Transition to renewable electricity: a retrospective look at key interactions

April 7, 2022
15h00 – 16h00

Leonardo ENERGY Webinar #544
copper.fyi/letube

Energy Evaluation Academy Webinar #20
energy-evaluation.org

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An initiative by
European Copper Institute
Copper Alliance

ENERGY EVALUATION

Mihai Tomescu
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In 2020, the EU has met its renewable energy target. Renewable generation across the EU has more than doubled since 2005, thanks to EU legislation and national policies and measures.

This webinar will look at the historic transformation of the power sector from an environmental perspective of key interactions, knock-on effects, and co-benefits and trade-offs following from life cycle analysis.

Transition to renewable electricity

A retrospective look at some key interactions

Mihai Tomescu | Energy Evaluation Academy #20 | 7 April 2022

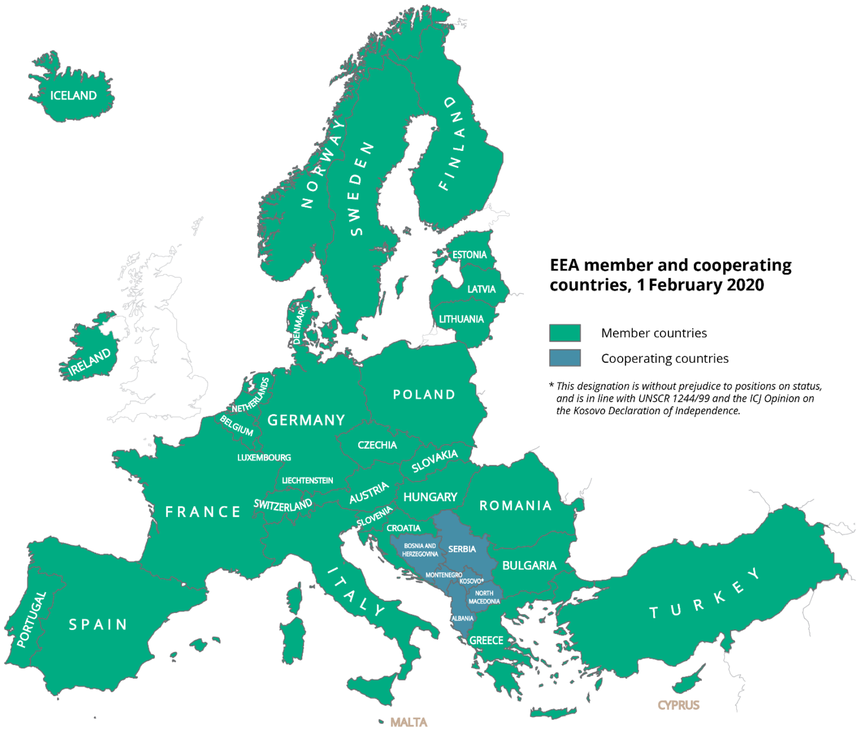
European Environment Agency

European Environment Agency (EEA)

Independent EU Agency

Mandate: Delivering data and knowledge to achieve Europe’s environment and climate ambitions

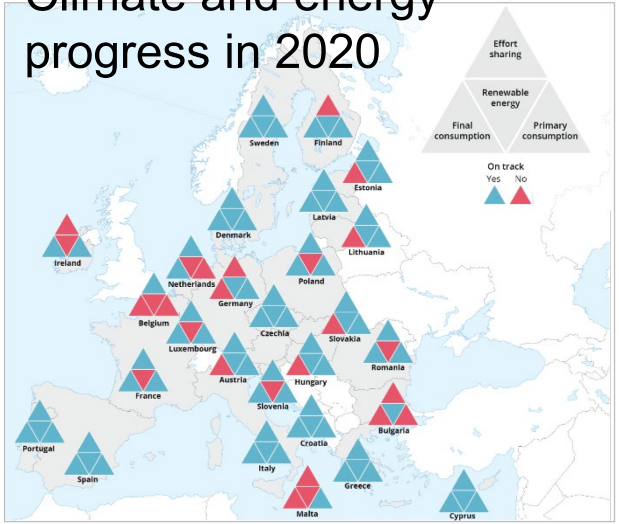
- Information and knowledge hub
- Interface between science and policy
- Network oriented

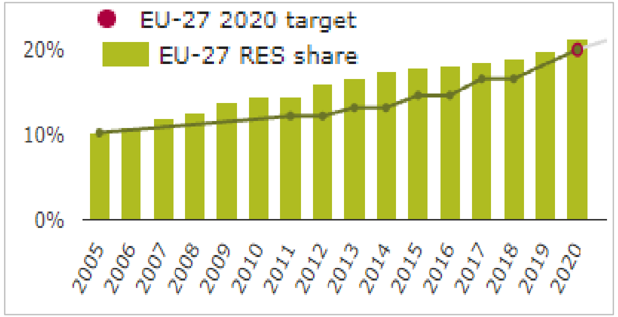


Energy transition and EEA activities

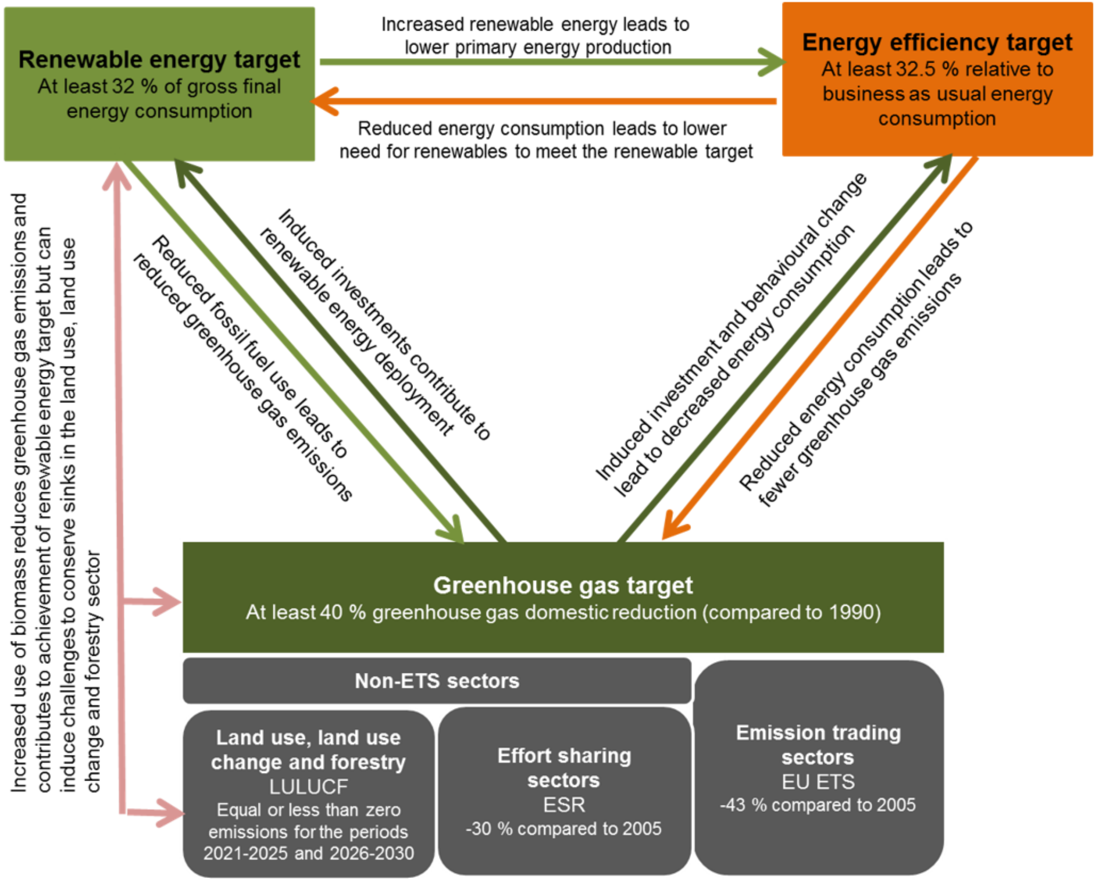
- Assist the European Commission with monitoring and reporting work:
  - Monitoring Mechanism Regulation (2020 targets); European Green Deal; European Climate Law; Regulation on the Governance of the Energy Union and Climate Action; LULUCF Regulation, etc.
- Support to countries and the EC:
  - Data reporting through EEA Reportnet 3.0
  - Quality checks and quality assurance
  - Data, indicators, assessments, knowledge

