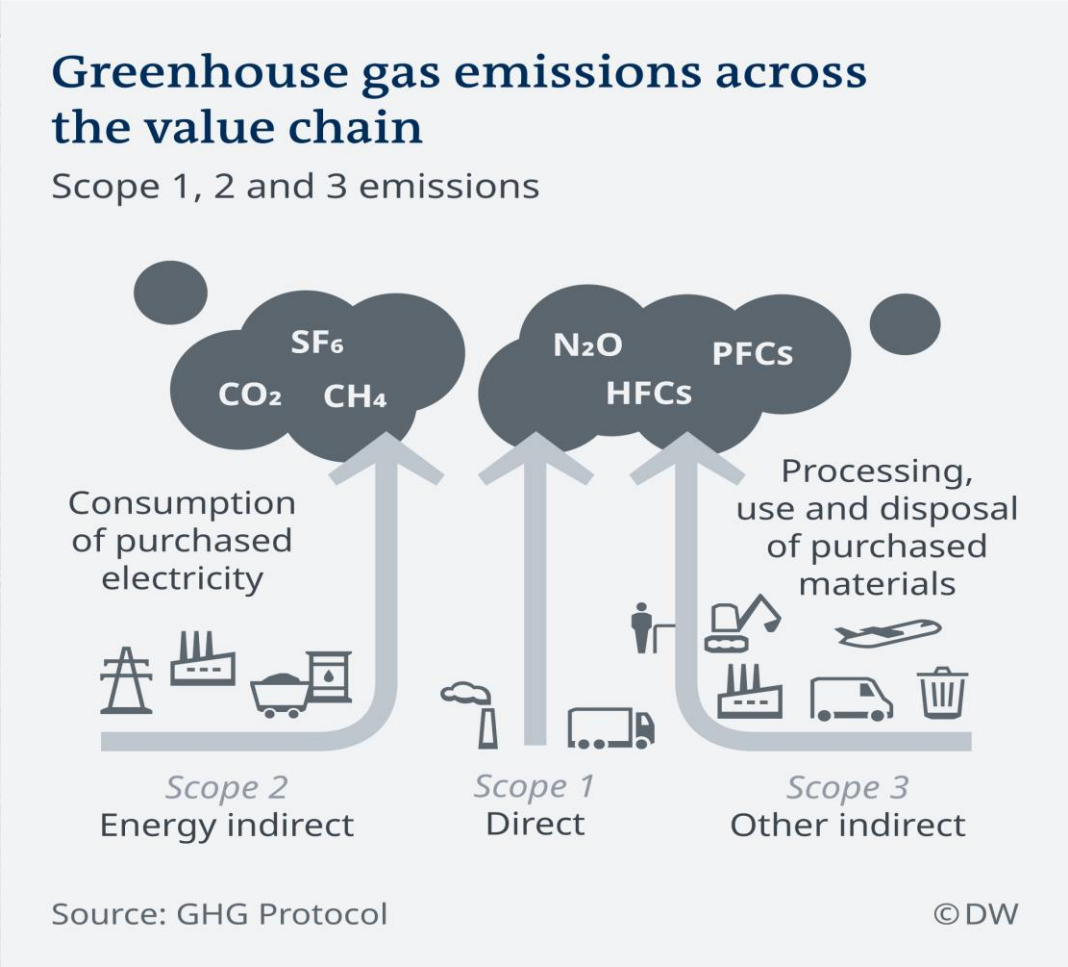
CLIMATE CHANGE DRIVERS

Greenhouse gas emissions by scope

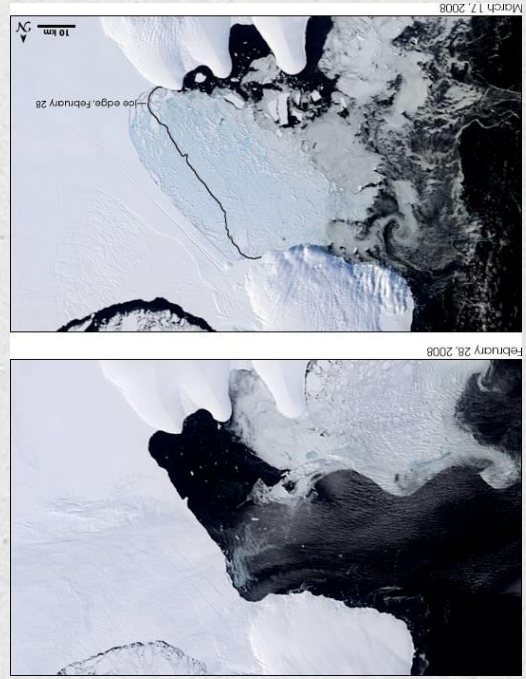


Why worry about climate change?

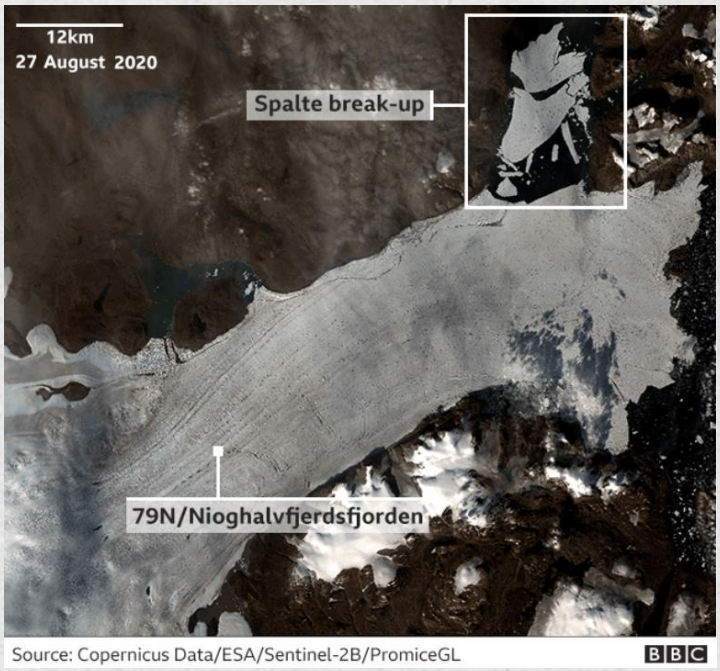
- Scientific consensus strengthening at the pessimistic end of predictions.
- Increased political and grass roots engagement and activism.
- Several factors interact to generate the perfect storm:
  - Fears over the effects of runaway climate change.
  - Ongoing degradation in carrying capacity of land.
  - Increased competition for water and land.
  - Competition for access to low cost resources.
  - Concerns over a growing population.
  - Increasing resource demand per capita.

