Joint Research Centre

the European Commission's in-house science service

Air quality co-benefits of climate action under INDC and <2°C scenarios (an economic evaluation)

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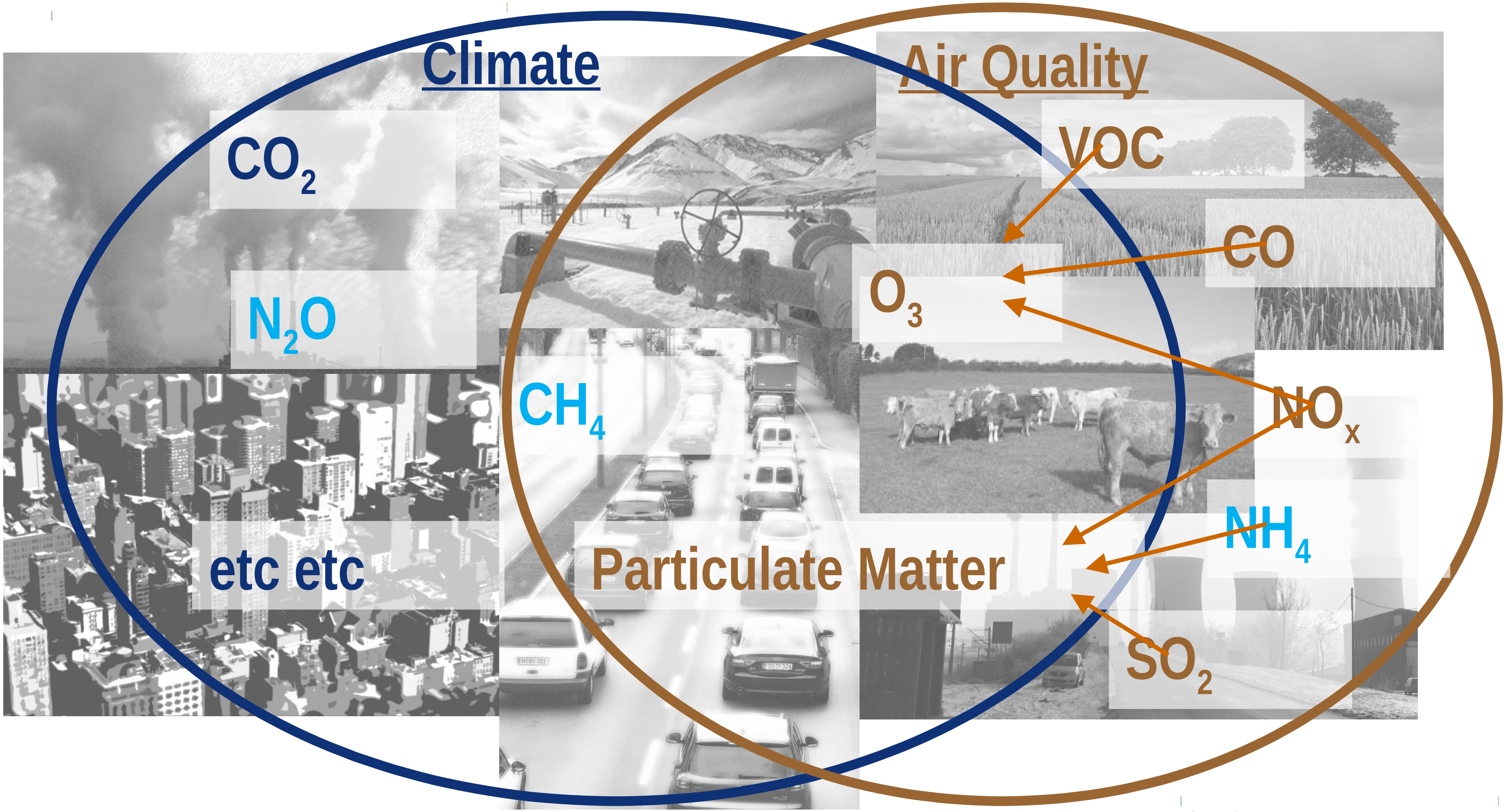
Climate change and air pollution

sharing sources



Scope:

Economic valuation of air quality co-benefits of climate action by 2030 and 2050

Mitigation scenarios:

(1) INDC (full implementation of pledges)

(2) Below 2°C

Underlying air quality control scenarios:

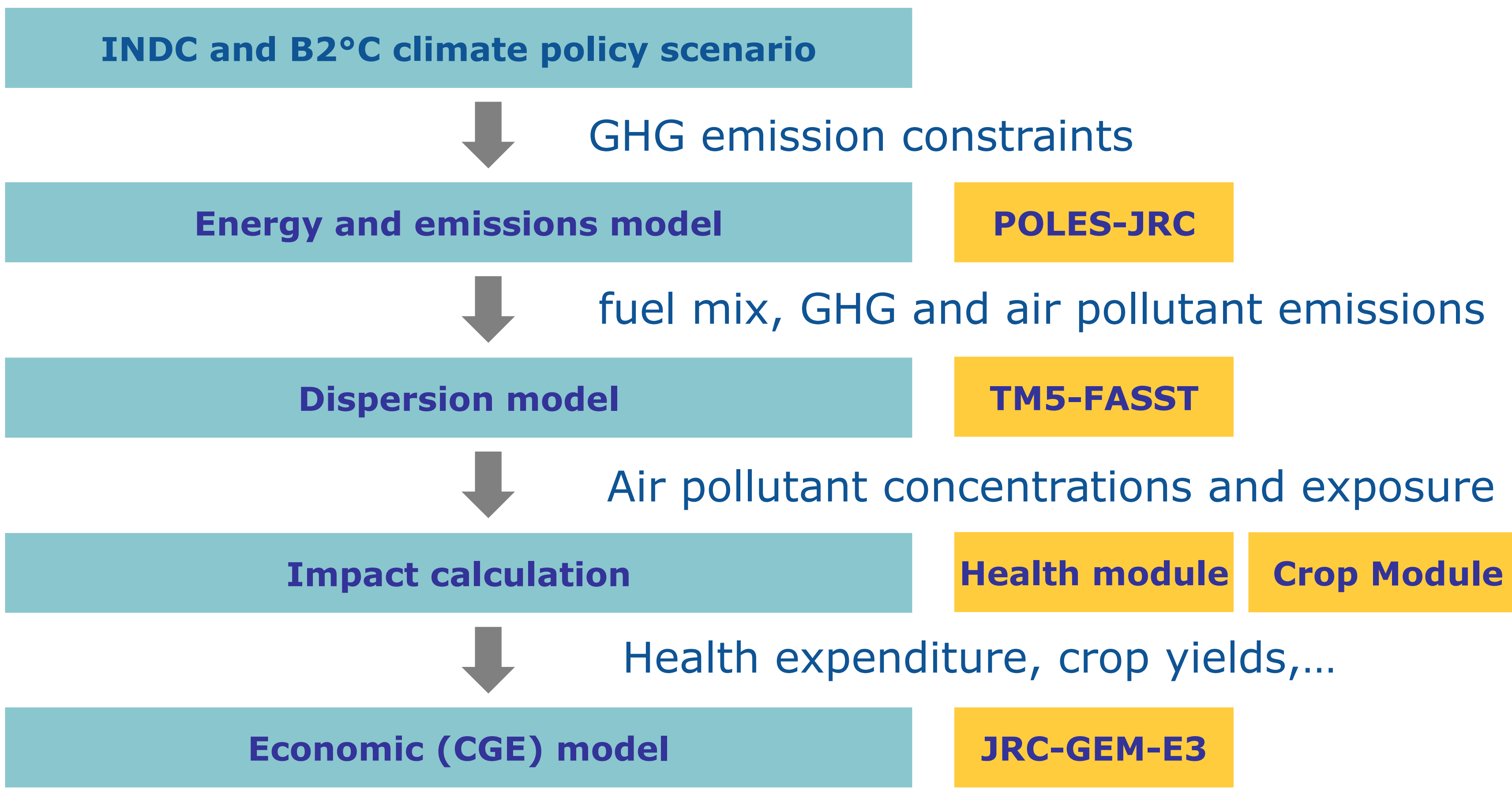
(3) emission control measures frozen at the level of 2010 (FROZ)

(4) continued implementation of currently programmed air quality legislation (PROG)