Climate and energy progress in 2020





Maximising the co-benefits of energy transition



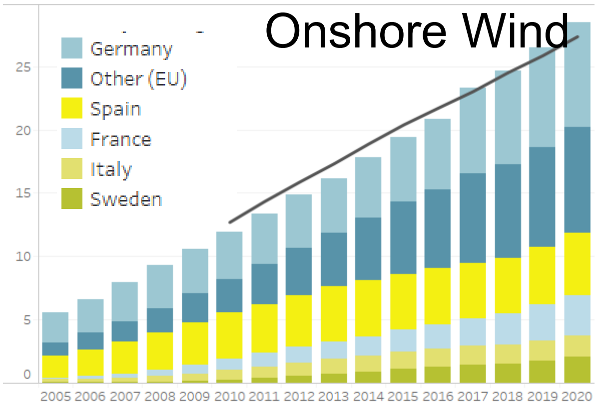
Sectoral substitution of fossil fuels by renewable energy sources (RES)

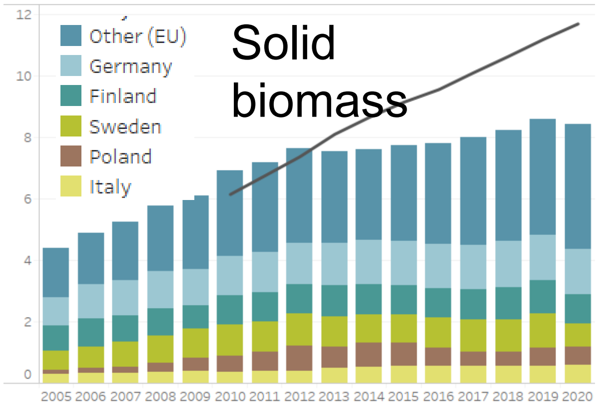
- Important climate mitigation option
- Can improve health/reduce air pollutant (AP) emissions
- Improve energy efficiency
- Job creation
- Can support energy independence
- Interaction with LULUCF

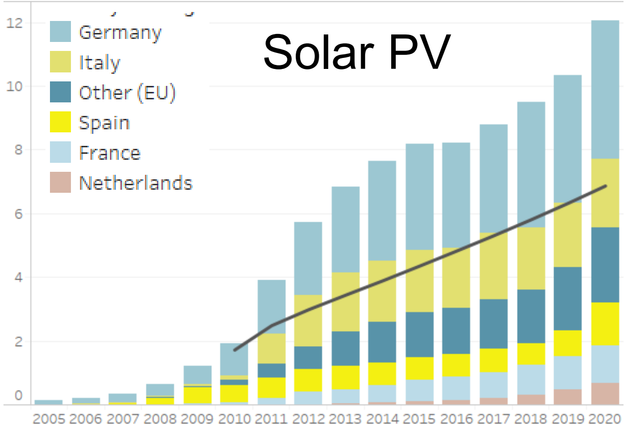
European Environment Agency

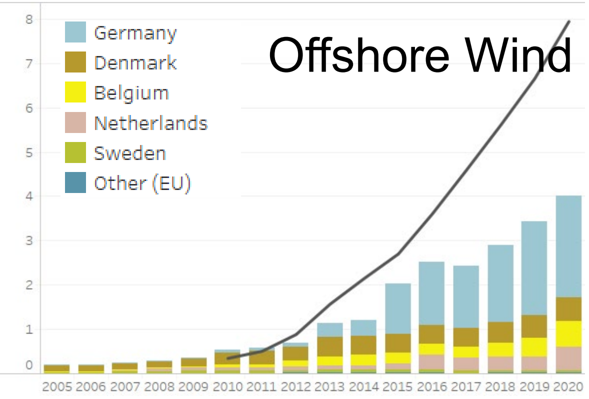
Source: European Environment Agency

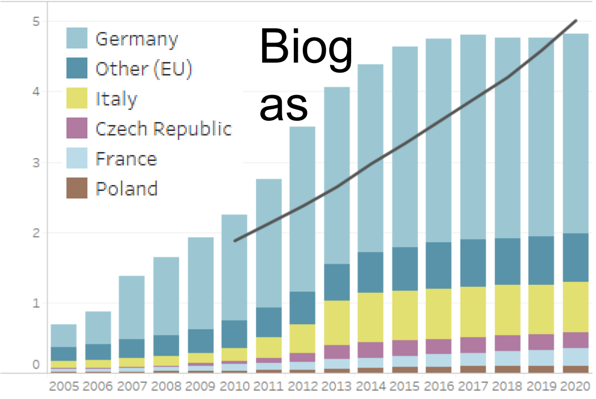
Close look at sectoral RES transformation (electricity, EU level)