Ice shelves collapsing

Wilkins ice shelf collapse
Feb 2008

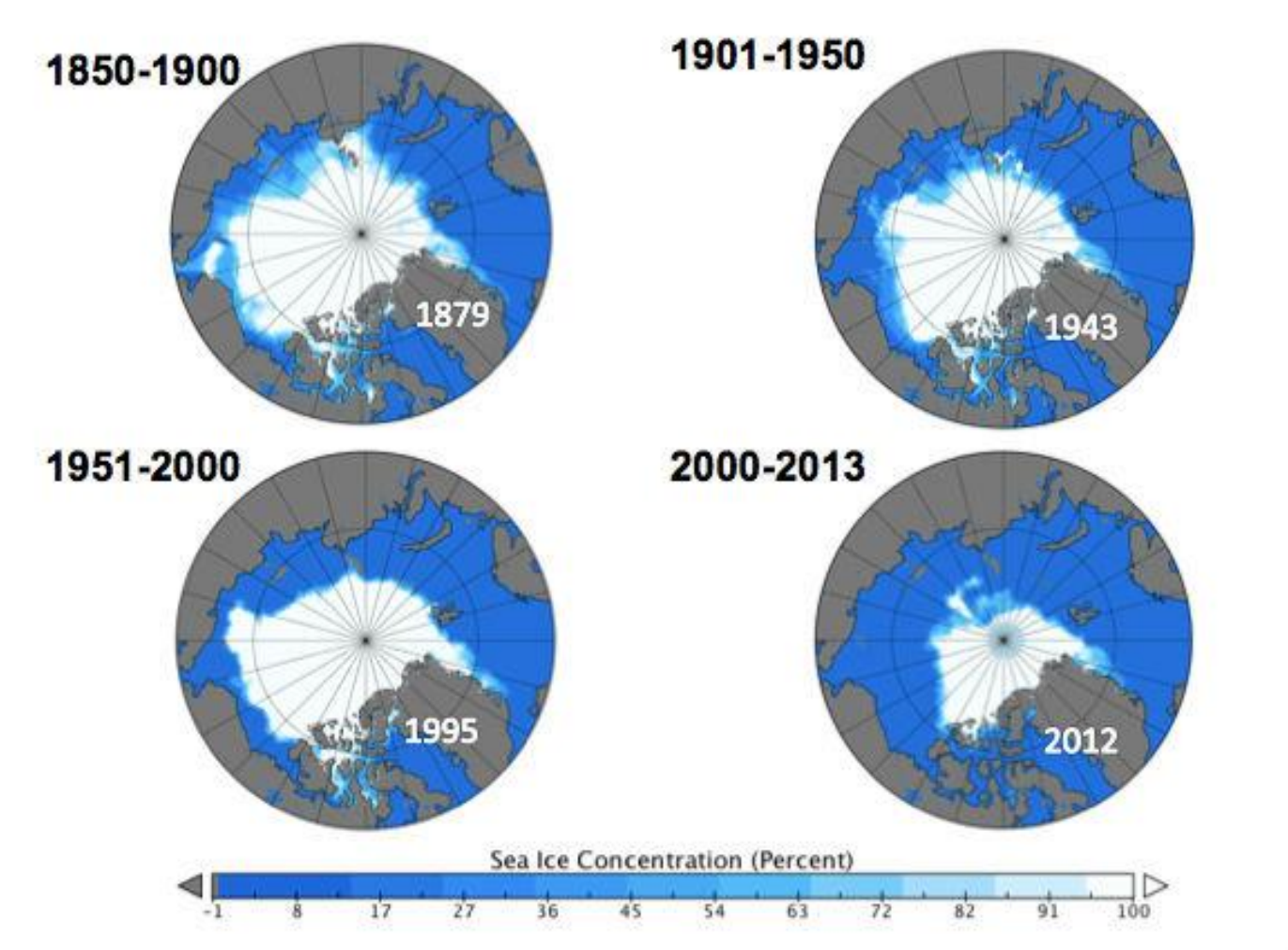


Spalte Glacier, Greenland
Sept 2020



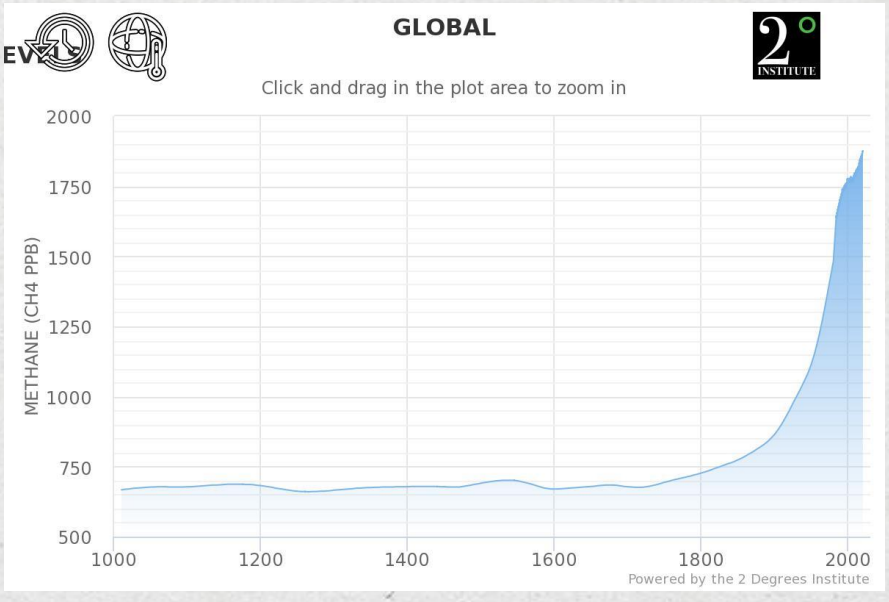
NASA Earth Observatory, 2008
BBC, 2020

Arctic sea ice history from 1850



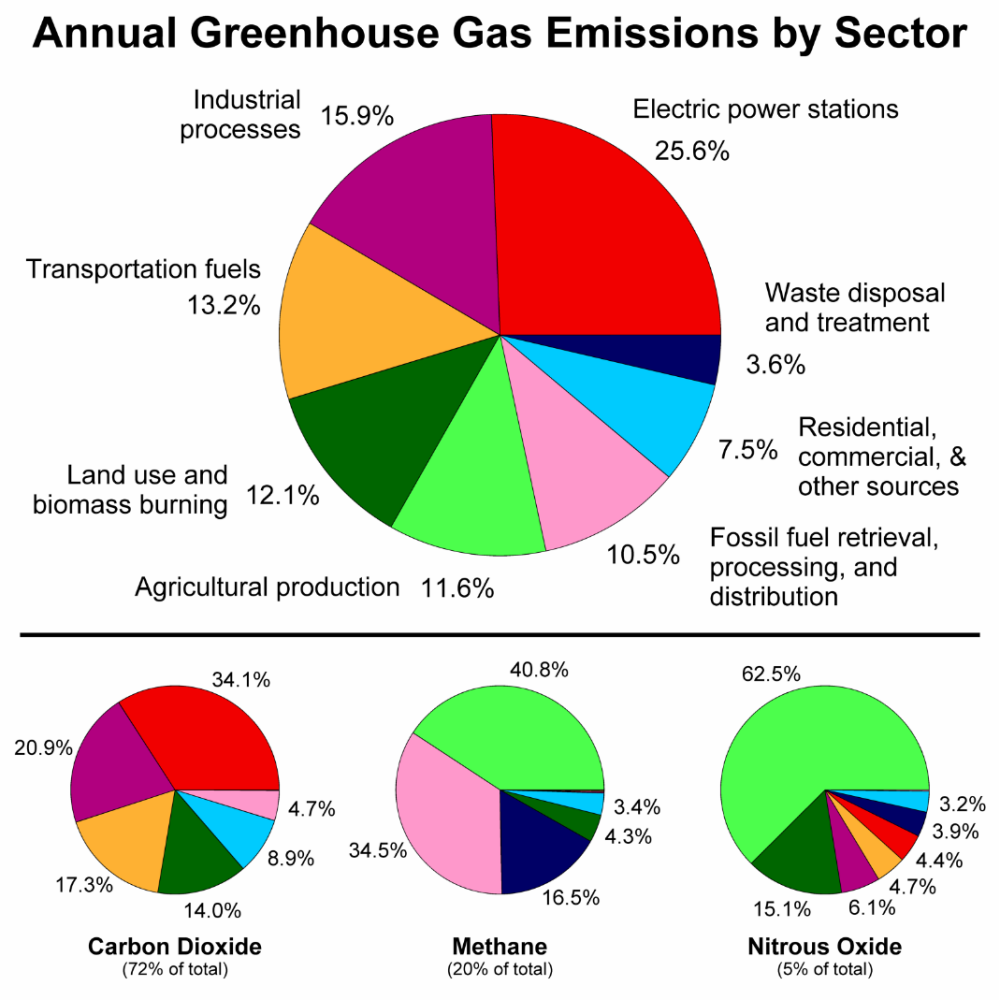
https://www.carbonbrief.org/guest-post-piecing-together-arctic-sea-ice-history-1850

