A multi-scale analysis of NECD impacts over Northern Italy

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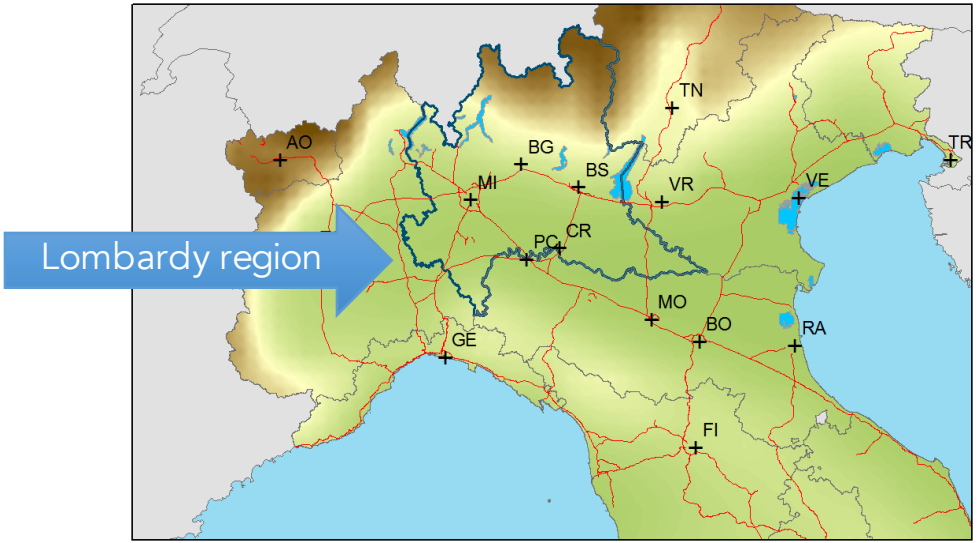
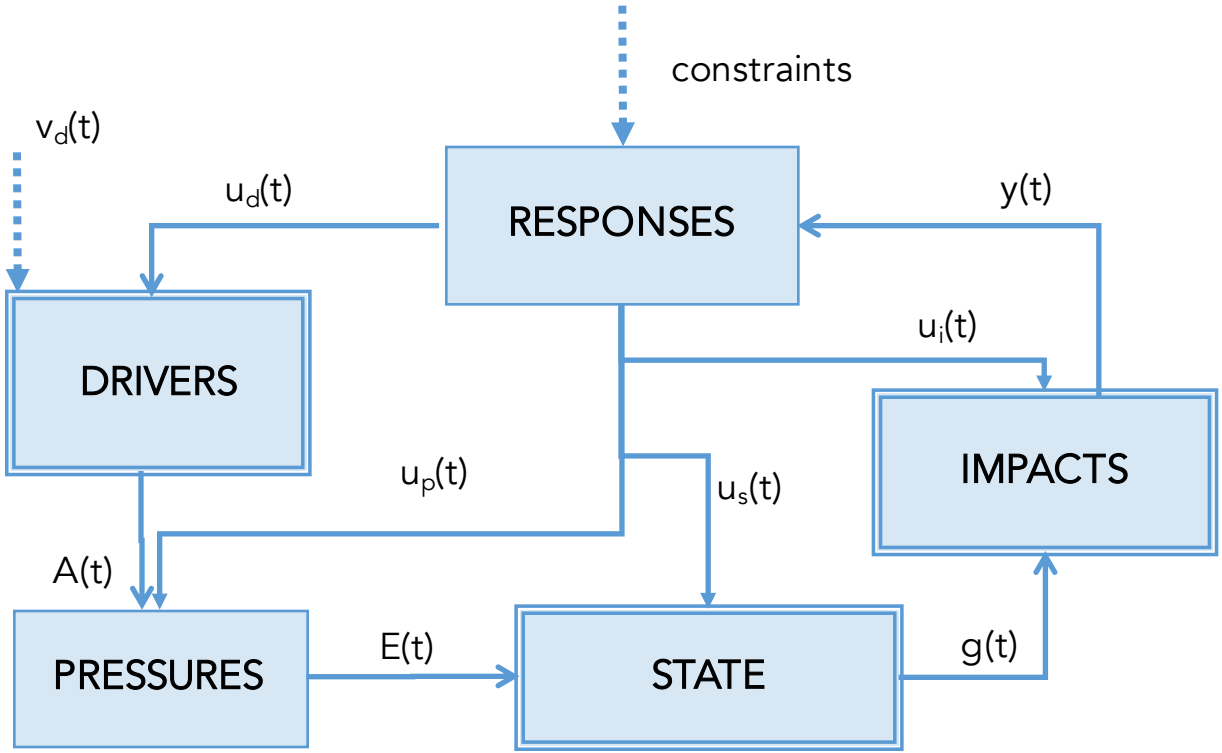
focus