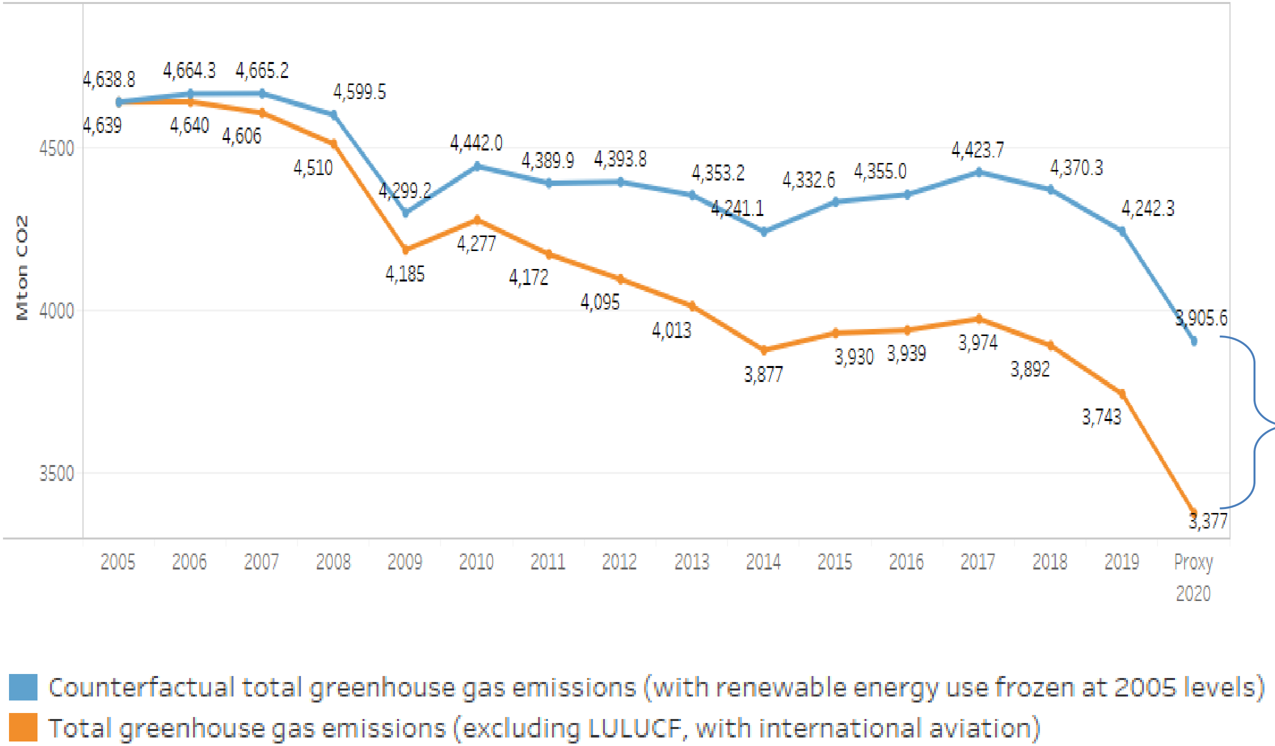
Continuous black line indicates the expected trajectory based on the National Renewable Energy Action Plans

Source: European Environment Agency
(Dashboard Renewable energy in Europe)

Approach

- Step 1: determine amount of RES consumed
- Step 2: determine reference emission factors of initial energy carriers
  - Calculate gross avoided GHG emissions estimates
  - **Counterfactual: ‘frozen 2005-RES shares'**
  - For NO_x, SO_2, PM_{10}, $PM_{2,5}$ and VOC, calculate (PEC per unit)*(pollutant emission factor per fuel)
- Step 3: attribution to Emission Trading Scheme (ETS) and non ETS sectors

Estimated effect of (all) RES on GHG emissions in the EU



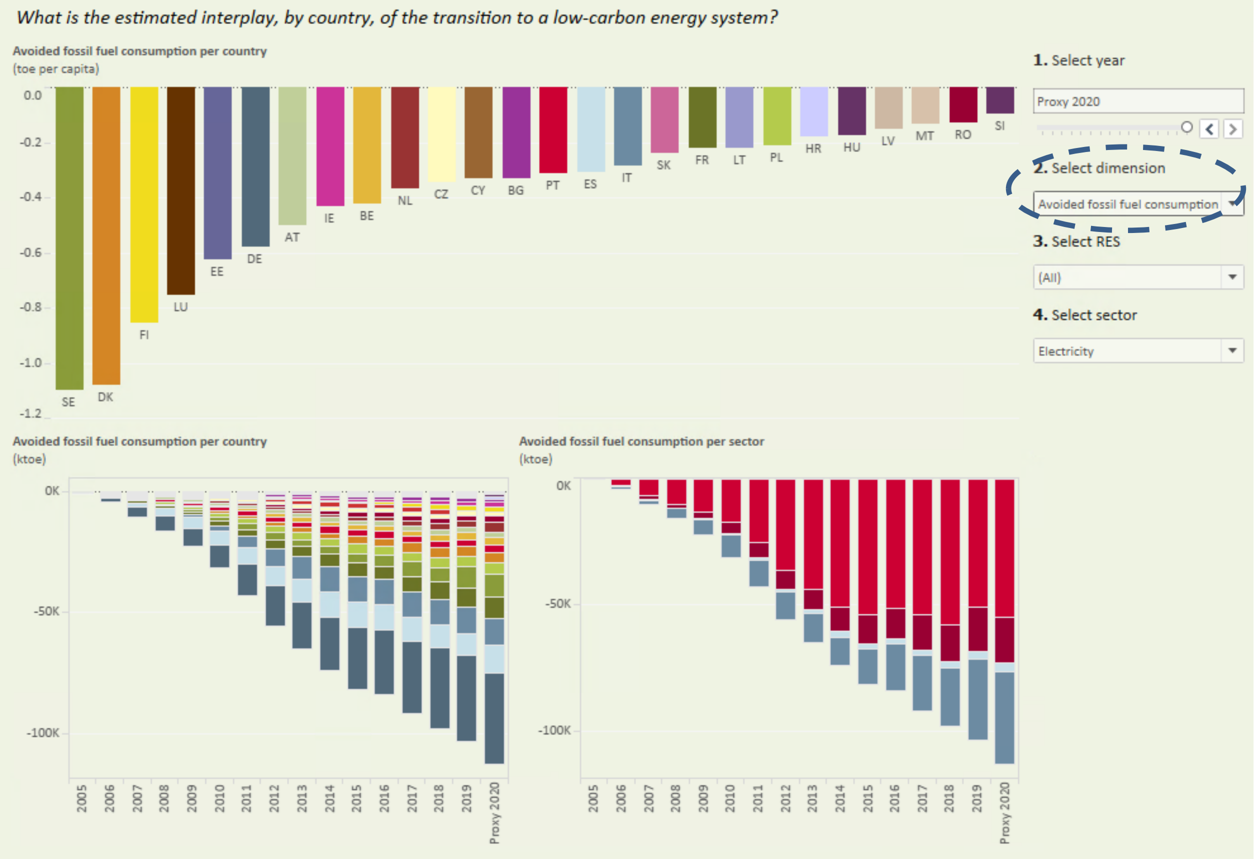
Compared with a scenario where all RES use is frozen at 2005 levels, the additional RES consumption since 2005 has...

... cut EU level GHG emissions by 12% by 2020.