Annual emissions over time



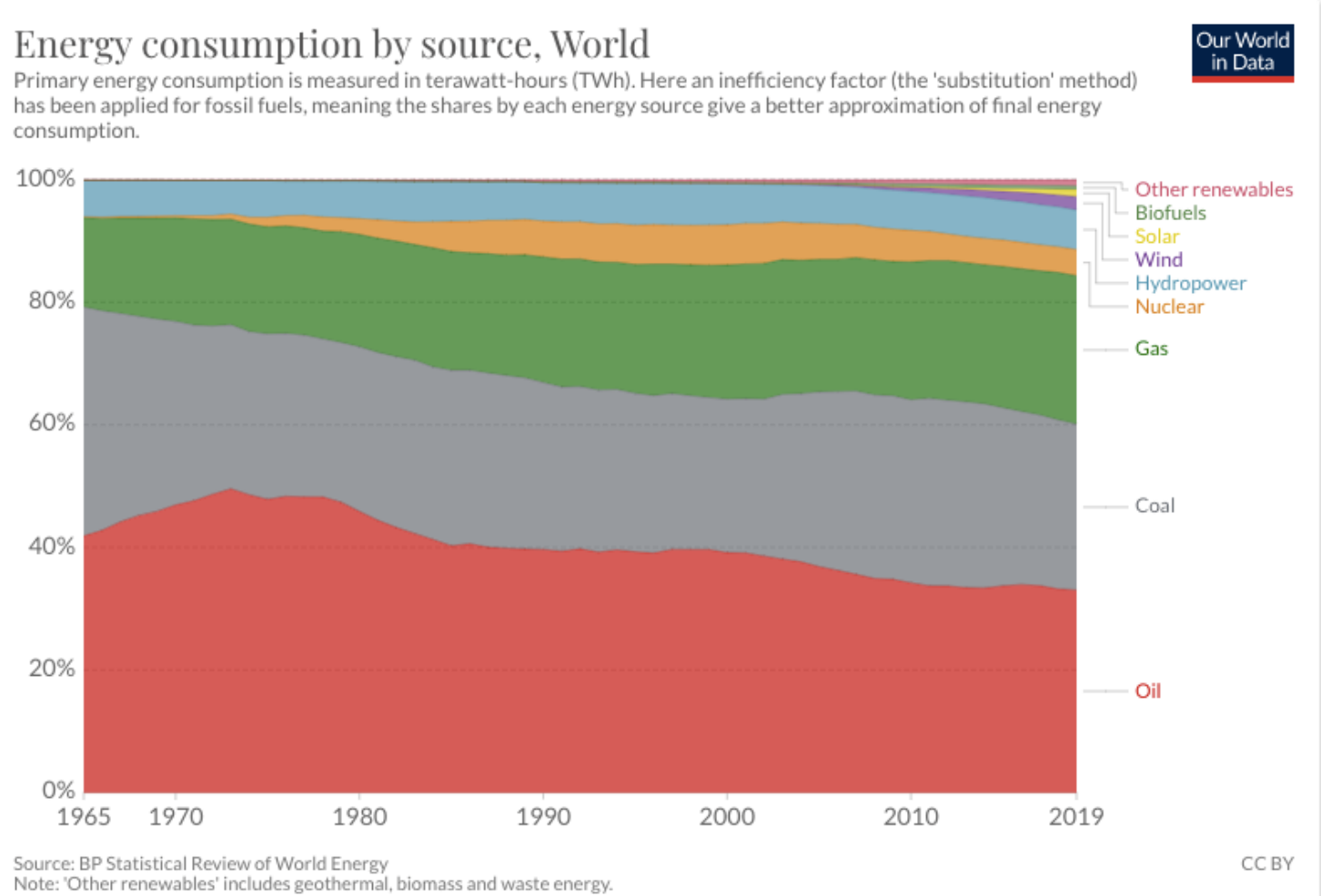
https://www.methanelevels.org/
https://www.co2levels.org/

Relative emissions by global sector



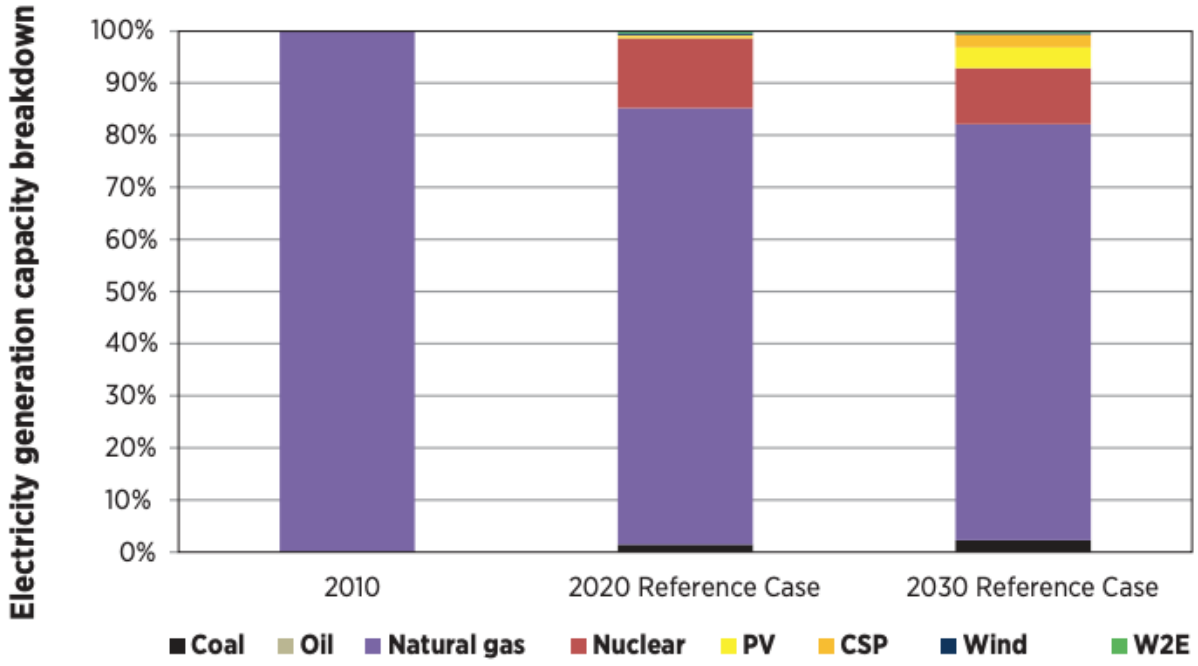
https://commons.wikimedia.org/wiki/File:Greenhouse_Gas_by_Sector.png

