HOW TO CONSIDER NEC REQUIREMENTS AND CO-BENEFITS (INCLUDING GHG) IN AN AIR QUALITY PLANS

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NAPCP – INTERACTION WITH AIR QUALITY

Interaction with plans and strategies

- Air quality planning interacts with plans and strategies for GHG reduction, energy, transport, noise,…
- Directive (EU) 2016/2284 on reduction of national emissions (“NEC Directive”) requires that National air pollution control programmes [NAPCP] contribute to a successful implementation of AQ plans
- Review of DG ENV of NAPCP: good practice model calculations of impact of NAPCP on AQ:
  - FR (changes of NO_2, PM_{10}, $PM_{2.5}$ and O_3),
  - DE: additional changes of wet and dry deposition NH_3, NOx and SO_2
- Review showed that most NAPCP consider National Energy and Climate Plans, and are using common datasets
- However, more systematic assessment of links between AQ and climate policies necessary

Source: Ricardo Energy & Environment, 2020. https://ec.europa.eu/environment/air/reduction/NAPCP.htm

INTERACTION WITH N BUDGETS

N budgets

Reactive nitrogen impacts biodiversity, climate, water quality, air quality and the ozone layer

- ➔ Policies to address reactive N emissions to air and water (biodiversity strategy, farm-to-fork strategy, Integrated Nutrient Management Action Plan, Zero Pollution Action Plan, NEC-Directive etc.)
- ➔ Regional and urban background AQ levels often effectively reduced by lowering NH_3 emissions
- ➔ National N budget instrument to cover different pathways of reactive N
- ➔ Cooperation with different policy areas necessary when addressing NH_3 and NO_x emission reductions
- German Umweltbundesamt proposed overall limit for reactive N for all sectors and media

  https://www.umweltbundesamt.de/presse/pressemitteilungen/uba-schlaegt-sektoruebergreifende-obergrenze-fuer

INTEGRATED ASSESSMENT MODELLING TO SUPPORT THE DESIGN OF NATIONAL AND REGIONAL PLANS COMPLYING WITH NECD AND THE GREEN DEAL

Integrated Assessment Modelling: objectives

The problem can be formalized as follow:

$$\min_{x} f(\boldsymbol{x}) = \min_{\boldsymbol{x}}[\mathrm{AQI}_m(\boldsymbol{x}), \mathrm{TC}(\boldsymbol{x})] \qquad m = 1..M$$

where:

- AQIm are a set of (M) Air Quality Index (PM10, PM10, NO2, yearly mean concentrations, AOT40, SOMO35,…).
- TC is the total cost of measures applied to reduce the air pollutant emissions.

Integrated Assessment Modelling: decision variables

The problem can be formalized as follow:

$$\min_{x} f(\boldsymbol{x}) = \min_{\boldsymbol{x}}[\mathrm{AQI}_m(\boldsymbol{x}), \mathrm{TC}(\boldsymbol{x})] \qquad m = 1..M$$

x is the decision variable set that includes **end-of-pipe** and **energy** (technological, fuel switch and behavioural) measures.

In a real application, decision variables are hundreds, often thousands.

Integrated Assessment Modelling: costraints

The problem can be formalized as follow:

$$\min_{x} f(\boldsymbol{x}) = \min_{\boldsymbol{x}}[\mathrm{AQI}_m(\boldsymbol{x}), \mathrm{TC}(\boldsymbol{x})] \qquad m = 1..M$$

The problem is subjected to **a set of (linear and non-linear) constraints** that defines the feasible space of the problem solutions.

The constraints are related to the specific problem and domain. They can include for example the measure physical boundaries (e.g. the feasible application levels) and the energy demand satisfaction but also the **GHGs emissions reductions set by the EU Green Deal** and the **precursors emission levels set by the NECD**.

Integrated Assessment Modelling: solutions

The problem can be formalized as follow:

$$\min_{x} f(\boldsymbol{x}) = \min_{\boldsymbol{x}} [\mathrm{AQI}_m(\boldsymbol{x}), \mathrm{TC}(\boldsymbol{x})] \qquad m = 1..M$$

If the decision variable set is not null, **the solution** of the multi-objective multipollutant problem is **an efficient AQ&LC policy complying with the NECD and GHGs emission reduction levels**.