Source: European Environment Agency
(Dashboard Renewable energy in Europe)

European Environment Agency

Effects of renewable electricity growth on fossil fuel use



Source: European Environment Agency

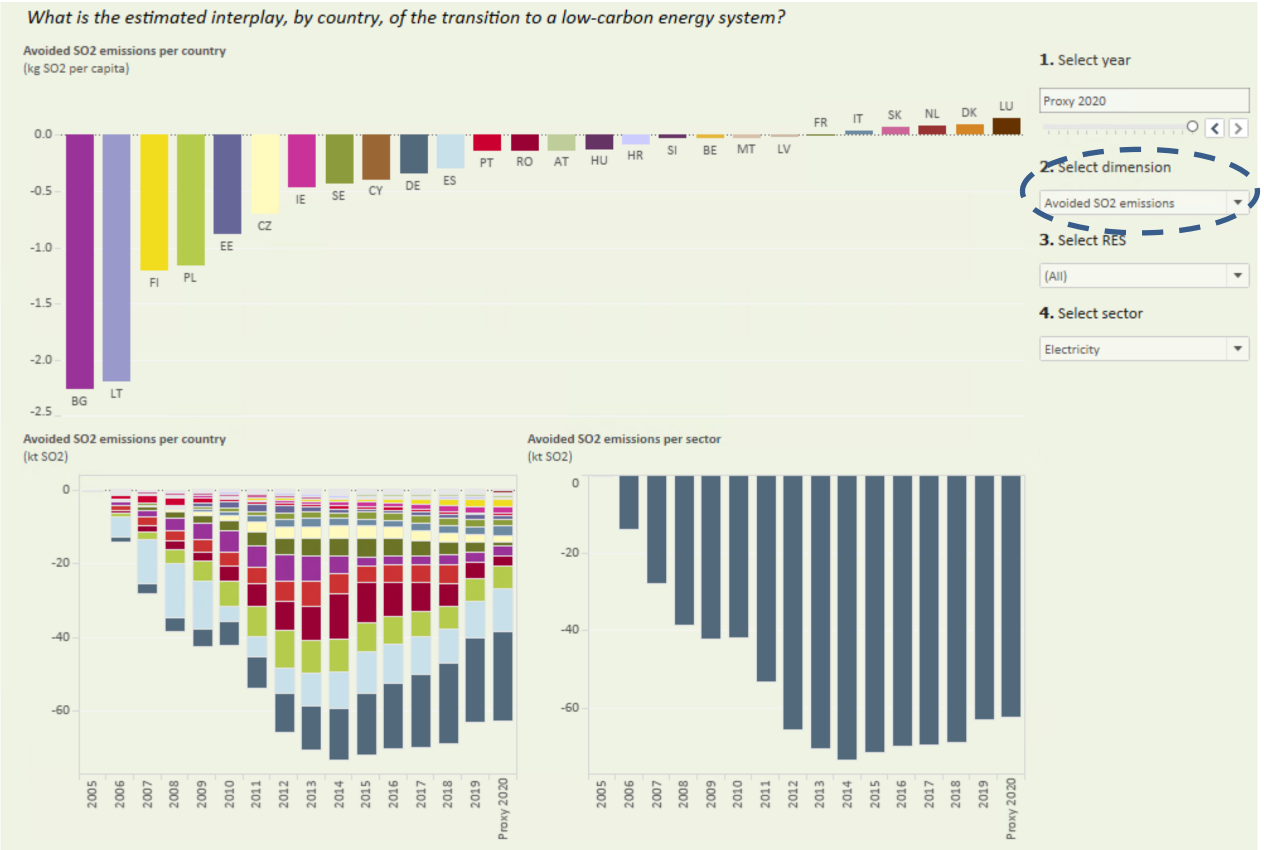
(Dashboard Impacts of renewable energy use)

Estimated cut of EU fossil fuel demand: 165 Mtoe (19%; all RES sectors)

In relative terms, highest substitution effects in countries where the RES electricity share grew most since 2005

Coal most displaced fuel, but also natural gas

Effects of renewable electricity on air pollutant emissions (1/2)



Source: European Environment Agency
(Dashboard Impacts of renewable energy use)

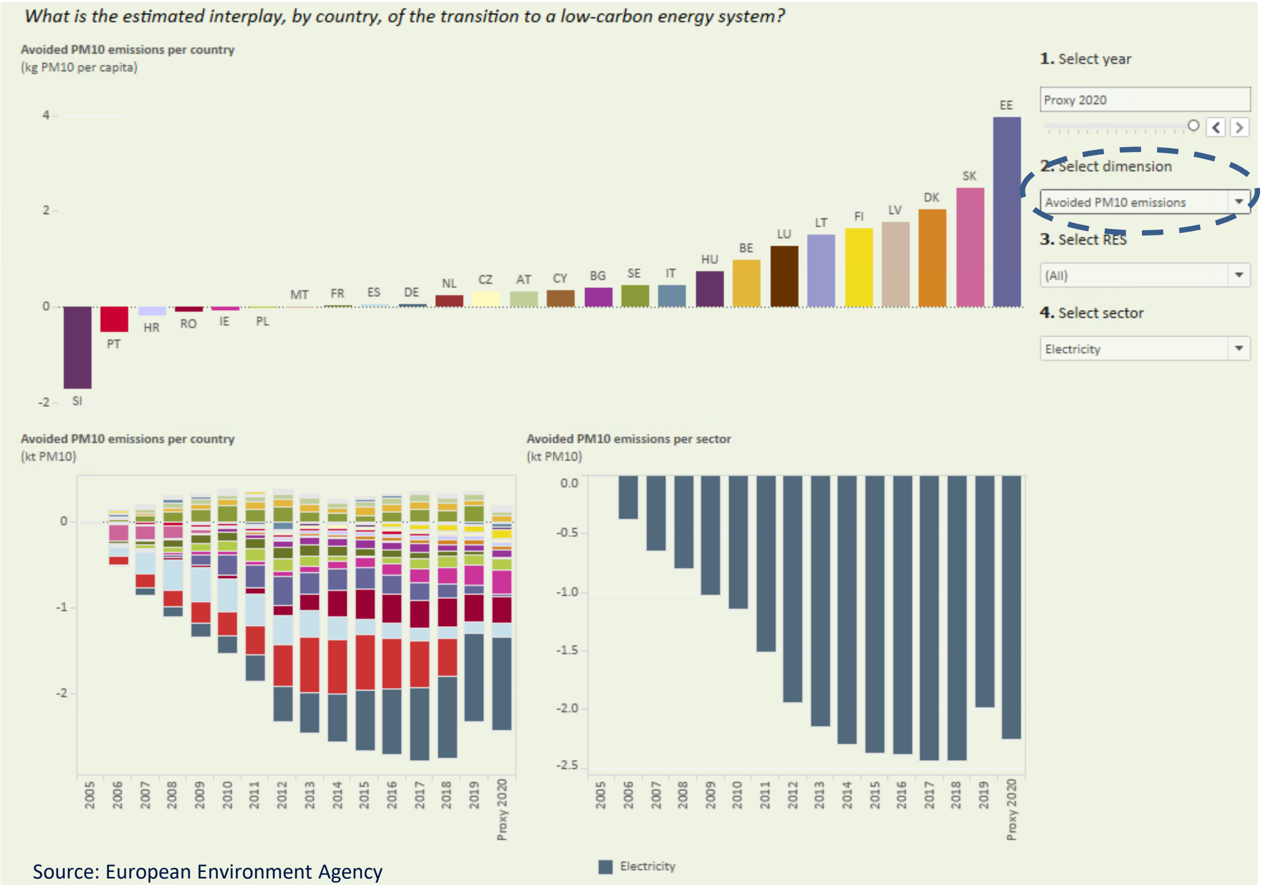
Overall decreases in emissions of SO_2 and NOx

Strongest decreases caused by increasing shares of wind power, solar PV

Increases where combustion of biomass displaced e.g. natural gas generation

European Environment Agency

Effects of renewable electricity on air pollutant emissions (2/2)



Source: European Environment Agency
(Dashboard Impacts of renewable energy use)