Energy consumption by source



UAE electricity generation capacity

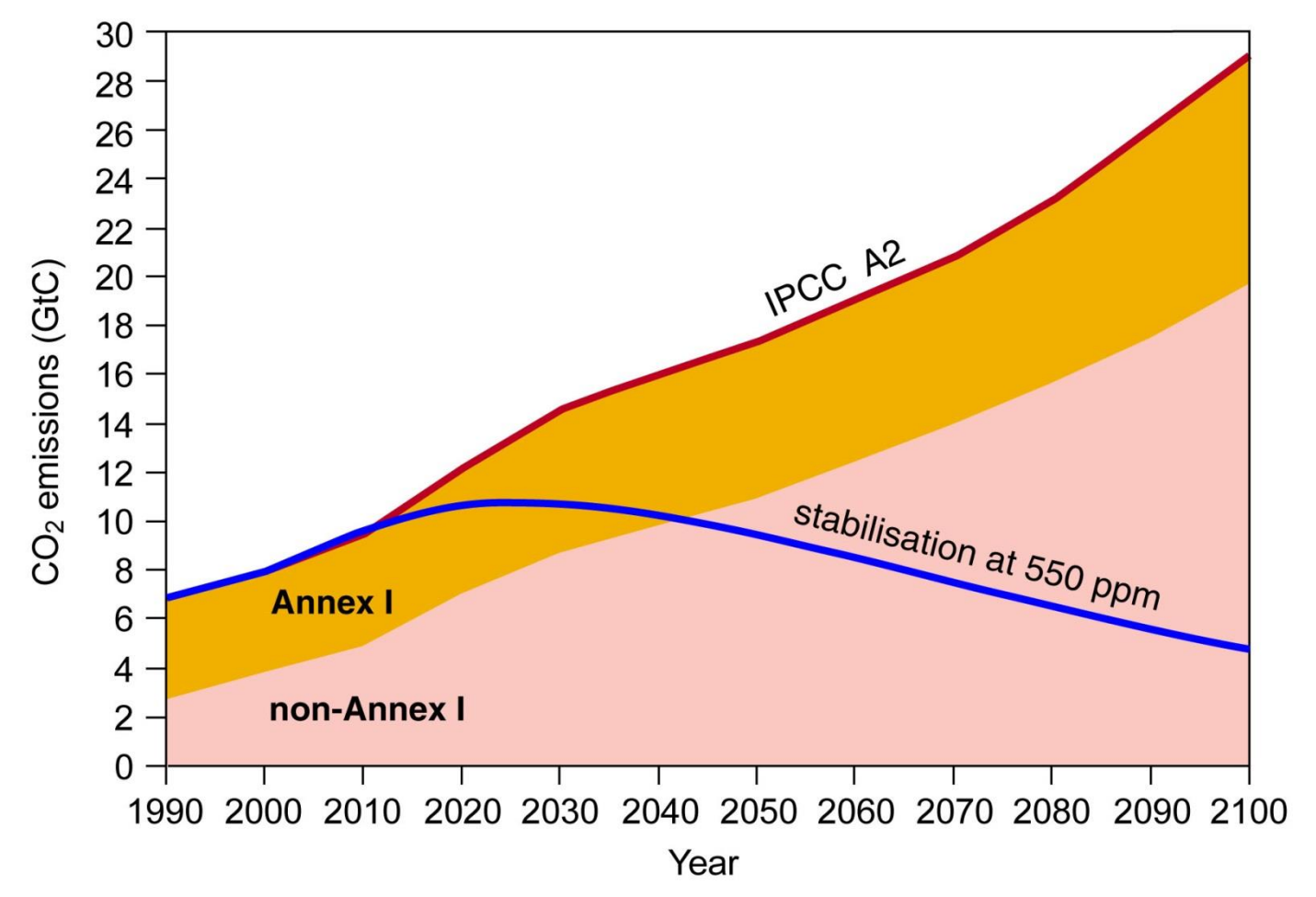
Figure 5: Breakdown of electricity generation capacity in the Reference Case, 2010-2030



Note: W2E, Waste-to-Energy by producing electricity through municipal waste or landfill gas utilisation.

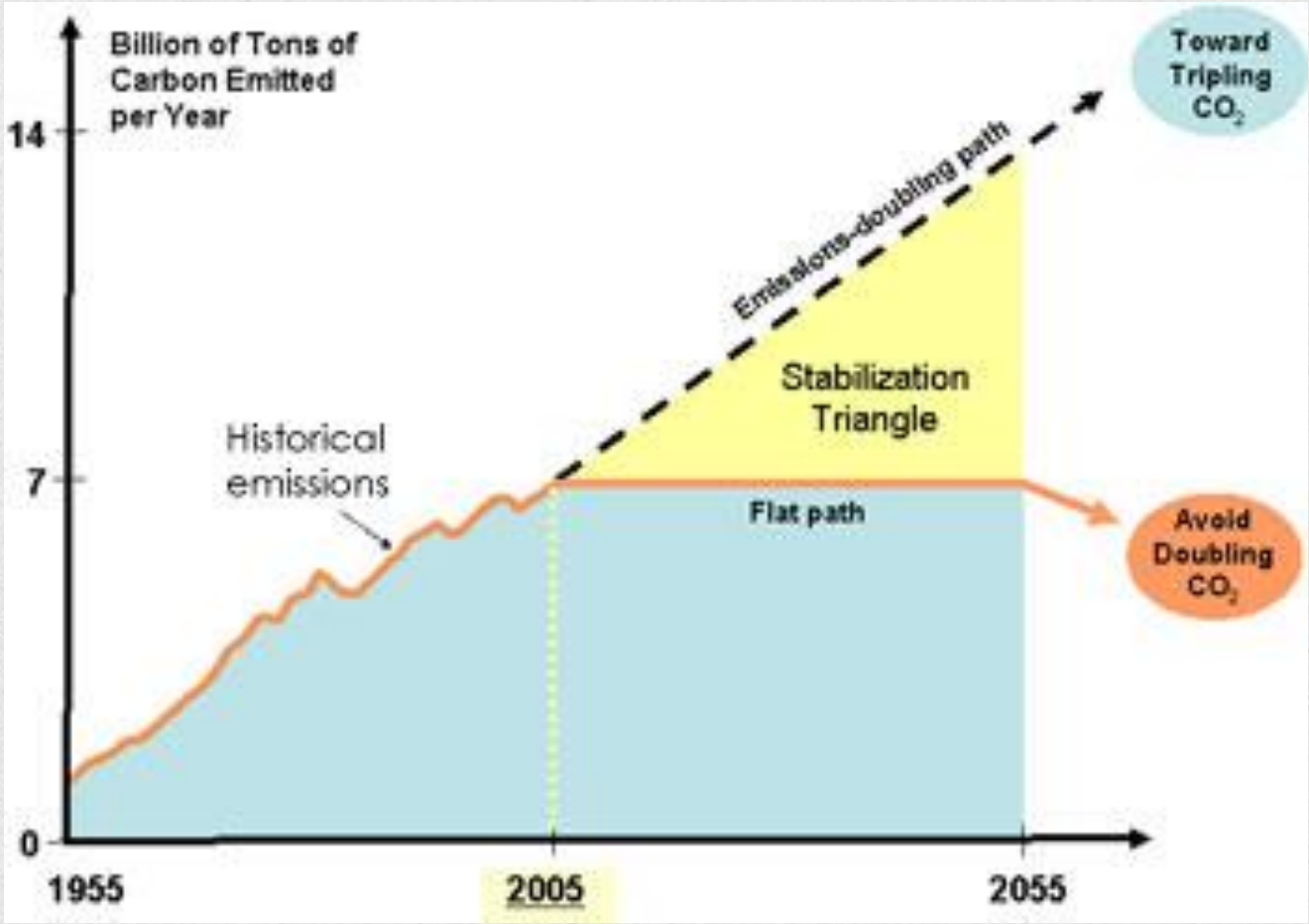
https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2015/IRENA_REmap_UAE_report_2015.pdf

Turning around the emissions curve



Business as usual emissions and IPCC emissions trajectory *Intergovernmental Panel on Climate Change*

Turning the curve through stabilisation wedges



Pacala and Socolow, Science 305(5686), P968-72, September 2004

Stabilisation wedges – manageable bites

Pacala and Socolow, Science 305(5686), P968-72, September 2004

The Kyoto Protocol and The Paris Agreement

1. Kyoto Protocol (1997): encouraging industrial-based countries to reduce and mitigate greenhouse gases (GHG) emissions. The protocol itself asks the participating countries to start deploying tools to measure and control their emissions.