Otherwise, when the feasible set is null, sub optimal solutions can be achieved reducing

- objectives e.g., considering just one or two AQI
- or constraints in particular, the levels of GHG and/or precursor emission reduction (NECD)

AQ&LC IAM tools

- GAINS model (Amann et al. 2011) that produced the scientific basis for NECD (European scale)
- GAINS national models used to design national AQ plans compliant with NECD,
- At regional scale the MAQ system (Turrini et. al 2018, De Angelis et al. 2021),
- …..

A CASE STUDY.
LOW EMISSION ROAD TRANSPORT SCENARIOS: ENERGY DEMAND, AIR QUALITY, GHG EMISSIONS, AND COSTS IN LOMBARDY REGION.

De Angelis E., Carnevale C., Di Marcoberardino G., Turrini E., Volta M, (2021). Low Emission Road Transport Scenarios: An Integrated Assessment of Energy Demand, Air Quality, GHG Emissions, and Costs. IEEE Transactions on automation science and engineering. **DOI** 10.1109/TASE.2021.3073241

Low emission road transport policy

- **Light duty vehicles, cars and mopeds are shifted to electric vehicles;**
- **Heavy duty vehicles are powered by biomethane.**

Fuel	Activity Level [PJ]			η [-]
	Cars	LDV	Mopeds	
Diesel	97.5	9.8	0.0	0.4
Gasoline	27.9	0.6	0.7	0.3
LPG	20.6	0.0	0.0	0.3
Natural gas	3.7	0.2	0.0	0.3
Gross electric fleet energy	160.9			0.9
Net energy considering engine efficiency (ICE and electric)	65.6			
Energy demand considering 46% electricity production and distribution efficiency	**142.6**			

Fuel	Activity Level [PJ]	η [-]
	HDV	
Diesel	66.2	0.4
Natural gas	0.1	0.3
Total	66.4	
Net energy considering engine efficiency on biomethane	**88.4**	

INCREASE IN ELECTRICITY DEMAND

Evaluation of low emission road trasport policies

$$f(\boldsymbol{x}) = \min_{\boldsymbol{x}} [\mathrm{AQI}_{\mathrm{PM2.5}}(\boldsymbol{x}), \mathrm{AQI}_{\mathrm{NO2}}(\boldsymbol{x}), \mathrm{TC}(\boldsymbol{x}), \mathrm{GHG}(\boldsymbol{x})]$$

$x \in \mathrm{X}$

Air Quality Indexes

Total cost

Greenhouse gases emissions

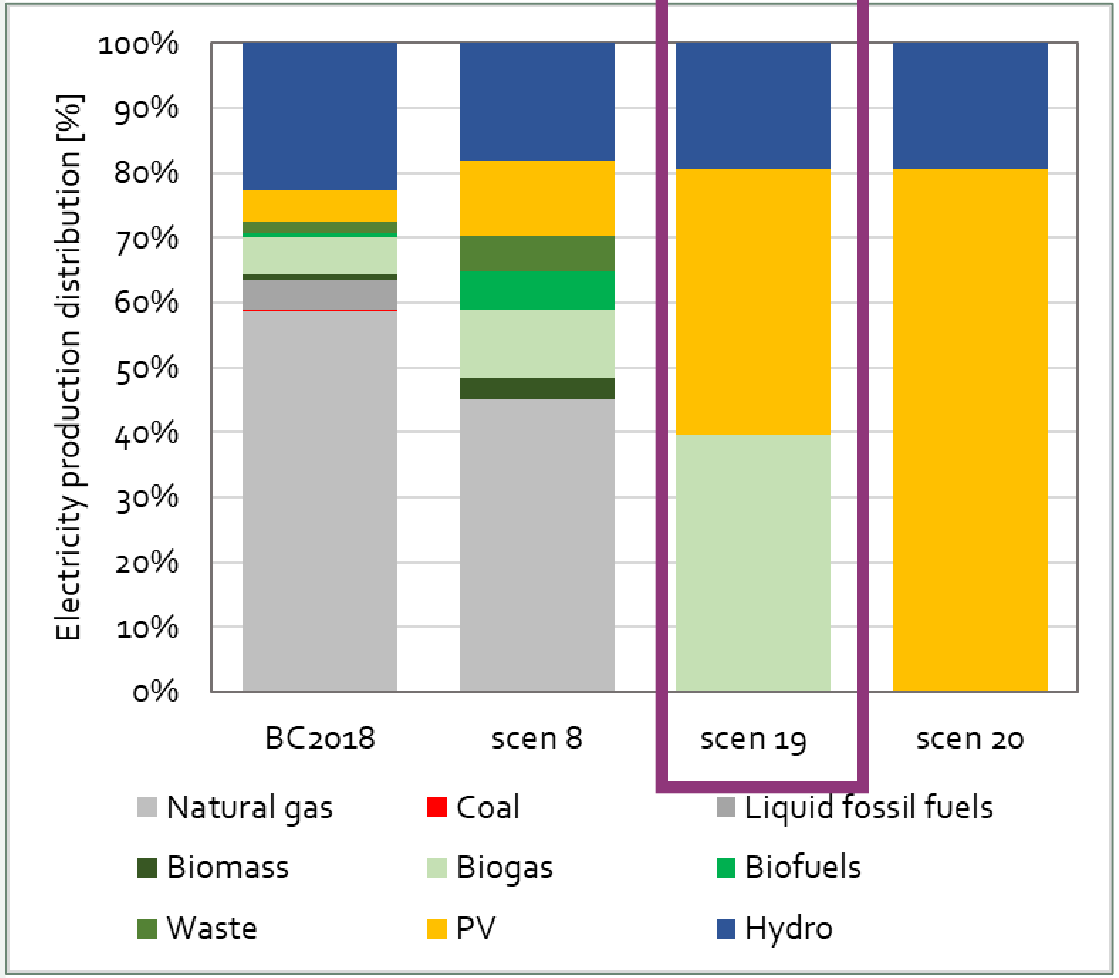
Control variables $\boldsymbol{x} = \begin{bmatrix} \boldsymbol{r} \\ \mathbf{nr} \end{bmatrix}$