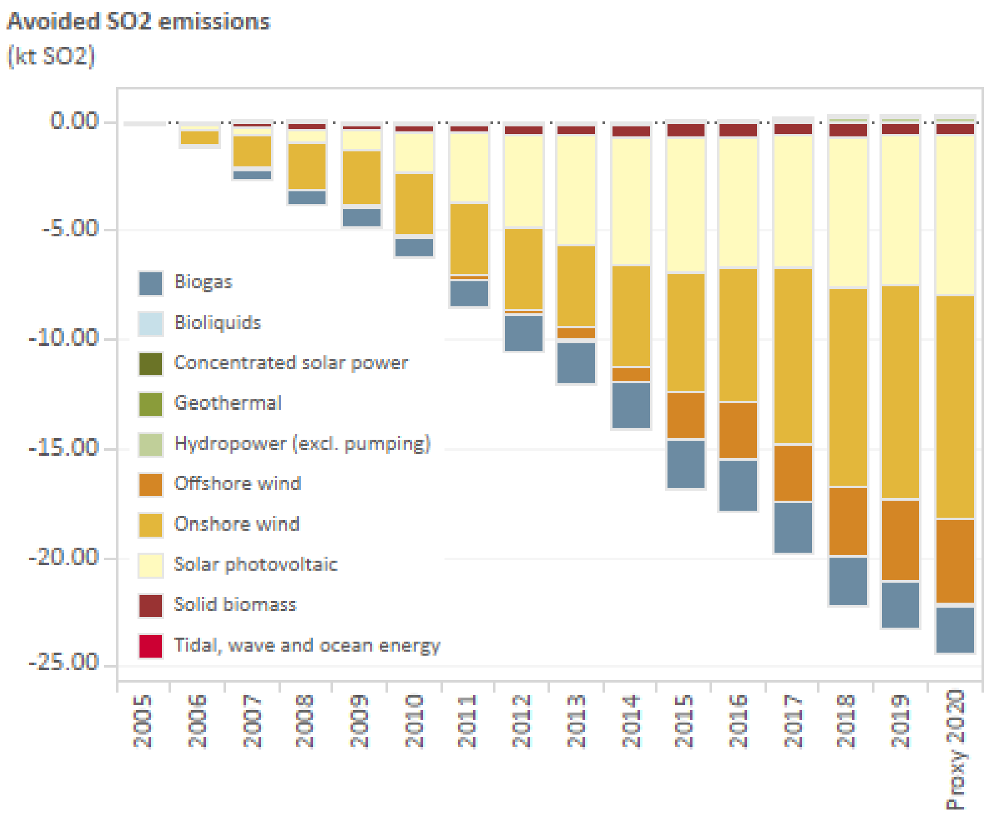
Overall increases in emissions of PM10 and VOCs

Decreases in countries that reduced the amount of (solid) biofuels in electricity generation

Increases in countries where combustion-based renewables increased

European Environment Agency

Germany: RES electricity effects on key air pollutant emissions



SO_2

- Large emission reductions due to increase in wind power, solar PV and biogas
- Small trade-offs due to increased solid biomass use and lesser hydropower production

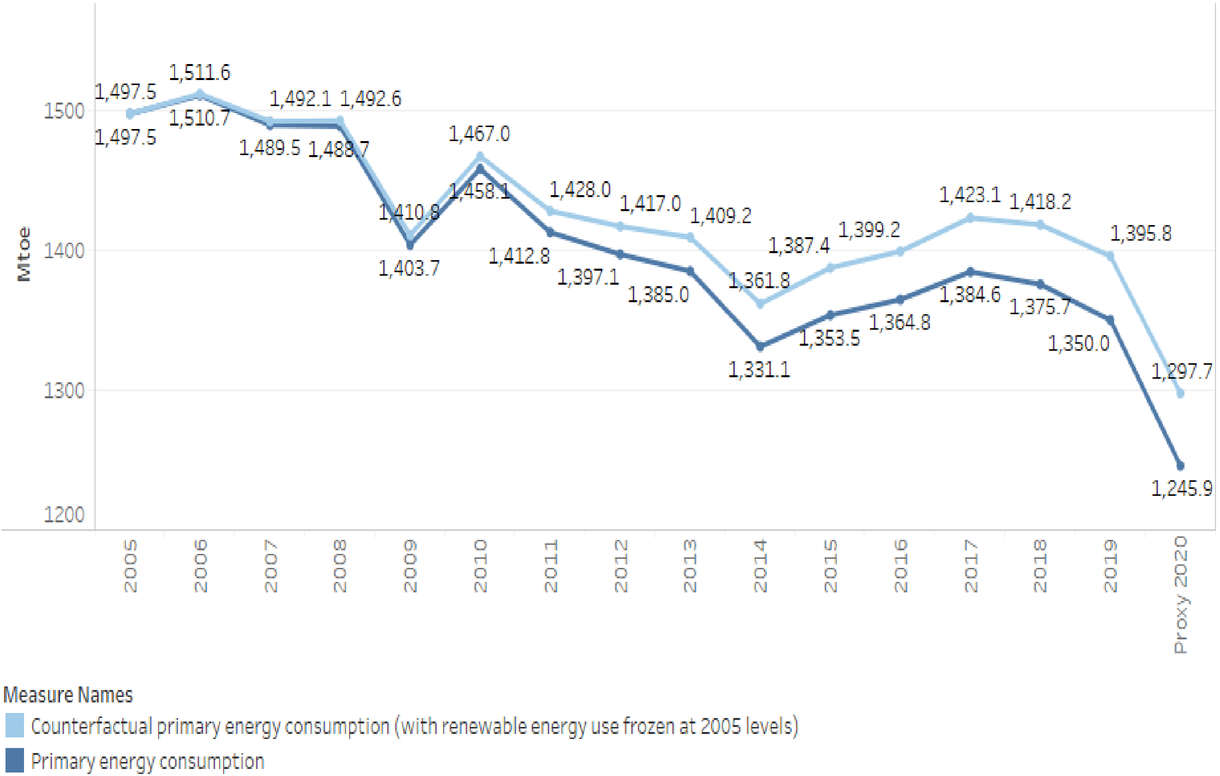
PM_{10}

- Significant decrease
- Some increase due to solid biomass combustion

Source: European Environment Agency
(Dashboard Impacts of renewable energy use)

European Environment Agency

RES effects on energy efficiency (EU level)



Reduction by 4% of EU primary energy consumption due to all RES (electricity, heating, transport)

Source: European Environment Agency
(Dashboard Renewable energy in Europe)

European Environment Agency

Conclusion

- Renewable electricity is essential for climate mitigation and has important co-benefits.
  - Important not to lose momentum: accelerated deployment needed to meet Fit-for-55% climate targets
  - Increasing the share of non-combustion technologies will decrease all AP emissions
- Reducing energy demand is key
- Insights into potential co-benefits & trade-offs can inform political choices and improve the quality of the energy transition paths chosen

Thank you

Mihai Tomescu| Leonardo ENERGY | 07 April 2022

Transition to electricity production from Renewable Energy Sources

Key interactions, benefits and trade-offs from an LCA perspective

Evert A. Bouman PhD
Senior Scientist – Environmental Impacts & Sustainability
NILU – Norwegian Institute for Air Research

European Environment Agency
European Topic Centre
Climate change mitigation

ETC Climate change Mitigation

- European Topic Centres (ETCs) are centres of thematic expertise contracted by EEA
- Supporting the EEA with implementation of the EEA Work Programme
- 8 ETCs as per January 2022
- ETC/CM consortium: 15 organisations/10 countries

Aether

emisia

Öko-Recherche

Öko-Institut e.V.