2. Paris Agreement (2015): States a specific target to keep global warming below 2°C. The involved countries in the agreement are obliged to state their own emissions reduction targets, and every five years, a follow-up review is to take place to enhance and empower climate change mitigation strategies.

https://www.myclimate.org/information/faq/faq-detail/what-are-the-kyoto-protocol-and-the-paris-agreement/

Who is affected by climate treaties

- Kyoto Annex I Parties with targets: Australia , Austria, Belgium, Bulgaria, Canada (withdrew), Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom, United States (did not ratify)

- Paris Annex 1 Parties with targets: Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Cyprus, Czechia, Denmark, Estonia, European Union, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland, United States of America.

https://www.myclimate.org/information/faq/faq-detail/what-are-the-kyoto-protocol-and-the-paris-agreement/

The UAE and the Paris Agreement

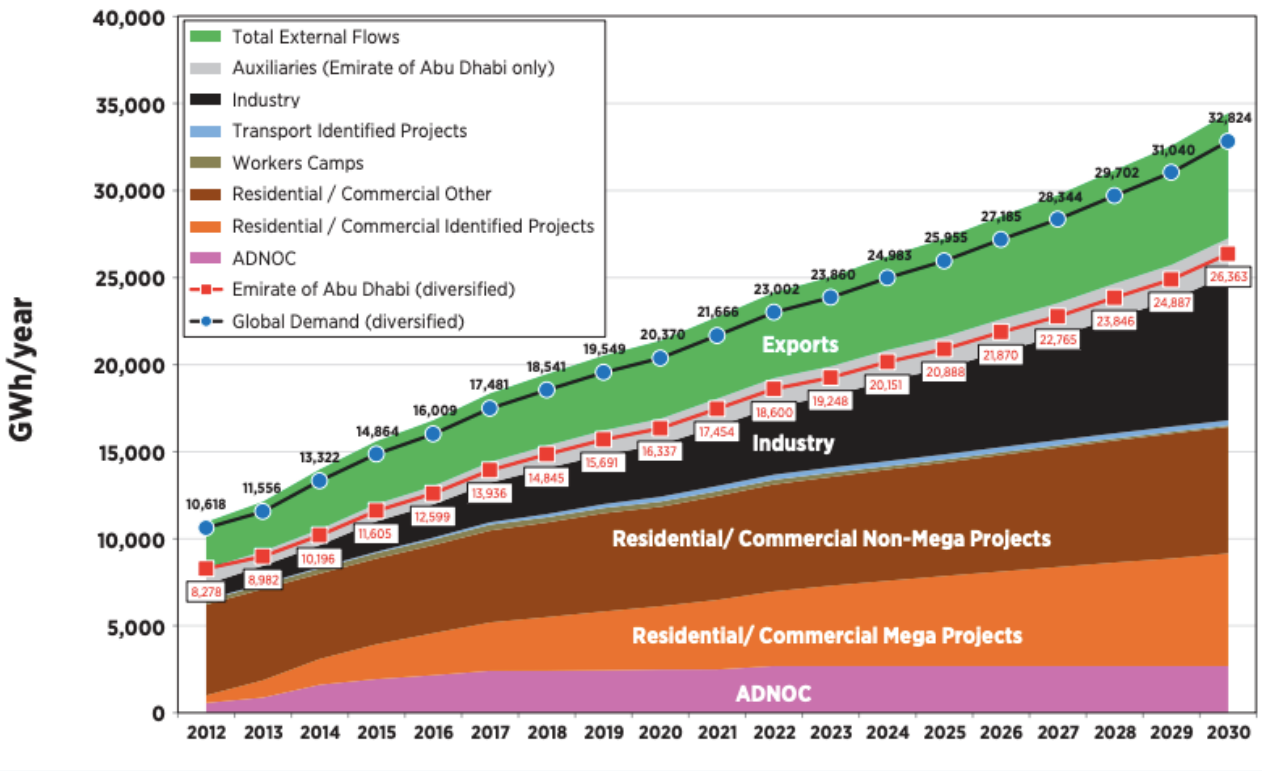
- The UAE was one of the first countries in the region to ratify the Paris Agreement in September 2016.
- In order to control the effects of climate change, the UAE is controlling emissions, reducing flaring of natural gas & increasing energy efficiency.
- Started new energy strategy, which involves the nuclear power and solar energy in addition to natural gas, which covers the majority of the UAE's needs.
- The International Renewable Energy Agency (IRENA) opened its permanent headquarters in Abu Dhabi's Masdar City in June 2015.
- Developing a major Carbon capture and storage (CCS) project in Abu Dhabi.

https://u.ae/en/information-and-services/environment-and-energy/climate change/theuaesresponsetoclimatechange

WHY FOCUS ON INDUSTRY?

UAE manufacturing increasing in profile

Figure 4: Breakdown of energy demand forecasts for Abu Dhabi emirate, including exports to other emirates



Source: ADWEC (2012)

Note: Abu Dhabi profile used as basis for extrapolation to the rest of the UAE.

The industrial win-win for Abu Dhabi

High level national reputational benefit: The UAE may be able to seize the whole-system benefits of resource efficiency that some stakeholders feel is a major missed opportunity in other nations

- Industrial growth is crucial to the future development of the UAE:
  - Added value, reduced risk and improved economic resilience through diversification.
  - Development of high value employment.
  - Reduction in imports and improvement of balance of trade.
- In order to make this growth sustainable industries must:
  - Add the maximum value to the energy and water resources allocated to them.
  - Be economically efficient and competitive.
  - Depend on more local supply chains and economic networks.
  - Have good environmental credentials to qualify for contracts with premium customers.
- The discipline of energy and water efficiency helps industries to focus on:
  1. Reducing costs and become more competitive.
  2. Measuring and reporting their environmental impacts.
  3. Engaging staff and management in environmental efficiency.
  4. Fully understanding, improving and integrating their processes.
  5. Understanding and improving efficiency in their wider supply chains.

ADDC's focus on industry

- Abu Dhabi's industrial sector is the 3rd highest consumer of power, (15,728GWh in 2022).
- Industrial consumption is concentrated on relatively few sites:
  - Around 700 sites, of which around 425 have demand of > 1MW
  - Makes it easier and more cost-effective to drive improvements.
- Could Abu Dhabi's industry be more efficient?
  - The equipment installed tends to be more modern and efficient.
  - Relatively low prices for power and water have disincentivised efficient operations. This can negate the benefit of efficient equipment.
  - Outcome: many sites could save 10-25% of consumption.
- Could industrial efficiency be a win-win for Abu Dhabi?

Is there potential for savings in Abu Dhabi?

- Despite high energy prices in Europe, industry can still make large energy savings:
  - Germany: Energy Networks Programme shows industrial energy savings within 1 year of 10%[1]
  - UK: Buildings could save 14% of energy (3 yr payback), and 39% of energy (7 yr payback)[2].
- AD energy prices almost guarantee that industrial energy efficiency could be improved.
- ADDC surveys show high potential to improve energy efficiency in Abu Dhabi factories.

Activity	Size of site	Savings potential
Light manufacturing	Small-Medium	25%
Paper board	Large	3-4%
Plastics extrusion	Medium	10-15%
Plastics extrusion	Large	20%
Paper tissue	Large	26%
Construction materials	Large	6%
Metals	Large	17%

1: Deutsche Energie Agentur, 2018.
2: The Non-Domestic Energy Services Market, BEIS Research Paper No.16, 2018.