INDC + PROG ☾ what is in the pipeline

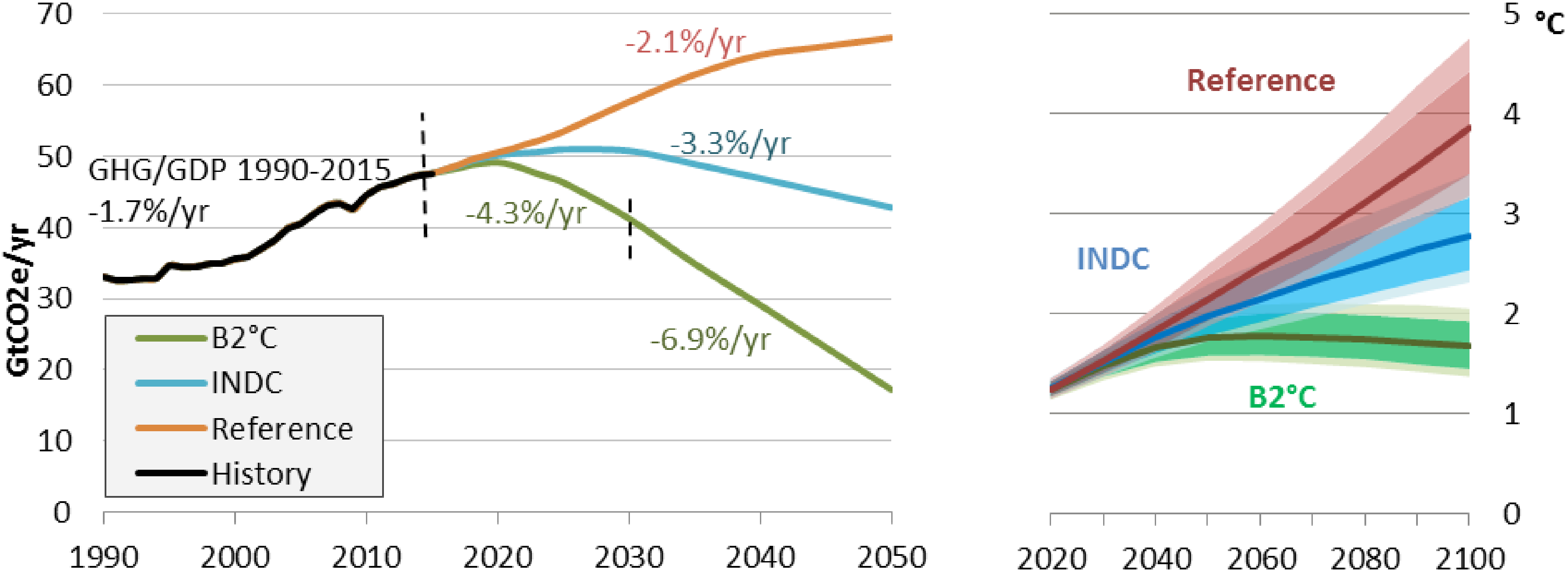
B2C + FROZ ☾ upper limit of achievable co-benefits

Multidisciplinary Model Chain:



GHG emissions constraints for climate mitigation scenarios

% values: average annual growth rates for GHG emissions intensity of the economy



Source: JRC, GECO2017

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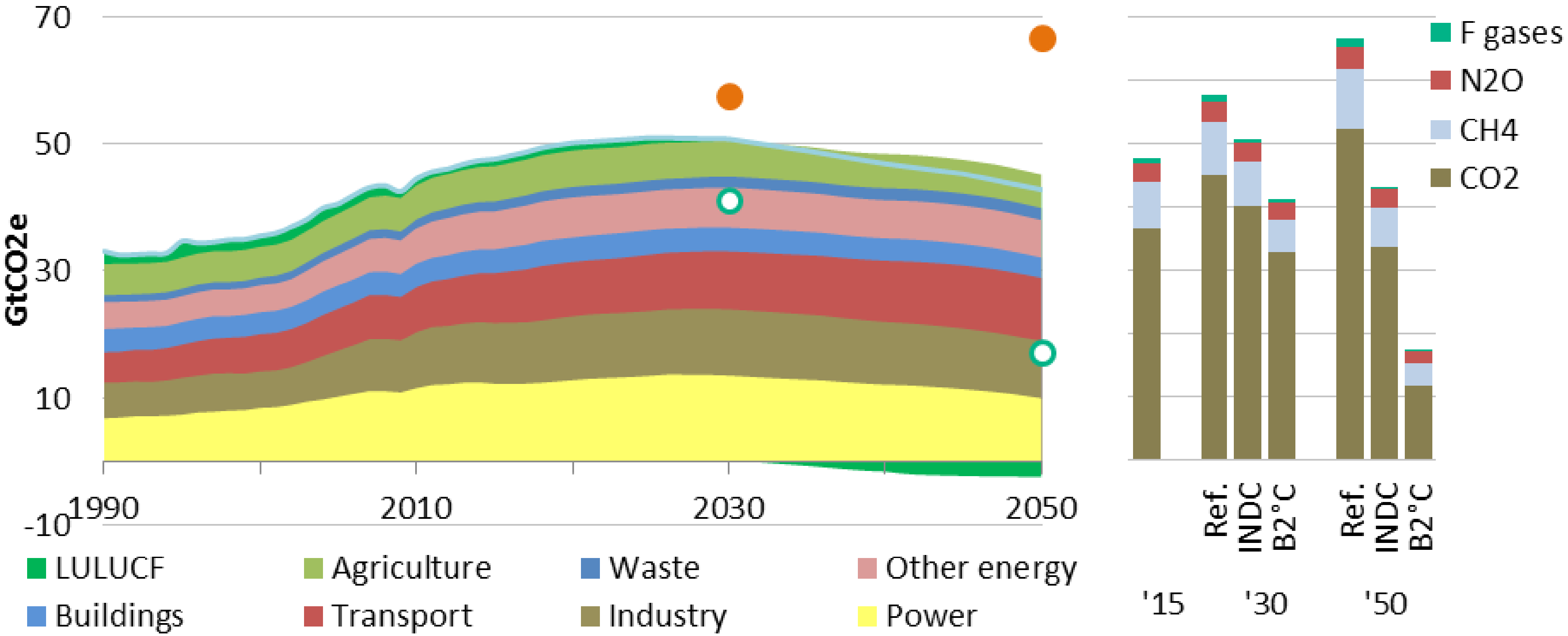
POLES outcome: CO2eq emissions by sector



Available by region (66 regions)

by energy source type (coal, oil, gas, solar, wind, nuclear,….)

From GHG ☾ pollutant emissions: emission factors

Emission intensity factors: from GAINS data, with +/- 40 flows, and each flow associated to a POLES variable (e.g. BC from biomass in industry).

FROZ: emission factors frozen in 2010.
PROG: as IIASA's GAINS CLE, similar approach used in SSPs

Scenario	Region income group	2030	2050
FROZ	All	2010 emission factor	2010 emission factor
PROG	High	Current legislation	75% of 2030 best feasible emission factor
	Medium +	Current legislation	75% of 2030 best feasible emission factor
	Medium -	Current legislation	Convergence to group's best emission factor
	Low	Current legislation	Convergence to group's best emission factor

Source: JRC, GECO2017

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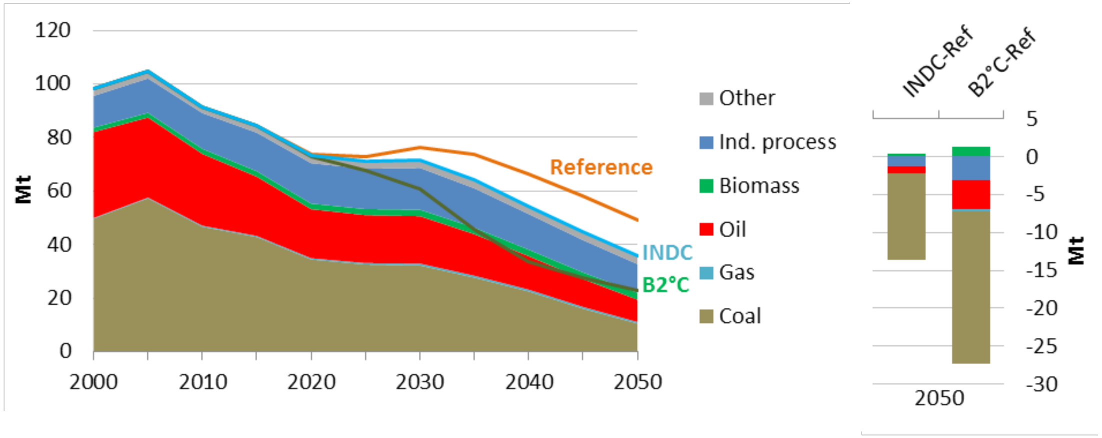
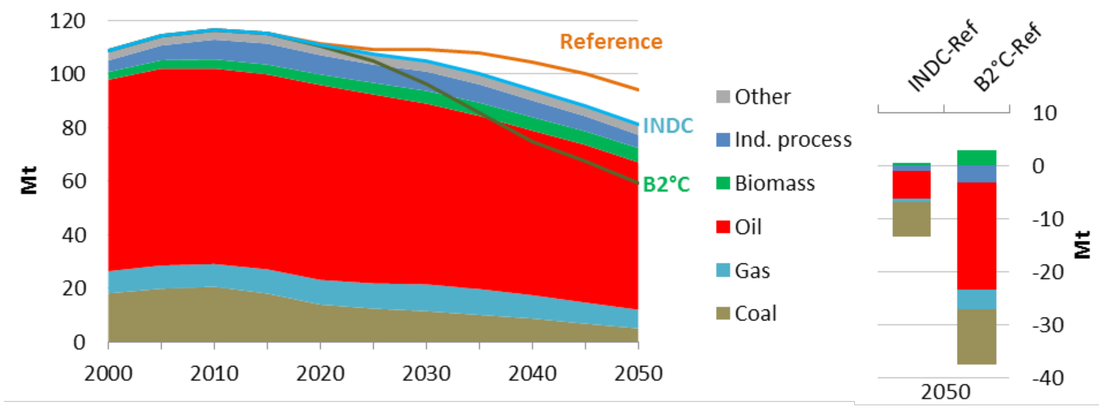
Global precursor emissions under progressive air quality policies (INDC+PROG)