CHMI

CITEPA

Transport & Mobility Leuven

NILU

vito

exergia

umweltbundesamt

klar FAKT

GAUSS

Source: VITO

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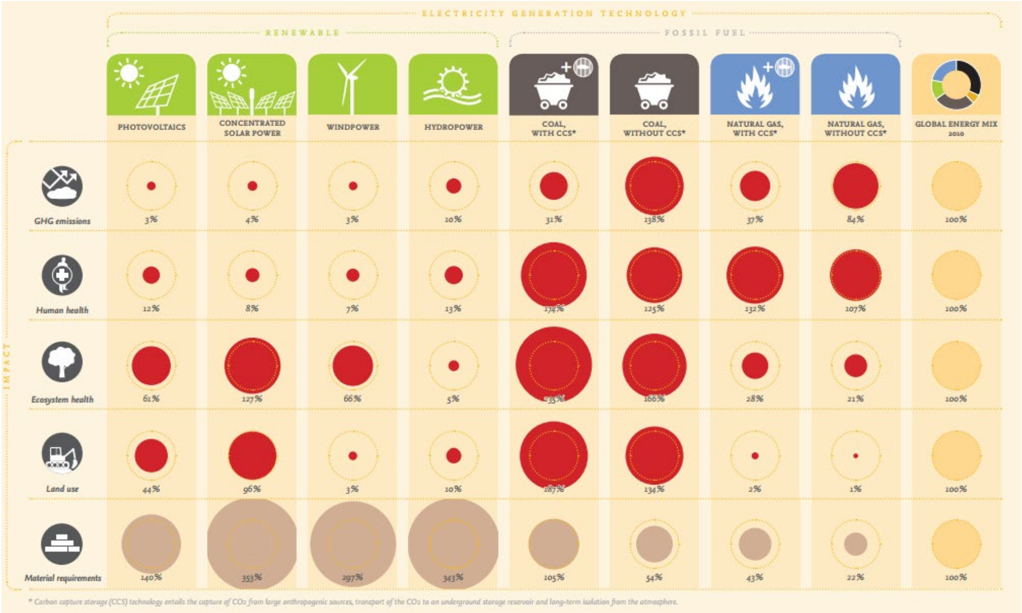
Introduction

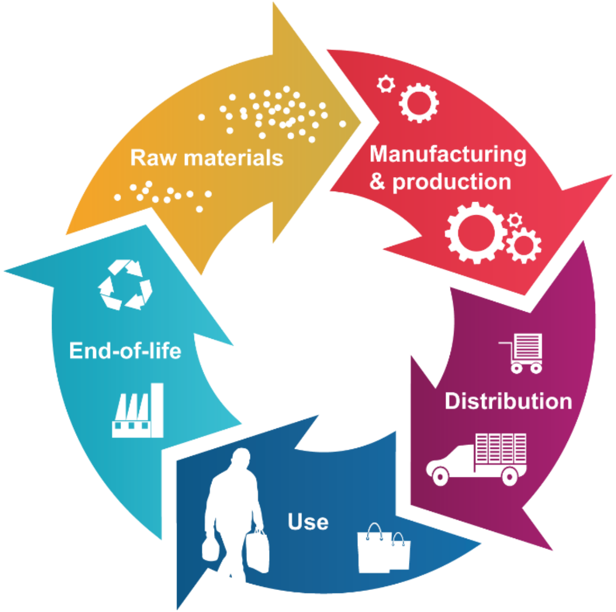
- The generation of electricity and heat contributes significantly to annual anthropogenic greenhouse gas (GHG) emissions of the EU-27
- GHG emissions for most renewable electricity generation are virtually zero during operation, but…
  - The construction of renewable power generation components and plants is both material and energy intensive
  - Power generation from renewable sources is not emission, nor impact, free



Source: UNEP, 2016

Life Cycle Assessment

- ETC/CME studied life cycle impacts of electricity generation in the EU-27 for the period 2005-2018
- LCA is a tool to quantify the potential environmental impacts of products, services, or processes throughout their life cycle
- Quantifies and attributes *direct* and *indirect* requirements associated with demand for a product
- Based on Life Cycle Inventories (LCIs)
  - Description of processes along the value chain, their inputs and outputs from and to economy and environment
- Impacts expressed in impact indicator potentials
  - Global Warming Potential
  - Freshwater Ecotoxicity Potential
  - Particulate matter formation potentials



Source: NILU

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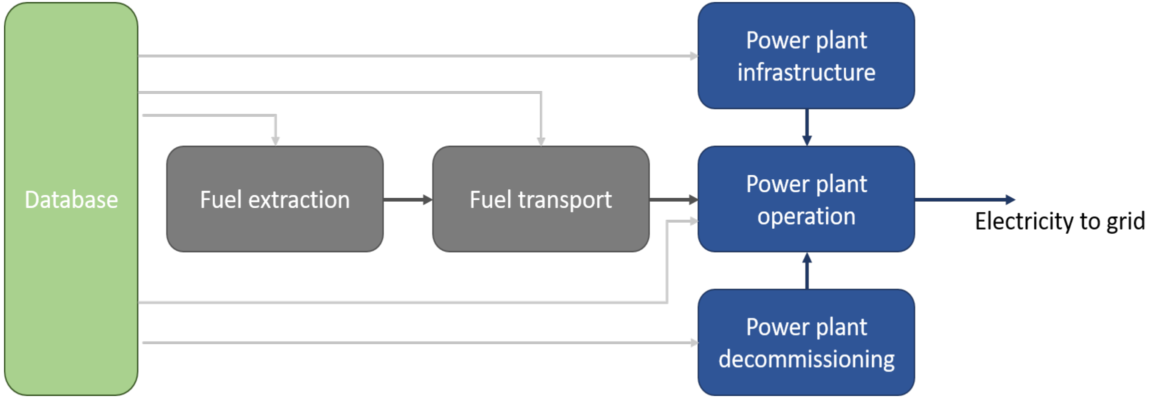
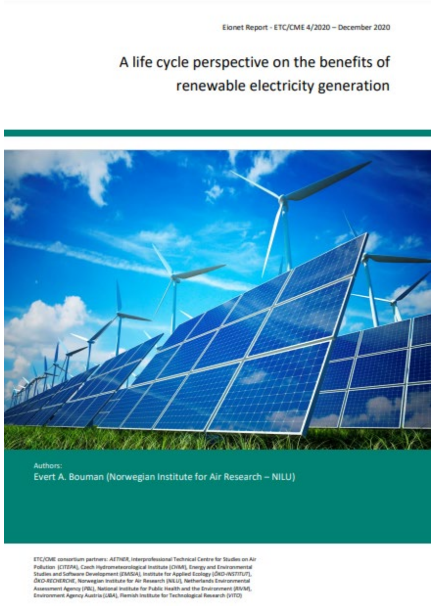
Overall approach