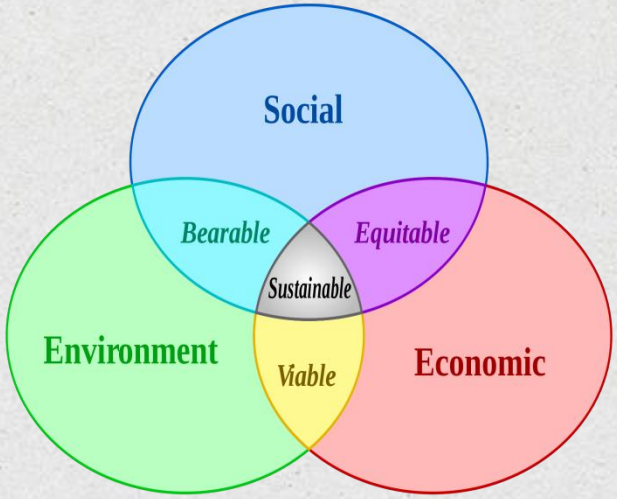
IMPORTANCE OF GOVERNANCE FOR DRIVING INDUSTRIAL SUSTAINABILITY

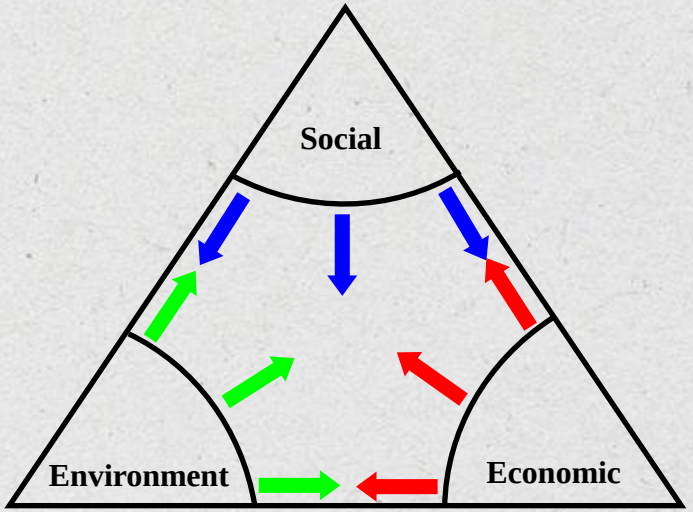
Setting the scene

- Many organisations wish to improve their efficiency, save money and improve their reputation for sustainability.
- Improvement activities must be aligned with the existing strategy and integrated with existing systems.
- Suggestion: start with energy, then broaden to address further resources such as water, waste, packaging and vehicle fuels.

Sustainability – great idea, but what is it?

- Sustainability defined by the UN's report "Our Common Future", 1987, also known as the "Brundtland Report"
- Illustrated by Elkington's 3-circles diagram
- How to operationalise? – ">250 interpretations"
- Trade-offs: perfection not feasible with today's technology





What are the benefits of sustainable operations?

- Organisations can receive a number of tangible and intangible benefits from improving management of natural resources, including energy:
  - Improved cost control.
  - Improved quality.
  - Reduced technical risks.
  - Reduced supply risks.
  - Better understanding of customer needs.
  - Better reputation amongst sensitive customer groups.
  - Better workforce engagement.
  - Better staff recruitment and retention.

What are the barriers to improvement?

- Business pressures:
  - Competition for focus and priority: “I have fires to fight”.
  - Lack of funds.
  - Lack of management resource.
- Skills and knowledge:
  - “We don’t believe in the potential”.
  - “We haven’t got the skills to do this”.
- Bolted horses
  - “If only we’d rented a different building…”.
  - “If only we’d chosen a different process….”.
- External policy drivers:
  - “There’s no proof that this is a problem anyway”.
  - “This isn’t going to happen now”.
- Low engagement:
  - Inertia: “Why should I change?”.
  - Lack of buy-in to corporate goals: “I don’t care anyway”.
- Barriers crystallise in any number of ways:
  - Can’t make meeting, won’t reply, Slow response.
  - Under resourcing.
  - Poor quality information.

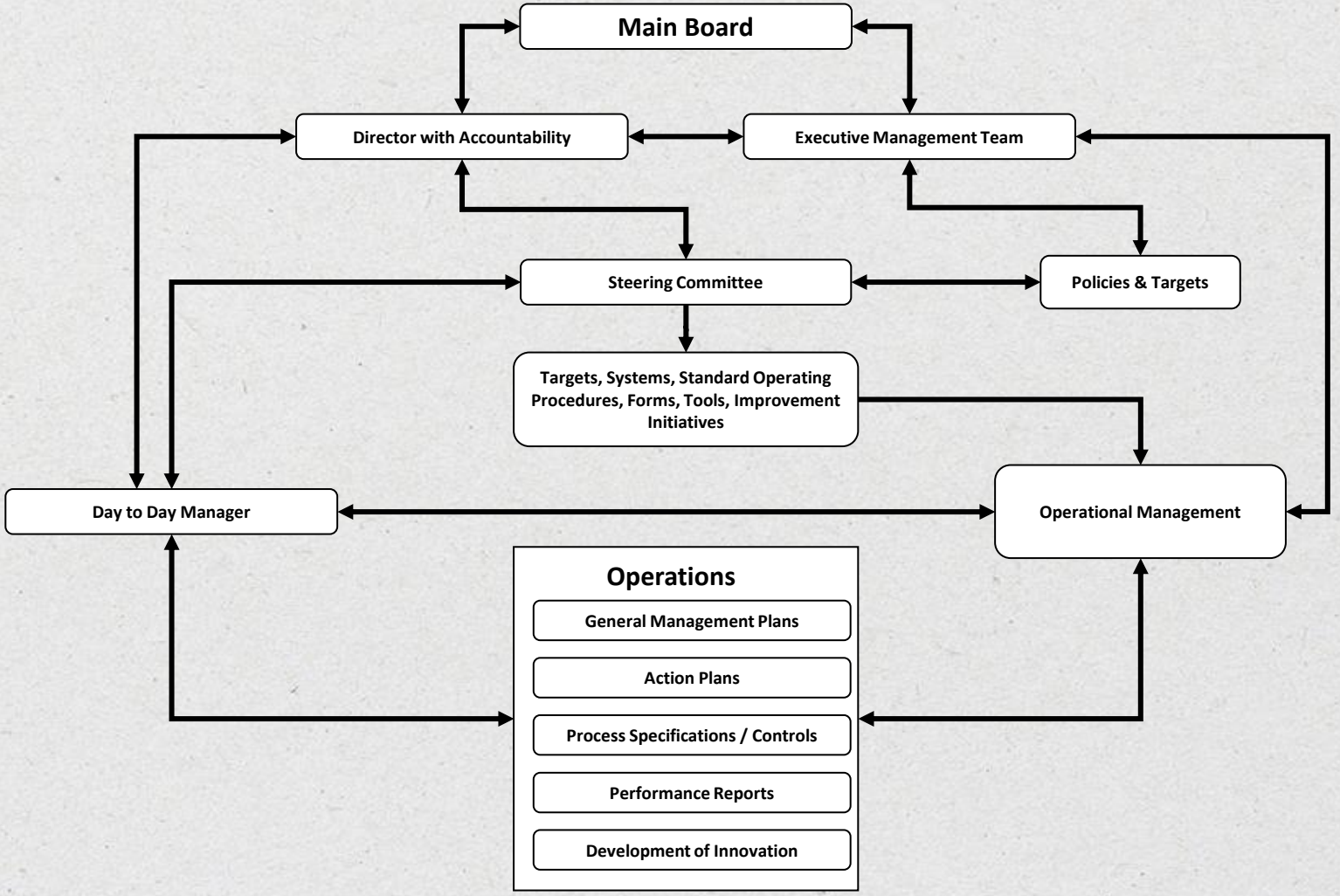
Why is governance important?

- Efficiency improvement requires senior level control to govern the process.
- This ensures that improvement measures do not risk the integrity of the manufacturing process, and that “Fear factors” do not kill off options that have low risks.
- The same system can be used to drive savings in multiple categories, including energy, water, packaging, waste etc.