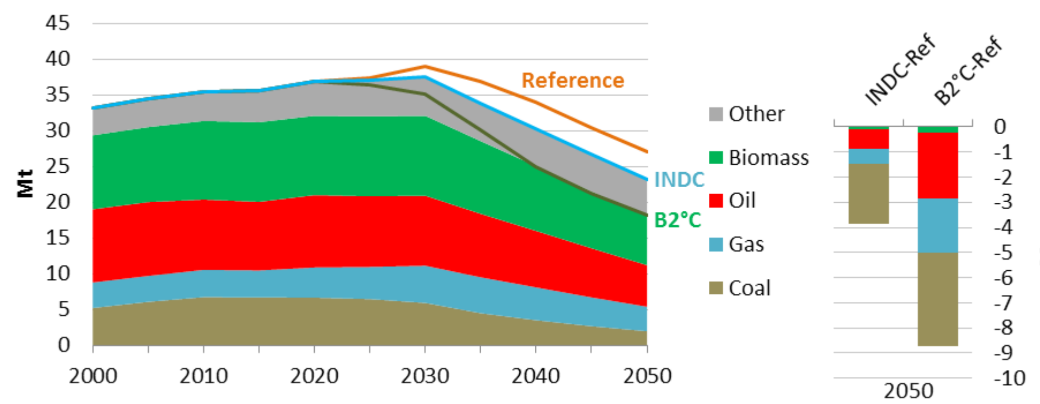
SO_2



NO_x



Primary $PM_{2.5}$

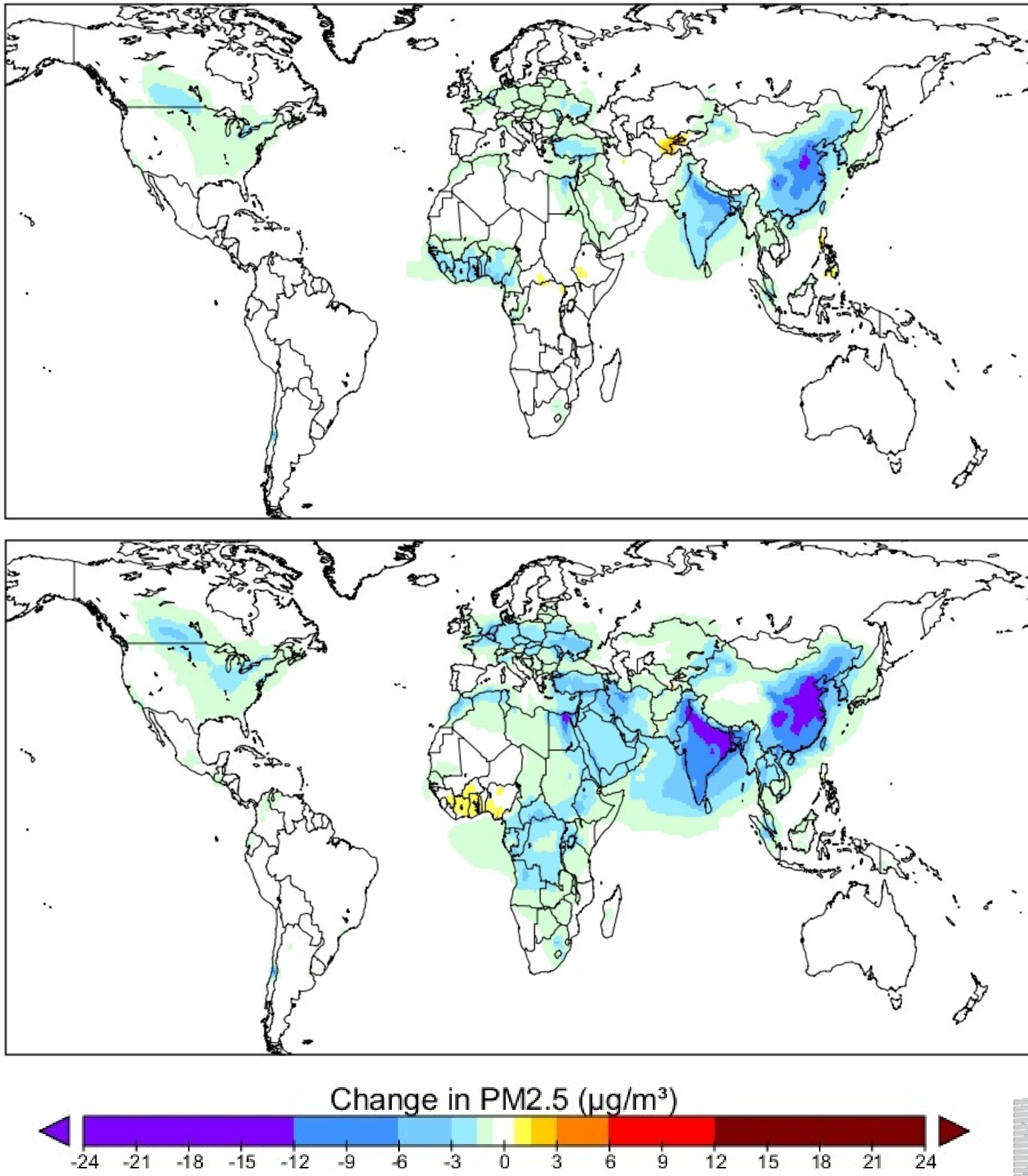


Source: JRC, GECO2017

Change in PM2.5 from climate policies relative to REF (PROG air quality policies, 2050)

INDC

B2°C



JRC TM5-FASST Air quality model

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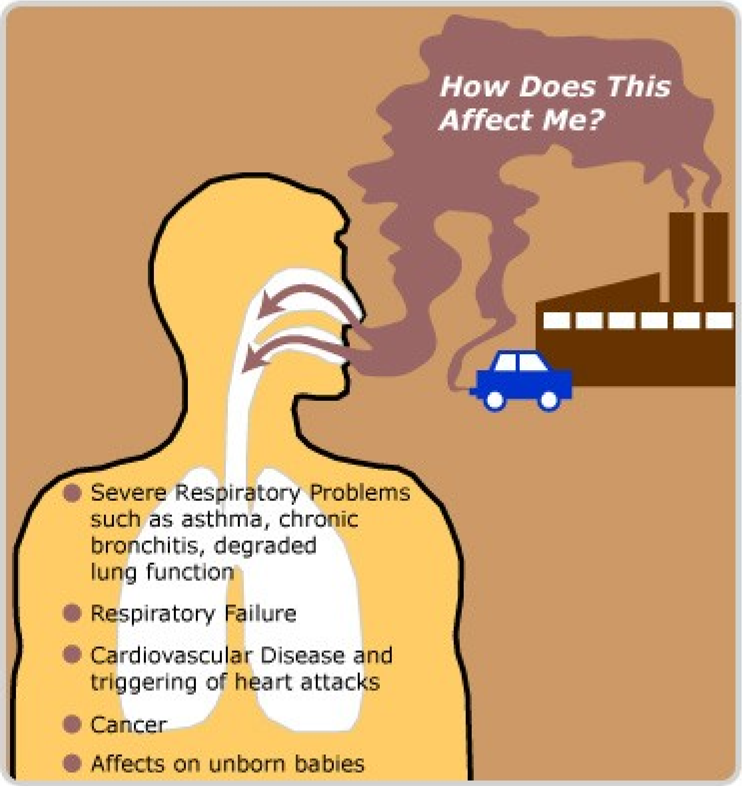
Impacts of air pollution:

Human health (PM2.5, Ozone)



- Premature mortalities
- Hospital admissions
- Work lost days

Crop yield loss (Ozone)