- Life cycle based approach
- Start from collection of LCIs for electricity production
- Use energy balance statistics to adapt LCIs for each Member State and year
- Calculate life cycle impact intensities per RES, Member State and year
- Scale up with annual electricity production
- Calculate 'gross avoided potential environmental impacts' relative to scenario where RES are frozen at 2005 level



Source: ETC/CME



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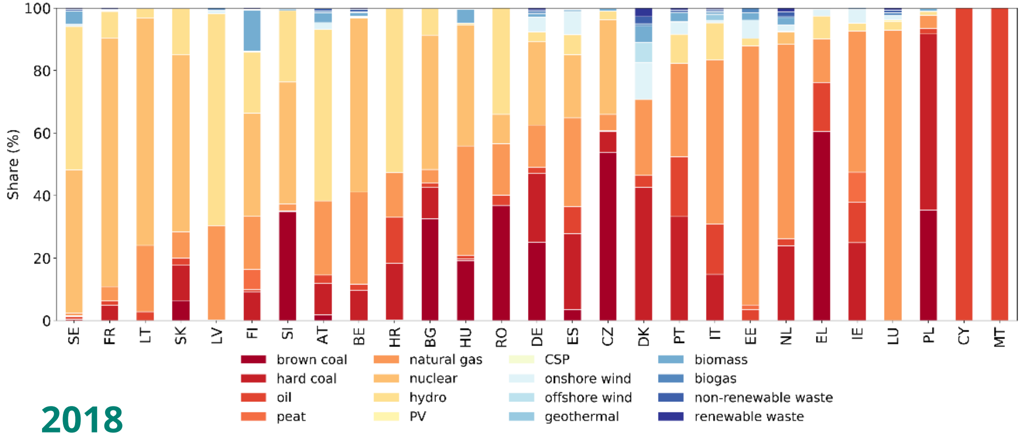
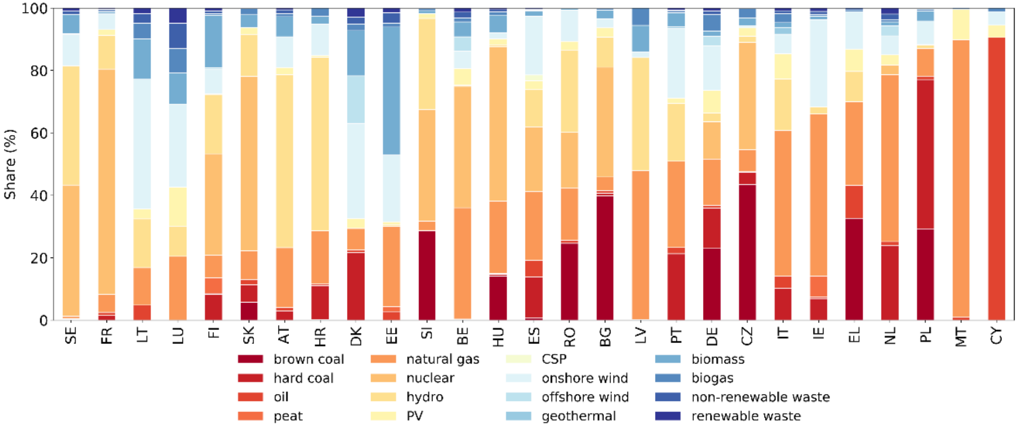
Trends in Electricity Production

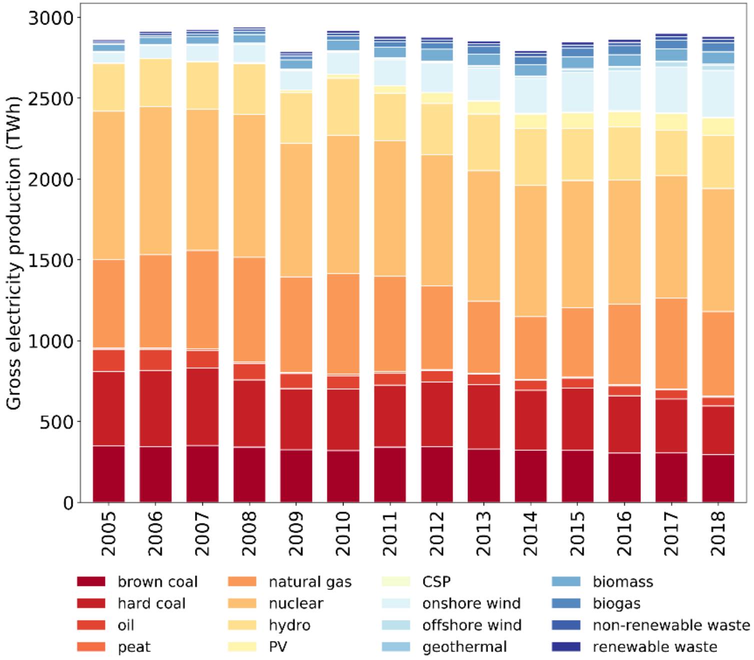
2005

Source: ETC/CME, based on Eurostat



2018





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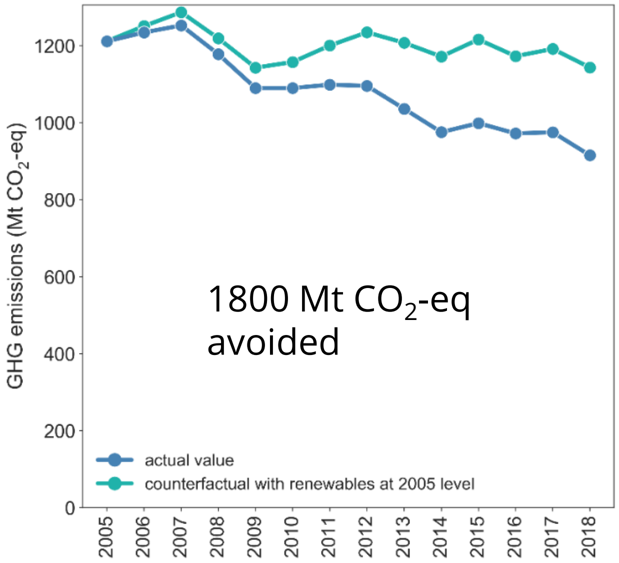
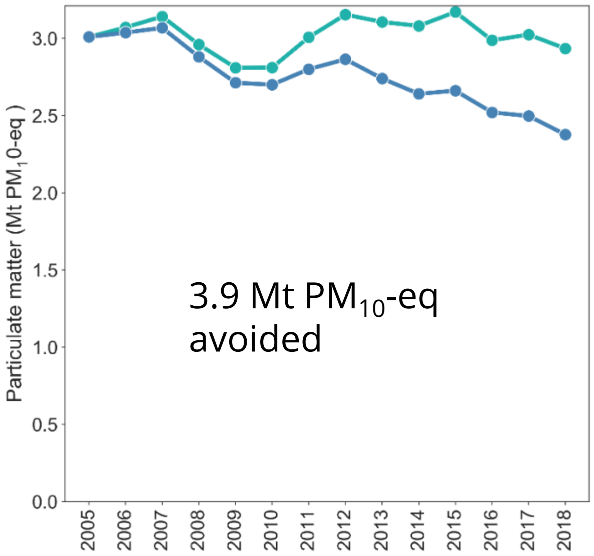
Potentially avoided impacts in a life cycle perspective