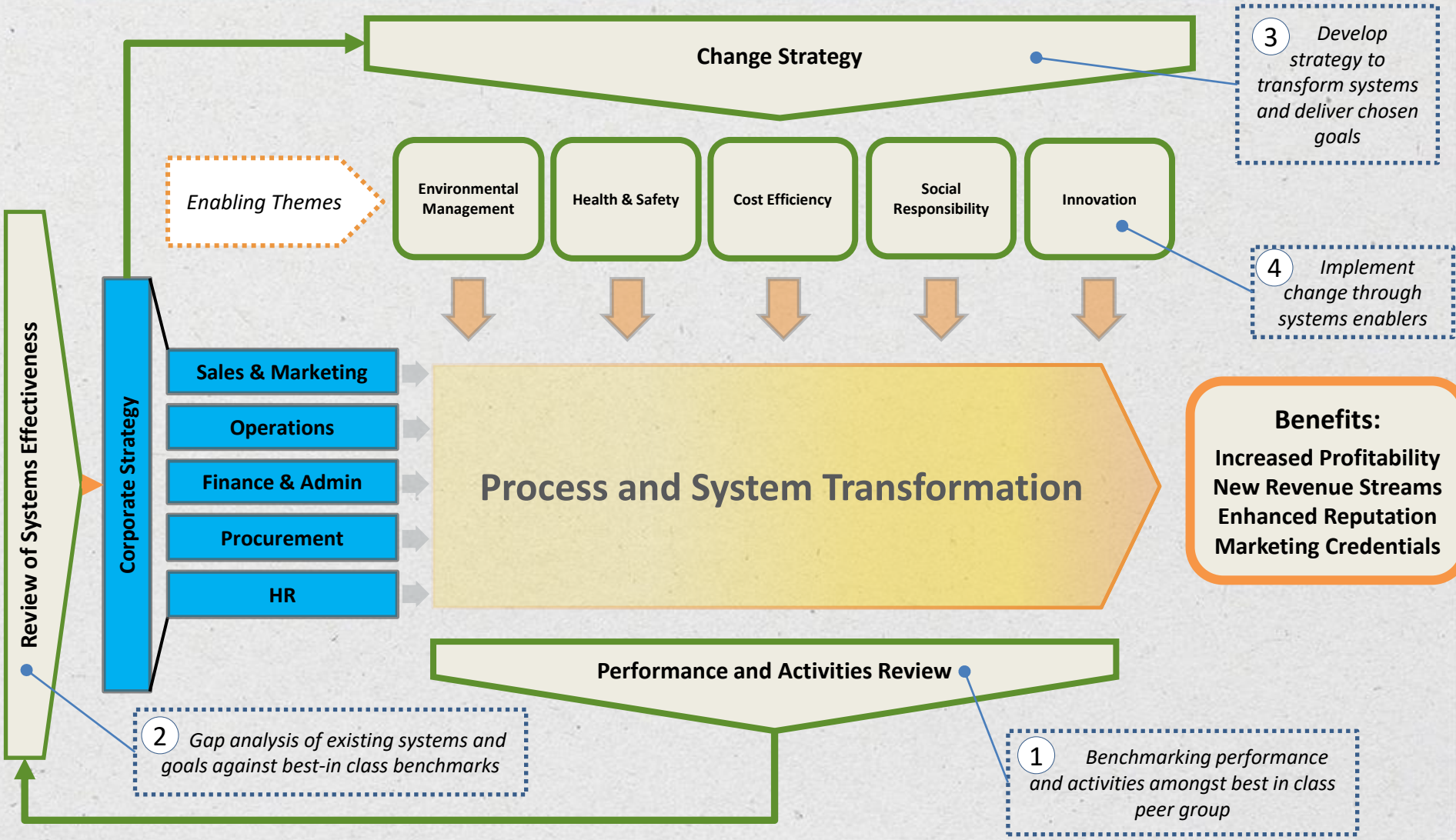
Properly done, sustainability delivers efficiency

- Sustainability can have a big impact on improving resourse efficiency.
- Resource efficiency improvement needs to be balanced so that it fully aligns with the organizational goals and existing systems.
- Typical touch points that assist this include:
  - Understanding the organisation's financial goals and agreeing payback thresholds for investment in efficiency measures.
  - Ensuring that efficiency is made a regular item on management and board meeting agendas.
  - Embedding efficiency goals into HR appraisal processes.
  - Working with the marketing and sales teams to build understanding of where improved efficiency and green credentials could be used to reduce the risk of losing sales.
  - Identifying with operational teams the low risk processes and operations that should be targeted first and the higher risk areas that need in-depth study.
  - Embedding cost-effective efficiency rules into procurement systems that align with the organisation's financial goals.
  - Working with the health and safety team to identify activities that achieve both efficiency and safety benefits, saving costs.
  - Building a comprehensive picture of risks and opportunities linked to resource consumption and feeding this into the strategy planning cycle for the organisation.

Exemplary governance framework



Four steps to kick-start the improvement cycle



Ongoing quality and continuous improvement

- The governance framework, implementation systems and the key documents should be integrated within the organisations existing systems for managing business improvement.
- As such, they should be subject to the same quality, health and safety and improvement processes as other systems.
- Proper integration not only prevents wasteful duplication, it also ensures that activities are designed to suit the organisation and outcomes are optimized.

FOCUSING ON ENERGY MANAGEMENT

What is energy management?

- Energy management employs best management practices to reduce consumption of energy whilst maintaining the ability of an organisation to deliver its goals.
- The scope of energy management includes all activities within the organisation and all ways in which energy consumption can be affected.
- Activities include procurement, operations, logistics and waste management.
- Ways of affecting consumption include the efficiency with which energy is used, the time at which energy is used and the nature of the energy resource concerned.

Energy Management Systems

- Energy management systems do not differ in nature from any other system that an organisation uses for organizing its affairs.
- However the specific topics, targets and tools used may be very unfamiliar to management teams.
- Some technical topic areas are accessible to the skilled engineers who will be part of the facilities management team. Risks in this area will be relatively well-understood and easy to control.
- Other topics will be very closely tied in to control of the core processes of the company – hence the importance of the governance process mentioned earlier.