- Production loss 4 major crops: wheat , corn, rice, soybean

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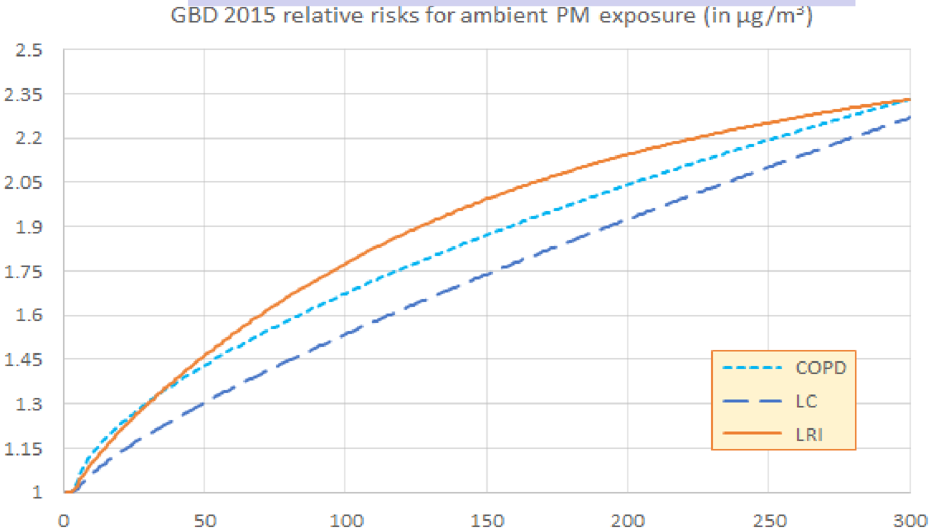
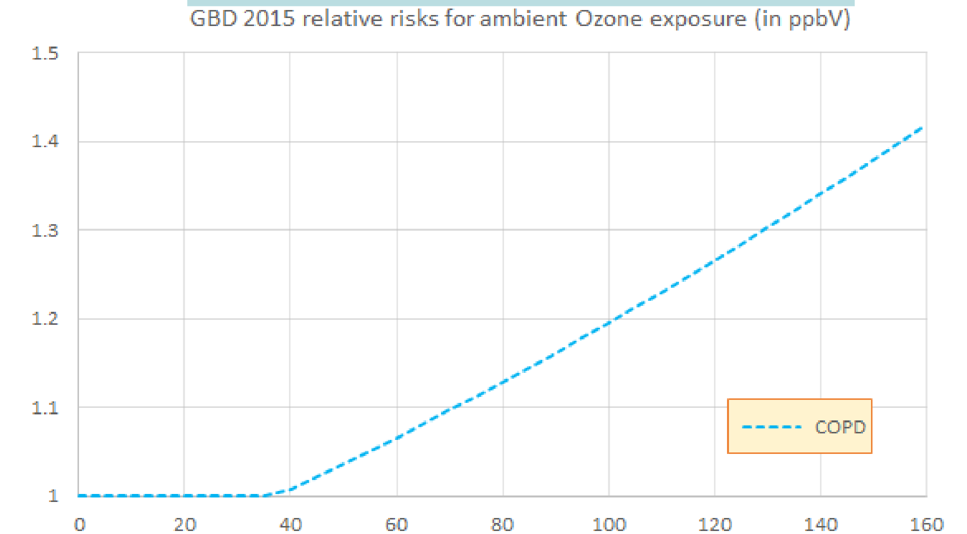
Relative risk for different health outcomes related to air pollution (Global Burden of Disease, 2015)