r: renewable sources electricity production

nr : non-renewable sources electricity production

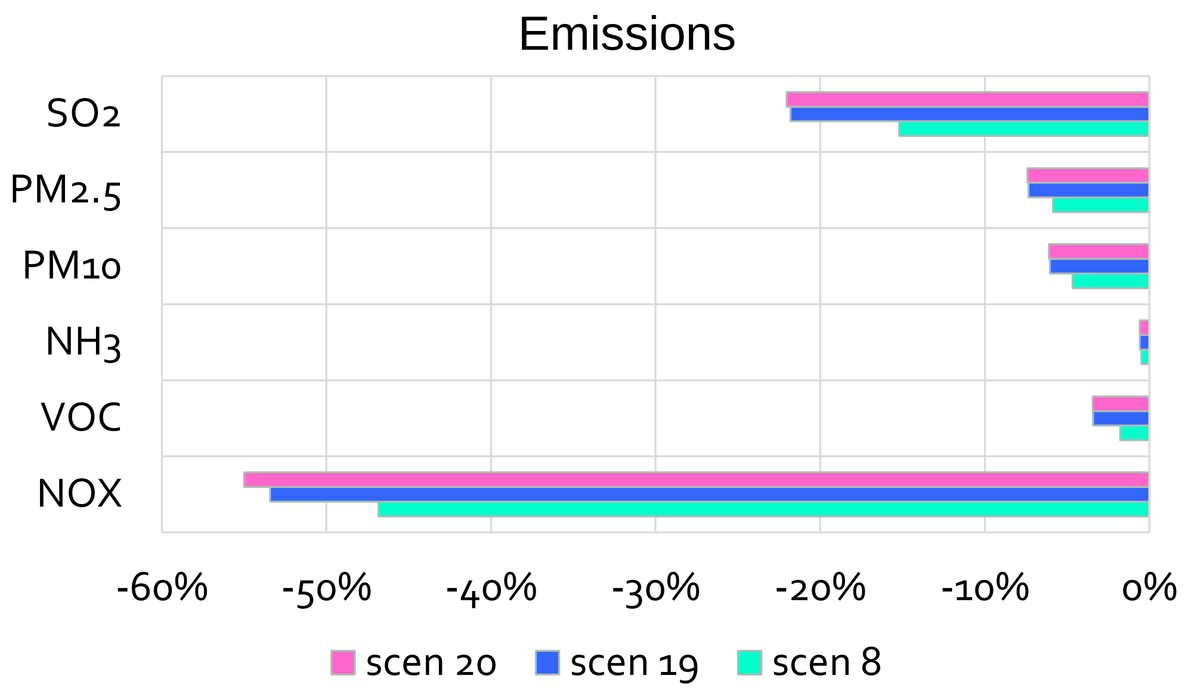
Results

Electricity production

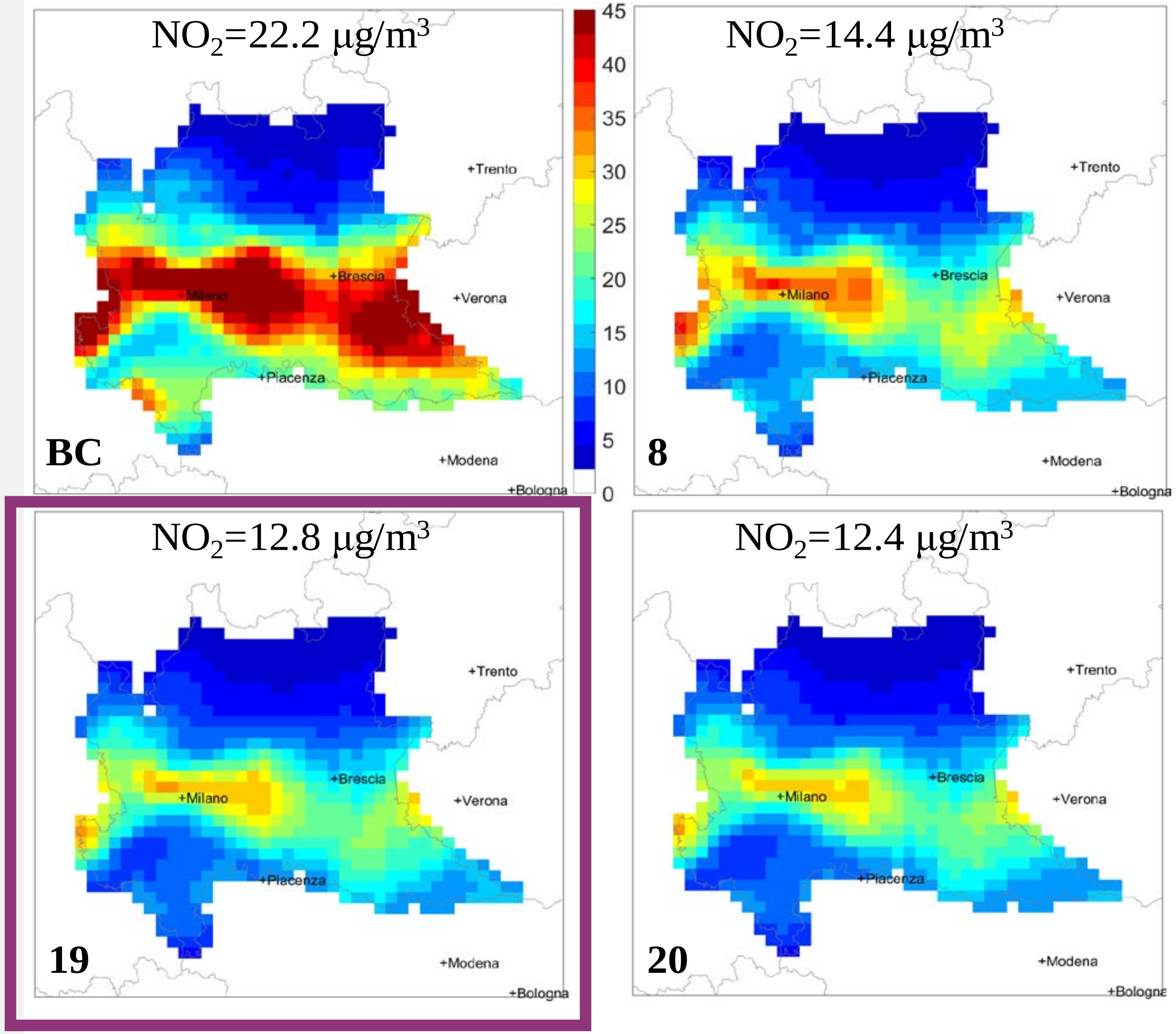


Objectives

Scen	Cost over BC [M€/yr]	$\Delta PM_{2.5}$ [%]	ΔNO_2 [%]	ΔCO_2 [%]
8	2905	-5.1%	-35.3%	-20.0%
19	10550	-6.1%	-42.4%	-29.1%
20	20773	-6.2%	-44.0%	-29.1%



Results



	Cost over BC	Mortality YLL PM2.5		Mortality YLL NO2	
	M€/yr	months	%	months	%
BC2018	0	9.9	-	1.3	-
8	2905	9.5	-4.8%	0.86	-35%
19	10550	9.4	-5.8%	0.76	-42%
20	20773	9.4	-5.8%	0.74	-44%

THANKS