Energy Management System model

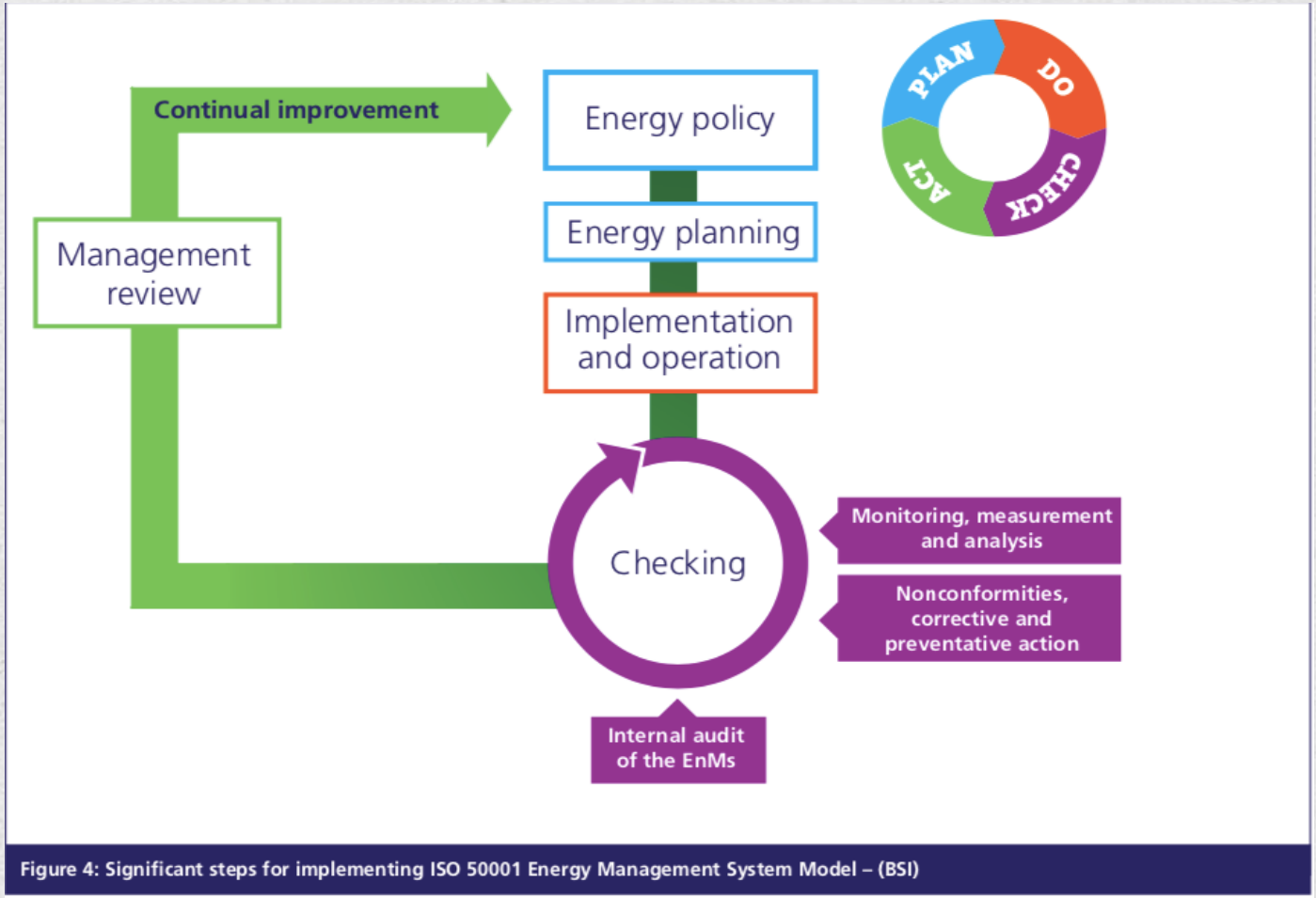


Figure 4: Significant steps for implementing ISO 50001 Energy Management System Model – (BSI)

Image from British Standards Institution, 2020

The energy planning process

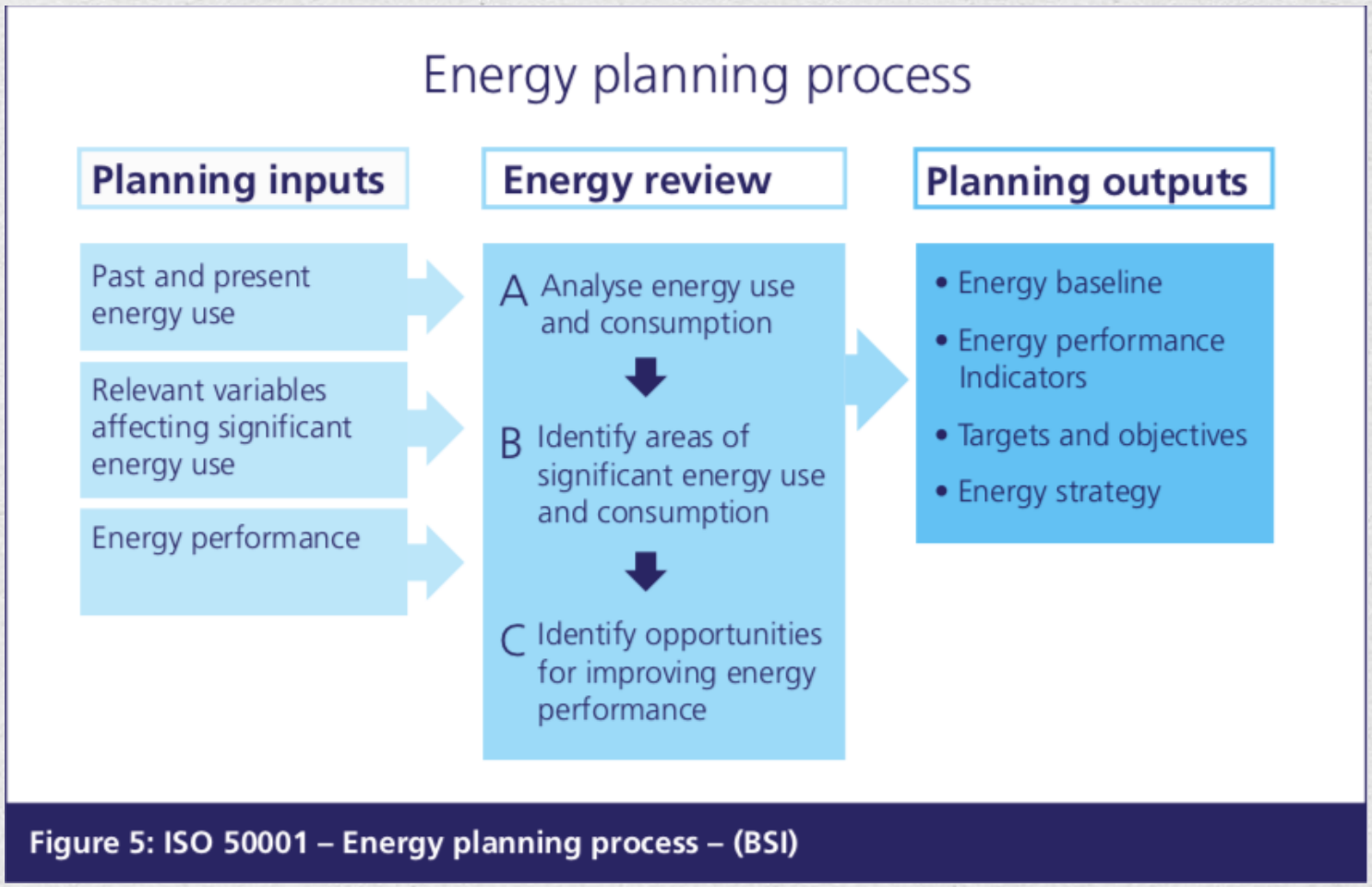


Figure 5: ISO 50001 – Energy planning process – (BSI)

Image from British Standards Institution, 2020

Key tools for improving energy resource efficiency

	Element	Description
1	Baseline Checklist	A checklist that characterizes the current way in which the resource(s) in question is being managed, covering the policies, systems, activities and targets – if any.
2	Risk register	A list of risks that the organisation is exposed to through consumption of the resource(s) in question, such as market price risk, reputational risk from over-consumption, safety, pollution etc..
3	Nomination of senior executive with accountability	Nomination letter for a named Senior Executive to be accountable for consumption and costs.
4	Nomination of day to day manager	Nomination letter and job description for a manager who will be responsible for day-to-day management of consumption.
5	Policy for management of the issue	A regularly revised policy that explains how the organisation will manage the consumption issue.
6	Executive Team/ Main Board reporting	A regular reporting process that highlights ongoing levels of consumption and throughput to senior management teams.
7	Benchmarking and best practice review	A review of the performance of peer group companies to help derive improvement targets, together with a review of global best practice to guide on improvement opportunities.
8	Survey	A survey report that shows how much of the resource(s) is being consumed, where, when and why it is being consumed, and a high level list of the actions that should be considered to improve efficiency.
9	Improvement plan and targets	An annual management plan and targets to reduce consumption, including identification of investment and human resource requirements.
10	Annual review	Annual review of systems, processes operations and results, with strategic improvement plan to drive continuous improvement.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RETHINK