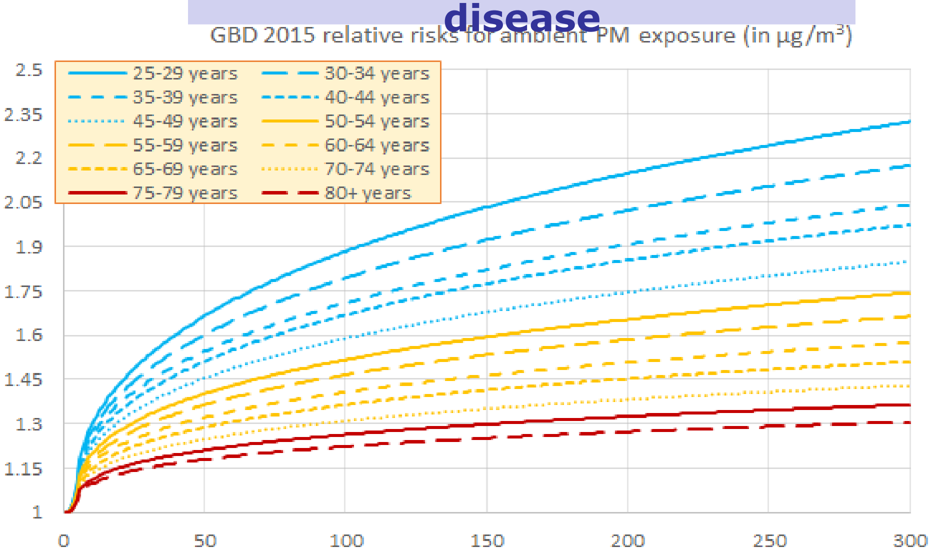
PM2.5, Respiratory diseases



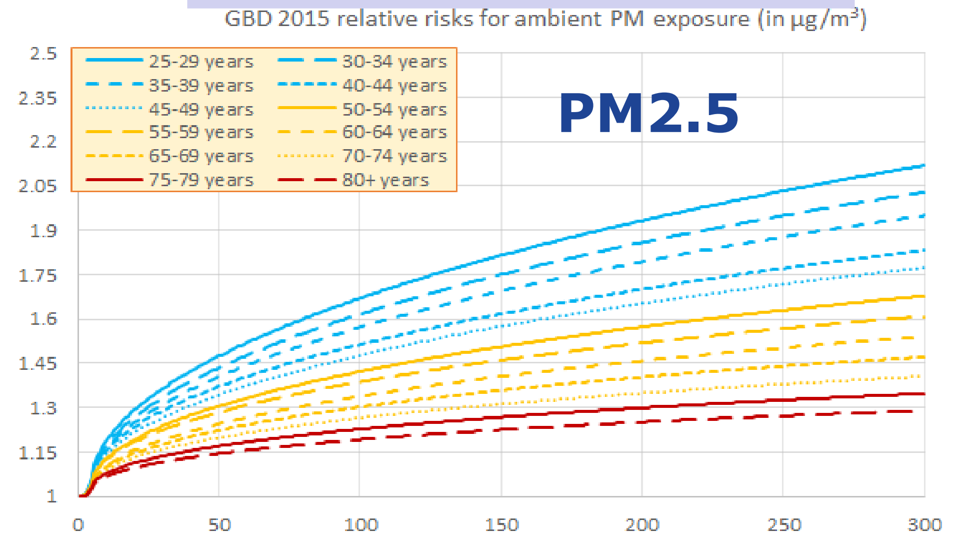
Ozone, Respiratory diseases



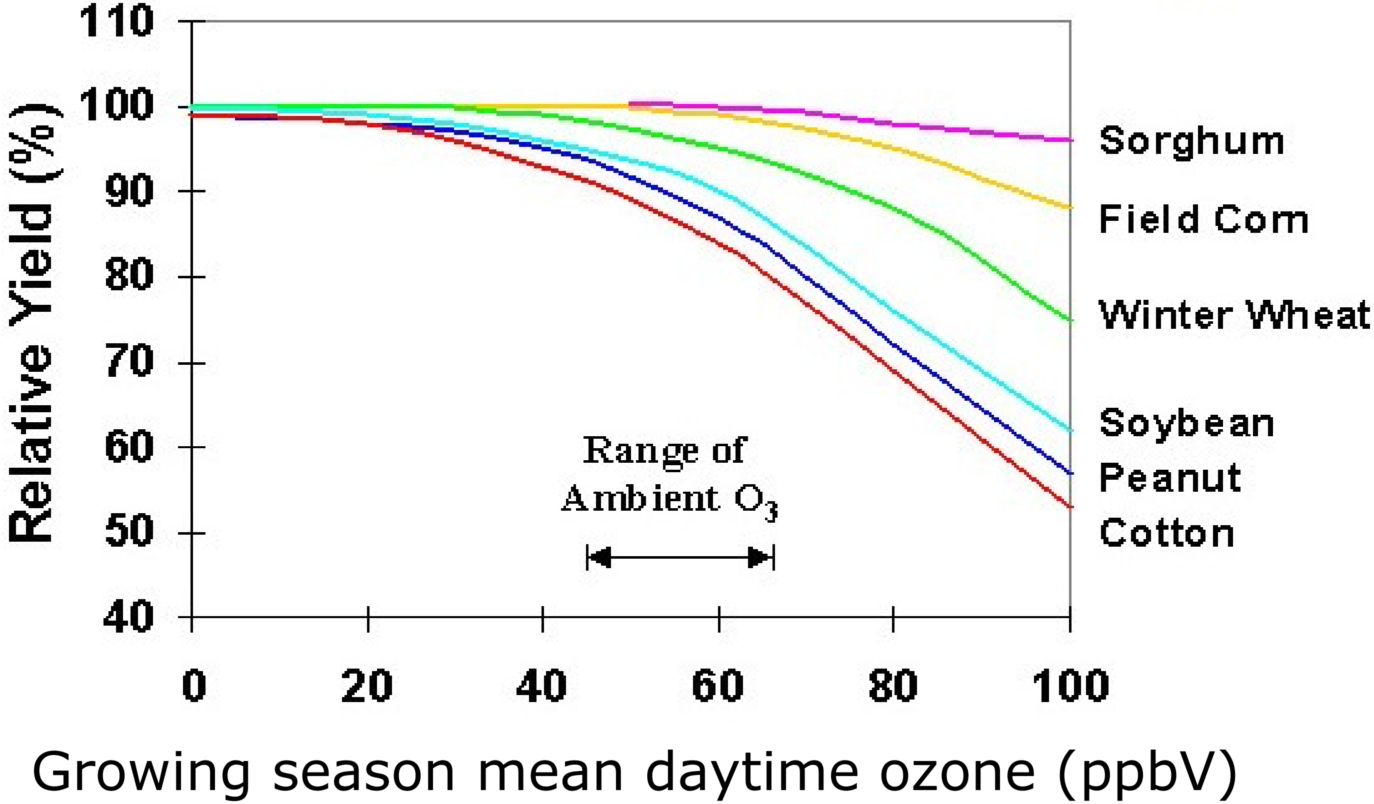
PM2.5, Ischaemic heart disease



PM2.5, Stroke



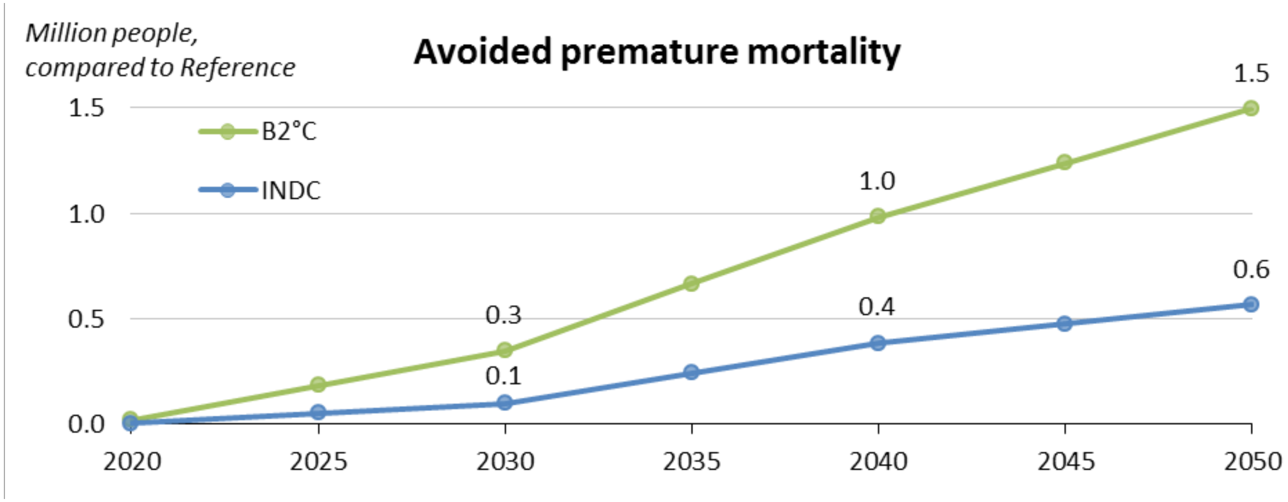
Crop O3 damage concentration – response functions

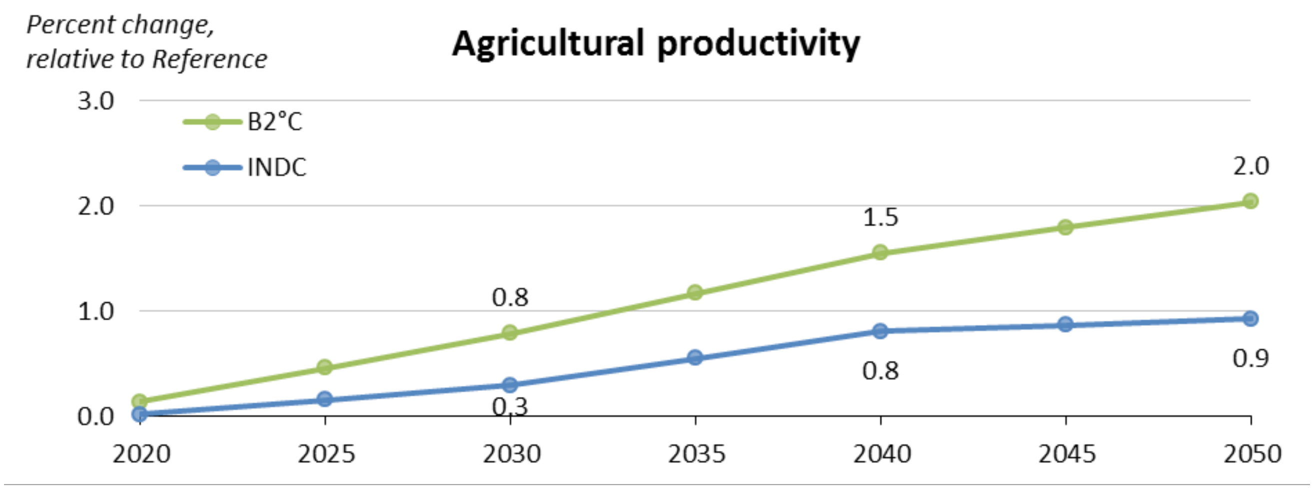


Source: Lesser et. al, 2009

Quantifying the benefits:

(FROZ)





Source: JRC, GECO2017

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Economic impacts:

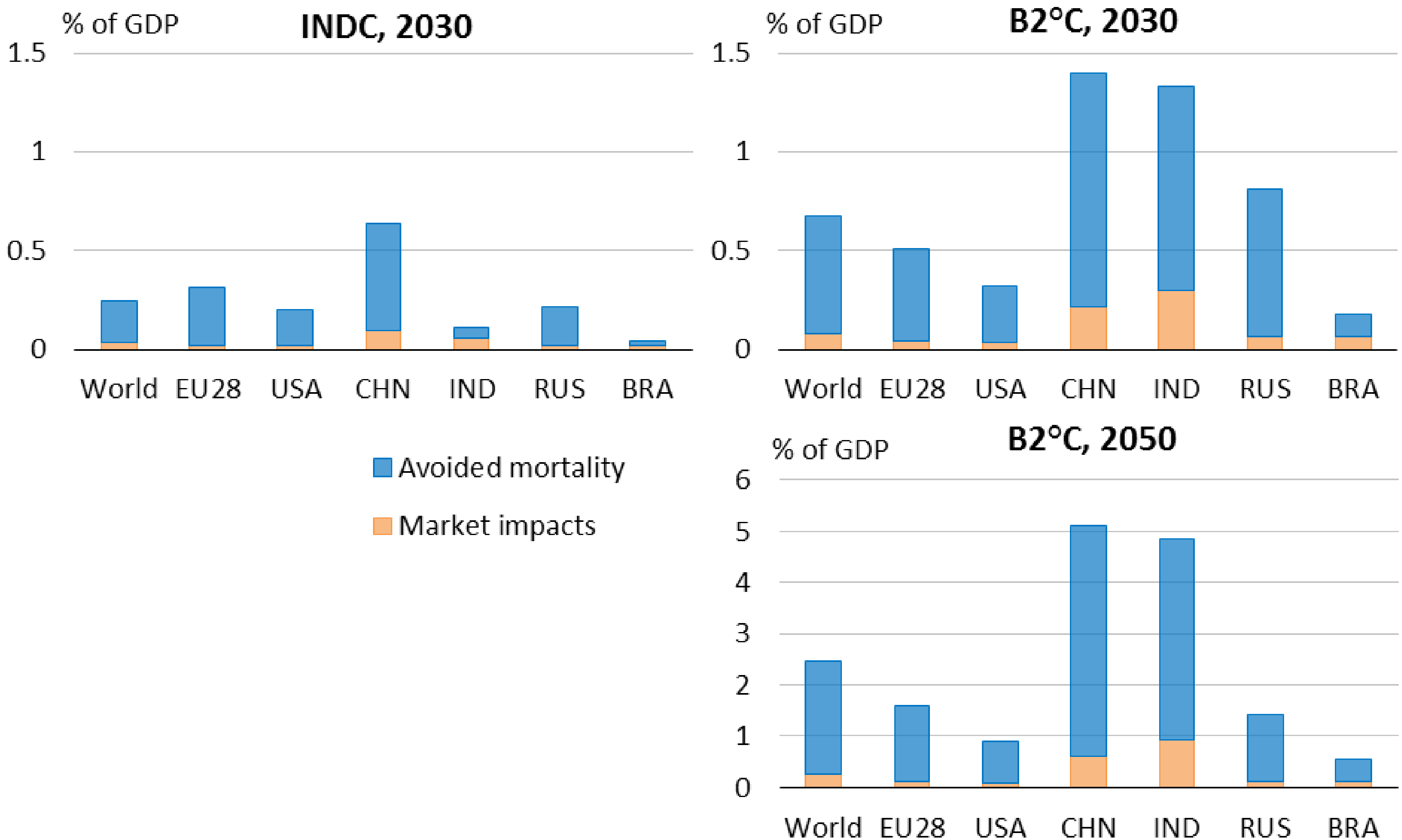
- Non-Market Macro-economic impacts
  - Mortality: Value of Statistical Life

$$VSL_i^t = VSL_{USA}^{2005} * \left(\frac{I_i^t}{I_{USA}^{2005}}\right)^{\alpha}$$

(*I* = GDP per capita, *α* = income elasticity factor)