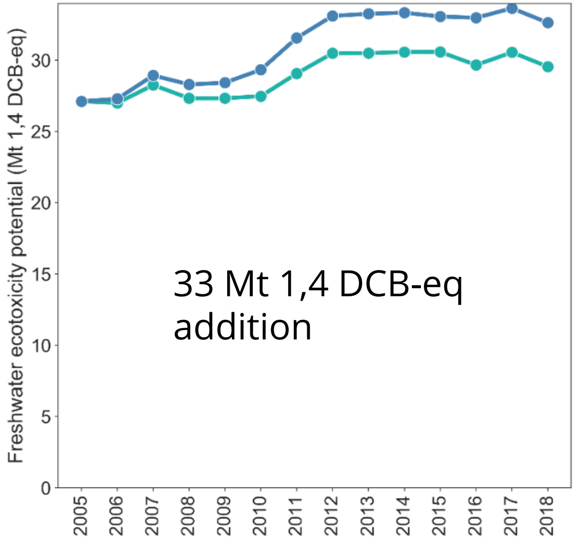
GHG emissions



Particulate matter formation



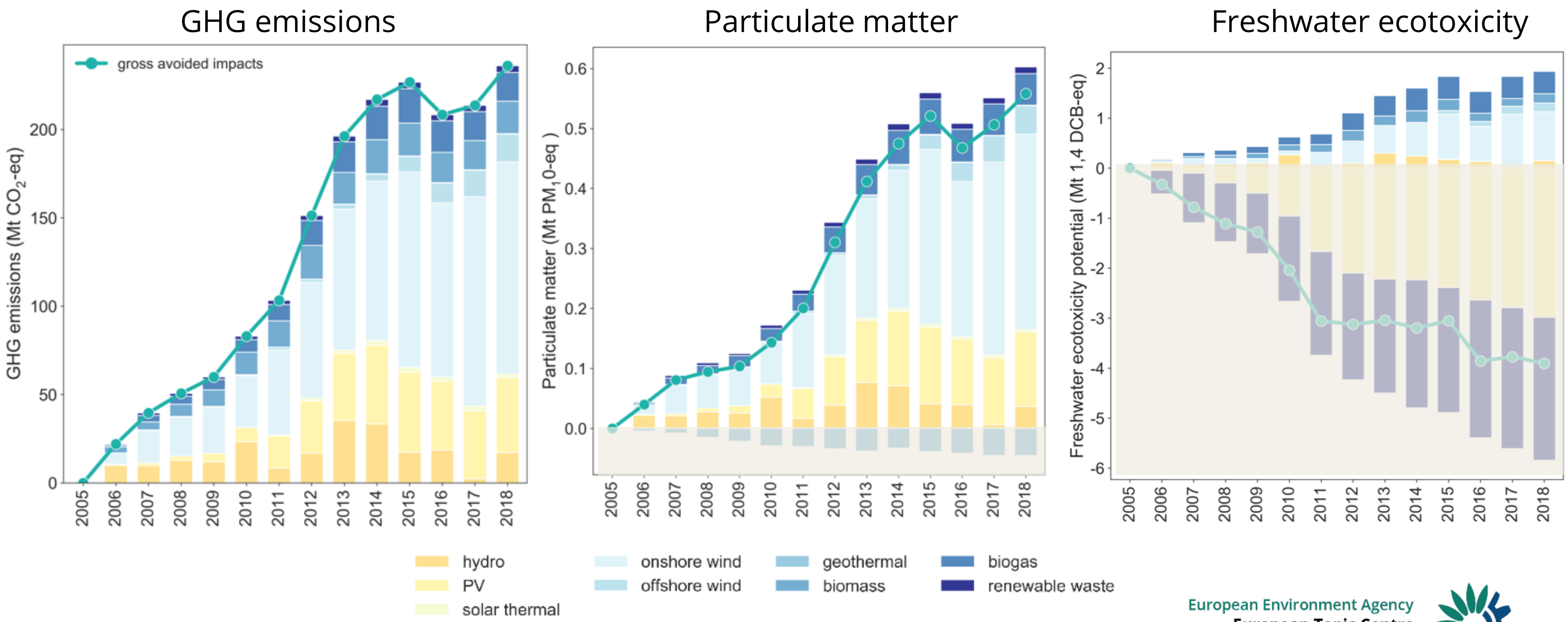
Freshwater ecotoxicity



Source: ETC/CME

NB: Impacts associated with electricity system only

Contribution of individual RES to avoided impacts



Source: ETC/CME

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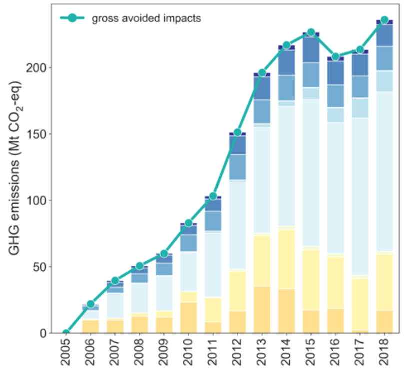
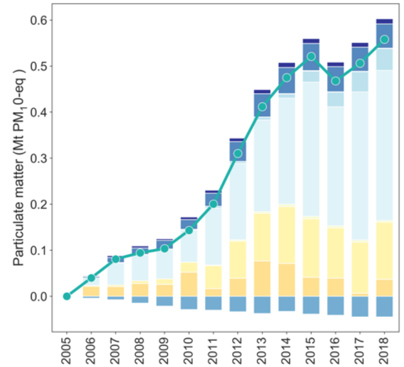
Drivers of impact intensities

- Energy transition to RES implies change from throughput intensive to infrastructure-intensive technology
  - Biomass combustion an exception
- This implies that life cycle impact indicators are associated with the infrastructure value chain compared to fuel value chain
  - More materials needed to produce same amount of electricity
  - Consequences for global material supply chains
  - Dependency on critical resources

- But climate and air pollution/quality benefits significant
- Better End-of-Life material recovery reduces impacts associated with primary material production upstream in the value chain





Source: ETC/CME

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Discussion

- Power plant lifetime extension may be an option to mitigate trade-offs from the increased use of non-combustion RES
- Energy and resource efficiency increases in combustion technologies lower impact intensities
- Circular strategies may reduce impact intensities as primary resources are avoided

- Uncertainty remains with respect to the source data in the LCIs
- In individual cases results are sensitive to single environmental emissions in the LCI
- Omission of impact indicators may obscure relevant results
  - e.g. Biodiversity not well reflected

Summarising

- The increased use of RES has led to an absolute decrease in potential impacts in the period 2005-2018 for most impact indicators studied
- Gross avoided impacts for the electricity system are driven by the increased production of onshore wind power and solar PV, and bioenergy sources.
- The increased use of RES comes at a cost in terms of freshwater ecotoxic impacts
- These costs are partially compensated for by using other RES to produce electricity
- Opportunities exist to decrease impact intensities
  - Examples are:
  - Focus efforts to increase efficiency,
  - Implement emission mitigation technology

Thank you

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Senior Scientist – Environmental Impacts & Sustainability
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