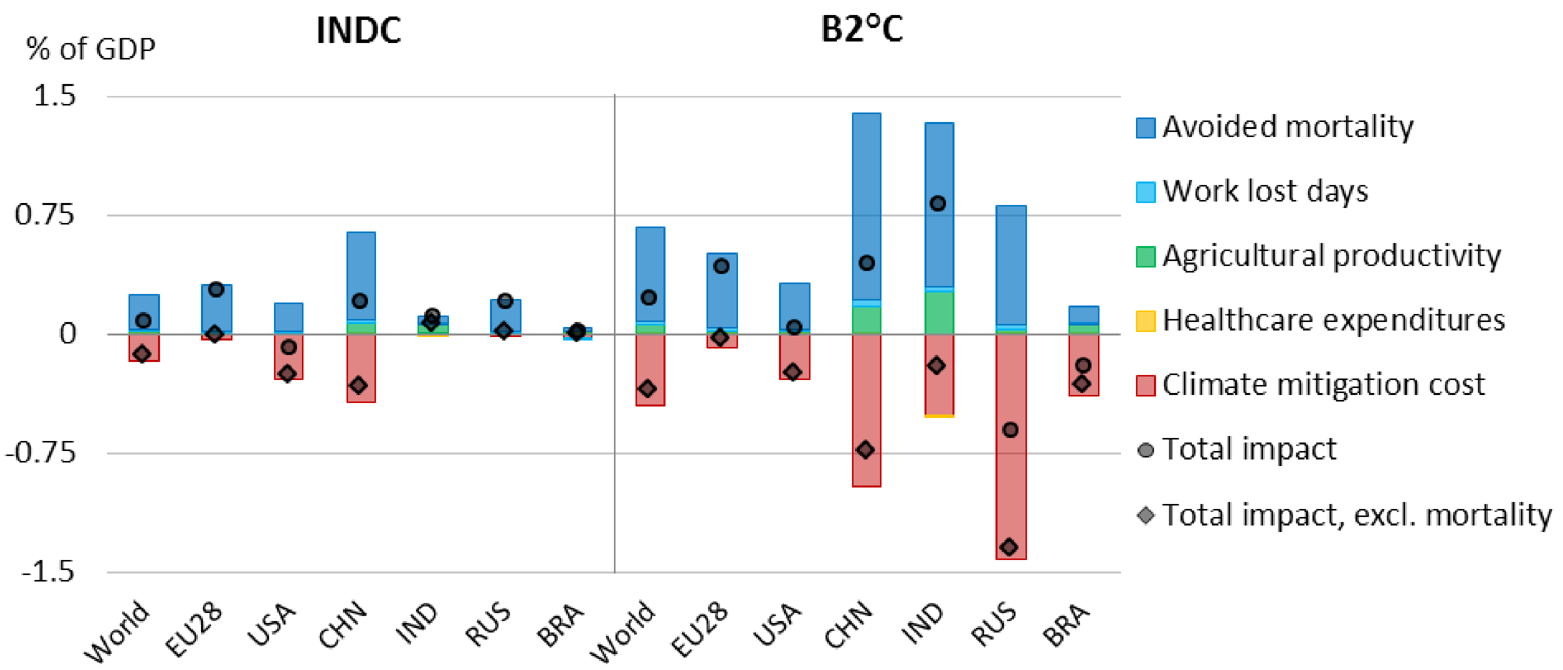
- Market Macro-Economic impacts (CGE Model JRC-GEM-E3):
  - work lost days
  - agricultural productivity
  - healthcare expenditures

Macro-economic impact of lower air pollution concentration levels as a consequence of climate policy



Source: JRC, GECO2017

Comparison of mitigation cost and air quality co-benefits in 2030



Source: JRC, GECO2017

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Key messages

- Major co-benefit of climate mitigation: avoided premature deaths from air pollution

  INDC scenario (+FROZ):

  100,000 avoided AP-related mortalities annually by 2030

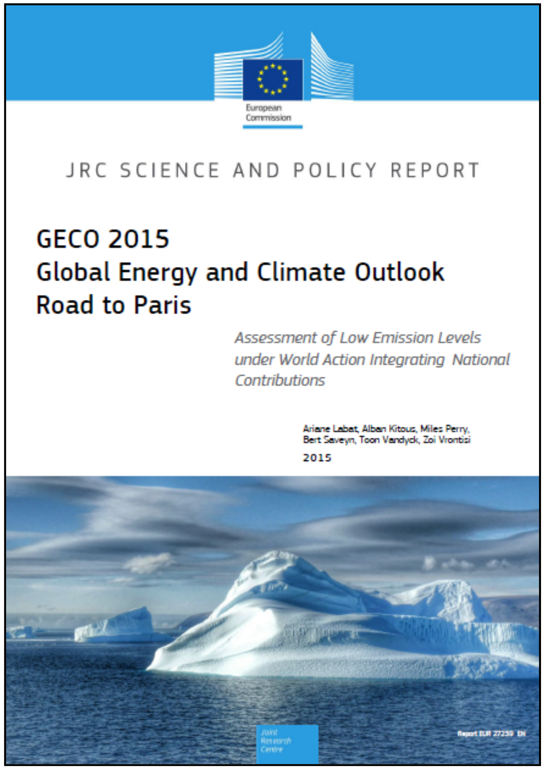
  (600,000 by 2050)

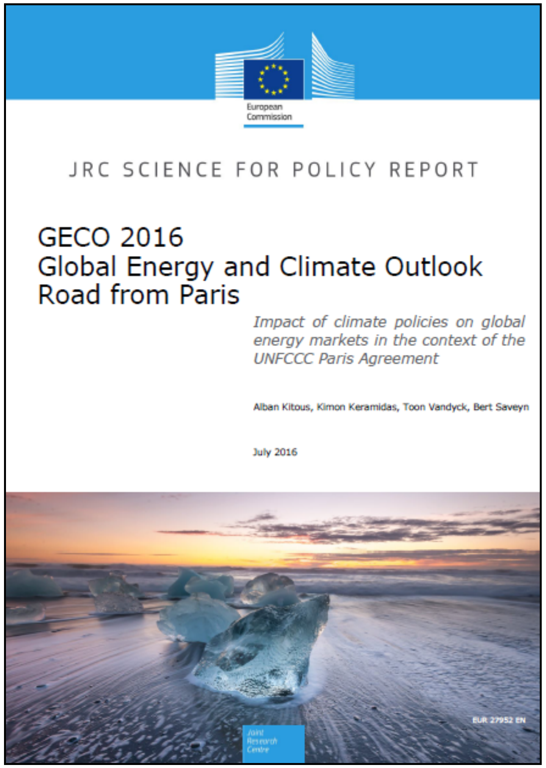
  B2°C scenario (+FROZ):

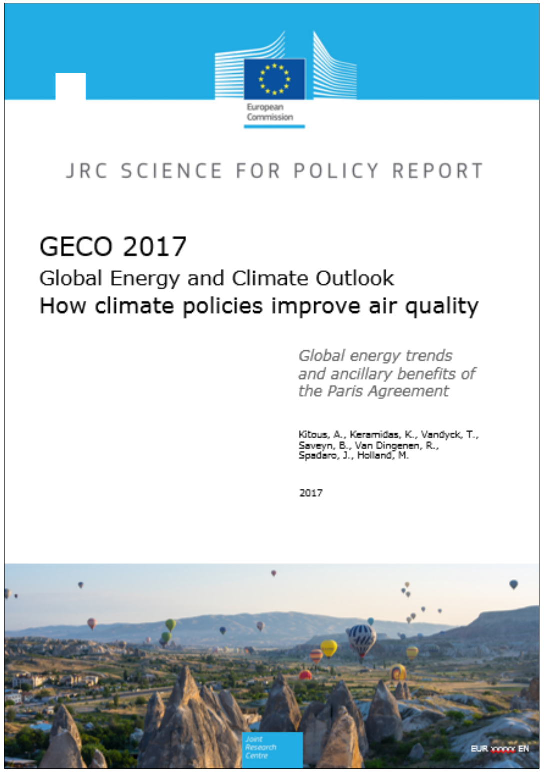
  300,000 avoided AP-related mortalities annually by 2030,
  (1.5E6 by 2050)

- By 2030, global air quality co-benefits more then compensate mitigation costs
- In contrast to GHG mitigation climate benefits, air quality co-benefits are short-term and local
- Climate action helps to achieve SDGs on health by 2030
- Further work: uncertainty propagation

Thank you!







(available soon)

https://ec.europa.eu/jrc/en/geco

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Caveats

- Does not consider the potential feedbacks of a changing climate (stronger when the climate mitigation policies are lower), either on the energy system or on the economic activity in general (agriculture, health, labour productivity, coastal infrastructures, migration).
- GDP impact of energy and climate mitigation policies considered here are not fed back into the scenarios, neglecting potential second order effects.
- Impacts of air pollution on buildings, acidification, eutrophication and ecosystems are not included.

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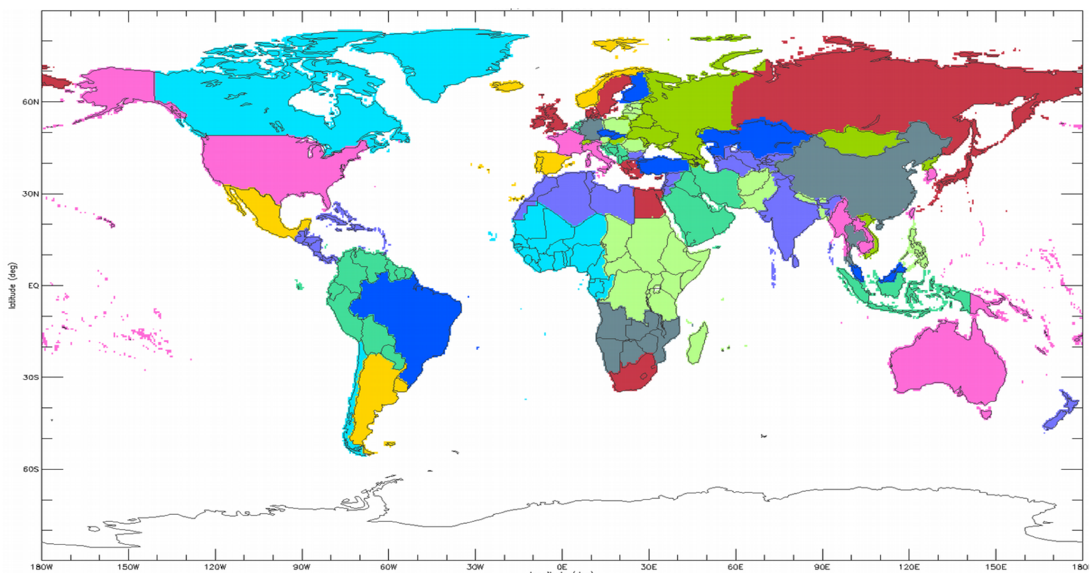
POLES-JRC regions

TM5-FASST regions



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POLES-JRC:
Prospective Outlook on Long Term Energy Systems

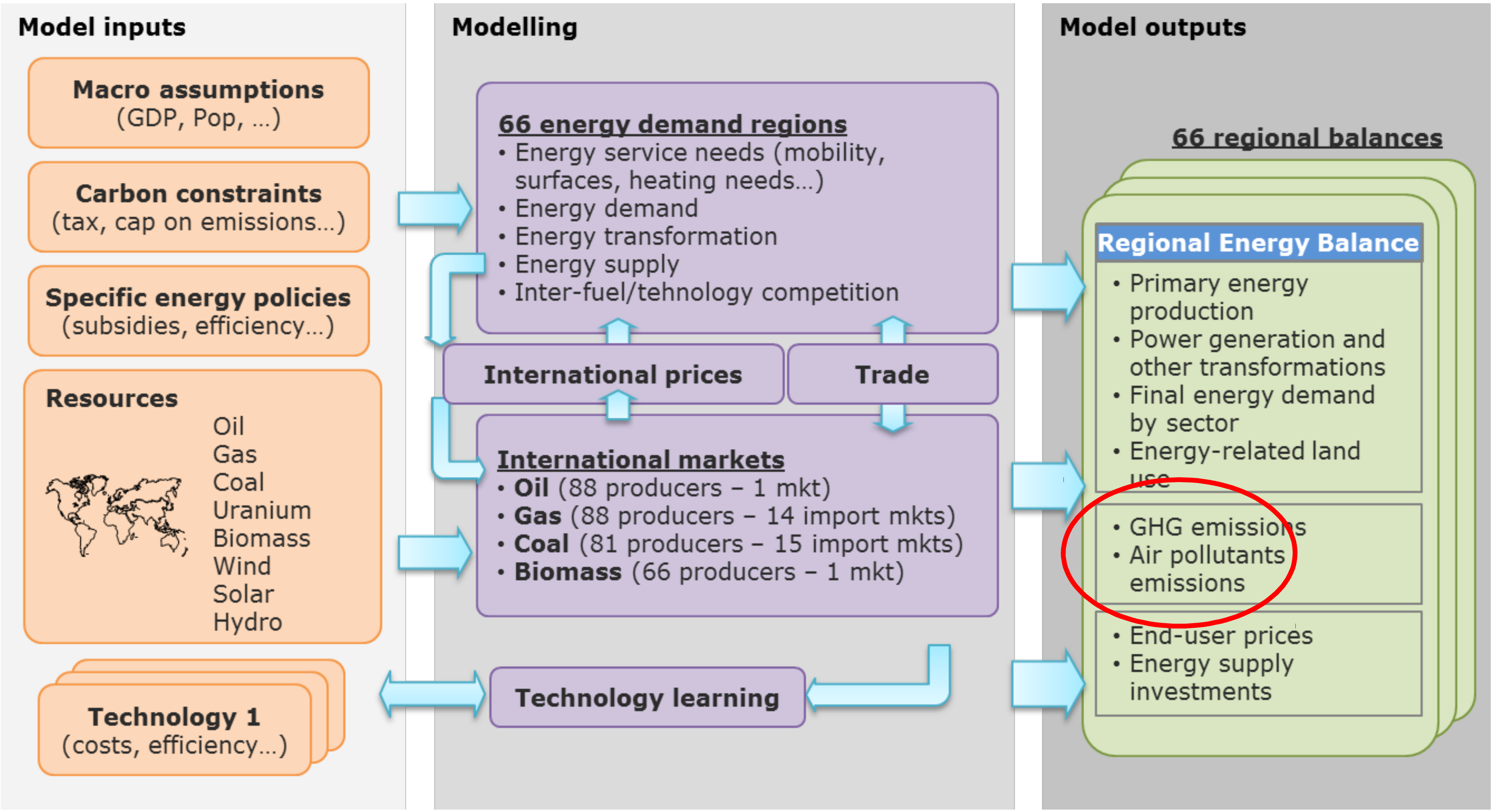
Global partial equilibrium model simulating the entire energy system, both demand and supply

Hybrid concept
- Bottom-up (engineering, explicit technology choices)
- Top-down (microeconomic foundation of economic decisions by agent, elastic demand)

Market-oriented: market equilibrium prices drive energy balancing of demand and supply per energy commodity
- Demand is function of price (via demand modules that use GDP, population and price as drivers of energy demand)
- Supply equals demand
- Supply a function of price (constrained by resource limits)

Lagged price effects (dynamic system)

POLES-JRC: Global partial equilibrium model simulating the entire energy system, both demand and supply



Source: JRC, GECO2017

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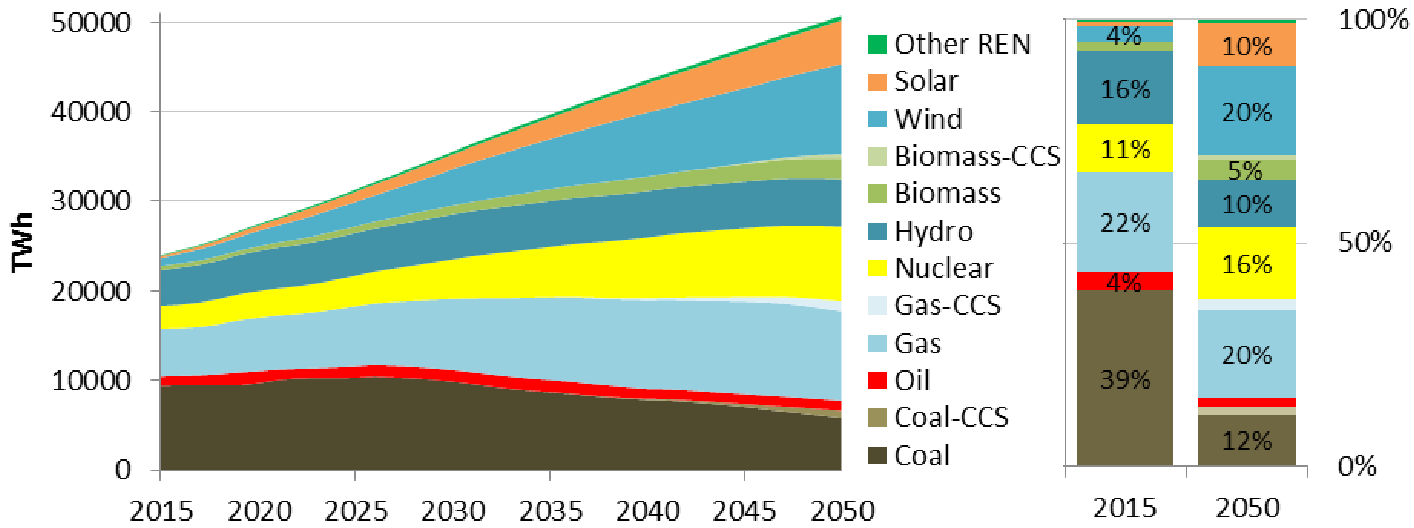

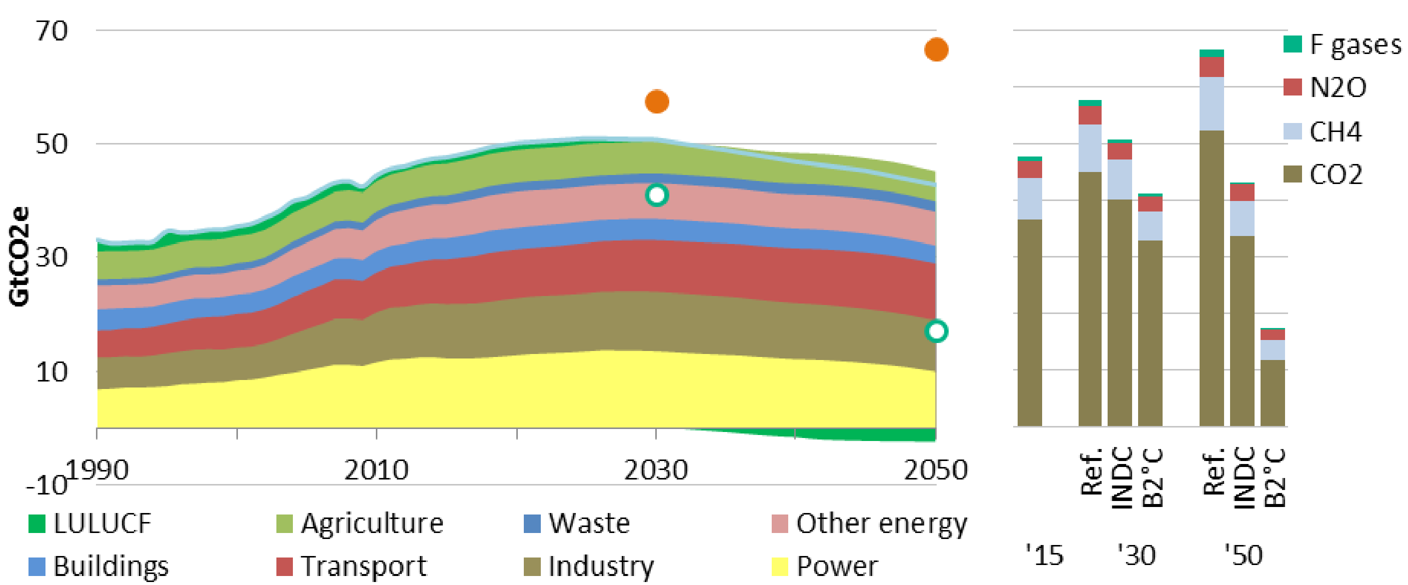

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Global pollutants emissions in 2010 and contributions from fossil fuels (Mt)

	Total	Excluding Fires	% in fossil fuels
SO_2	94	74	81%
NO_x	132	102	88%
$PM_{2.5}$	98	20	50%
CO	993	195	36%
VOC	140	40	36%
NH_3	61	1	2%

Remainder from biofuel

Remainder from agriculture

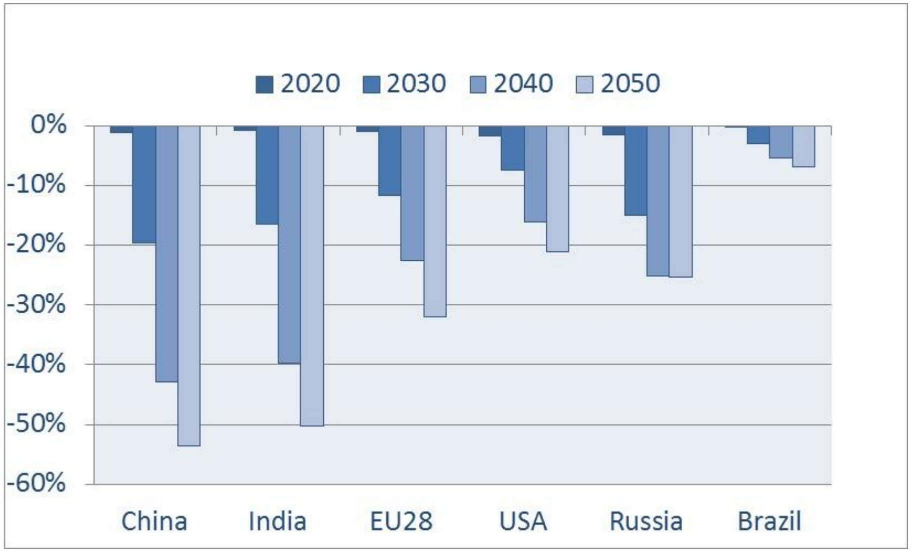
Source: JRC, GECO2017

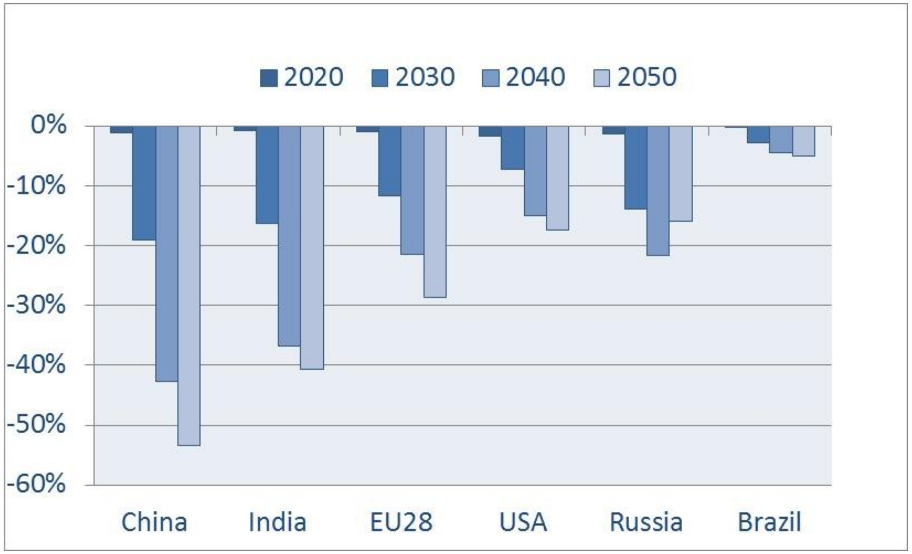
Relative reduction in anthropogenic PM2.5 exposure compared to REF

PM2.5 = Primary (BC+OC+other) + Secondary (SO_4+NO_3+NH_4)

Maximal co-benefit case:
AQ policy = FROZ,
CLIM policy = B2°

AQ policy = PROG,
CLIM policy = B2°C





Highest benefit in highly polluted – fast growing – low income regions
Lower benefits in regions relying on land-use measures

Source: JRC, GECO2017

Relative reduction in anthropogenic PM2.5 exposure compared to REF

PM2.5 = Primary (BC+OC+other) + Secondary (SO_4+NO_3+NH_4)

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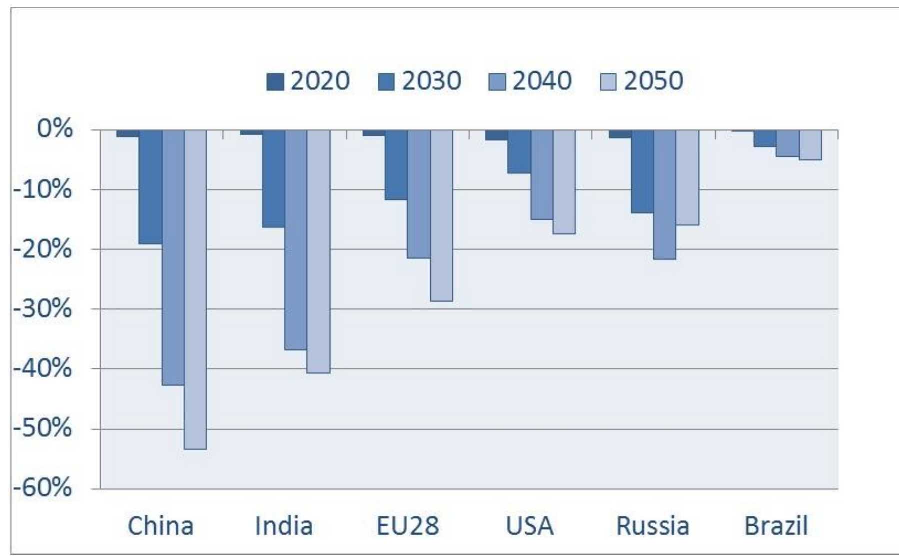

Highest benefit in highly polluted – fast growing – low income regions
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Source: JRC, GECO2017

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Morbidity: multiplier factors x Mortality

Morbidity-to-mortality multiplier factors for calculating cases of illness related to ambient air pollution (morbidity = multiplier factor × Total cause-specific deaths).

Illness	$PM_{2.5}$ (Non-Linear)	$PM_{2.5}$ (Linear model)	Ozone
Bronchitis, children [6 to 12 years]	4.82	3.04	
Asthma Symptom Days, children [5 to 19 years]	50.9	32.1	
Chronic bronchitis, adults [older than 27 years]	1.43	0.90	
Work Lost Days, workers [15 to 64 years]	547	345	
Hospital admissions [aged 64+ for ozone]	1.13	0.71	22.48
Minor Restricted Activity Days			23,215
Restricted Activity Days	1,967	1,240	

Source: JRC, GECO2017

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