- Is NECD effective in Lombardia Region?
- which regional policy?
- which tools?



DPSIR



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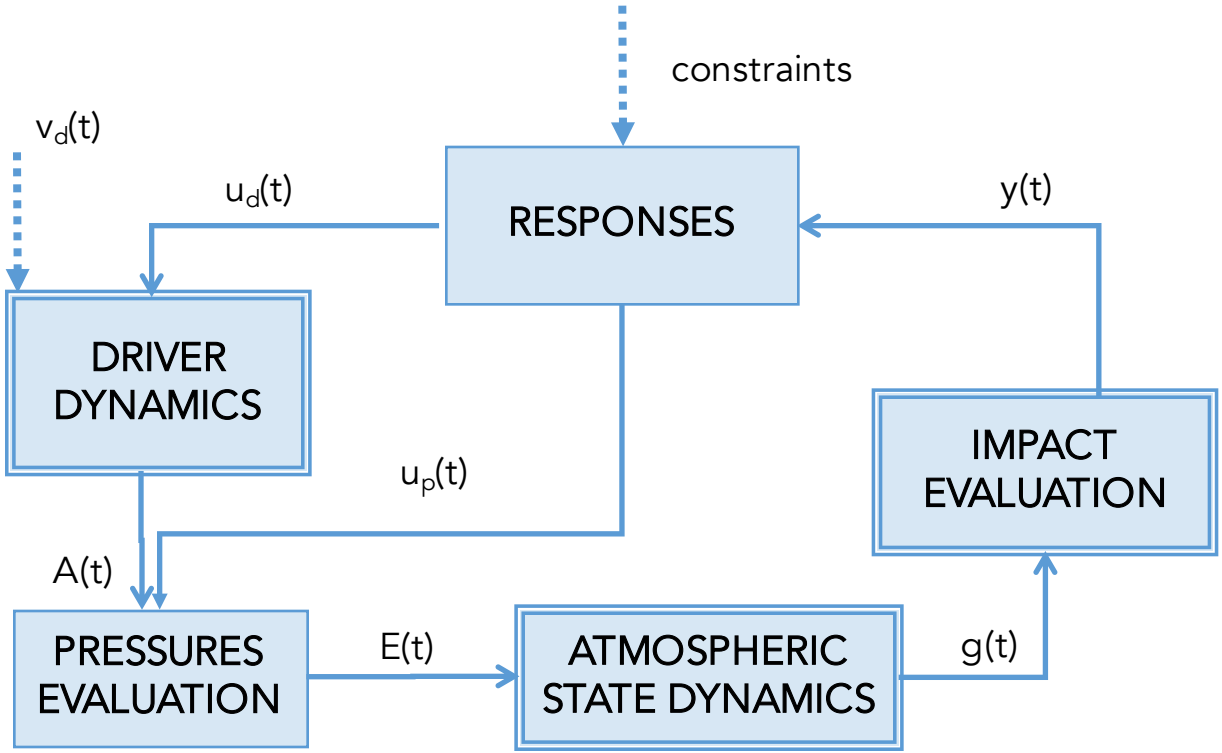
MAQ



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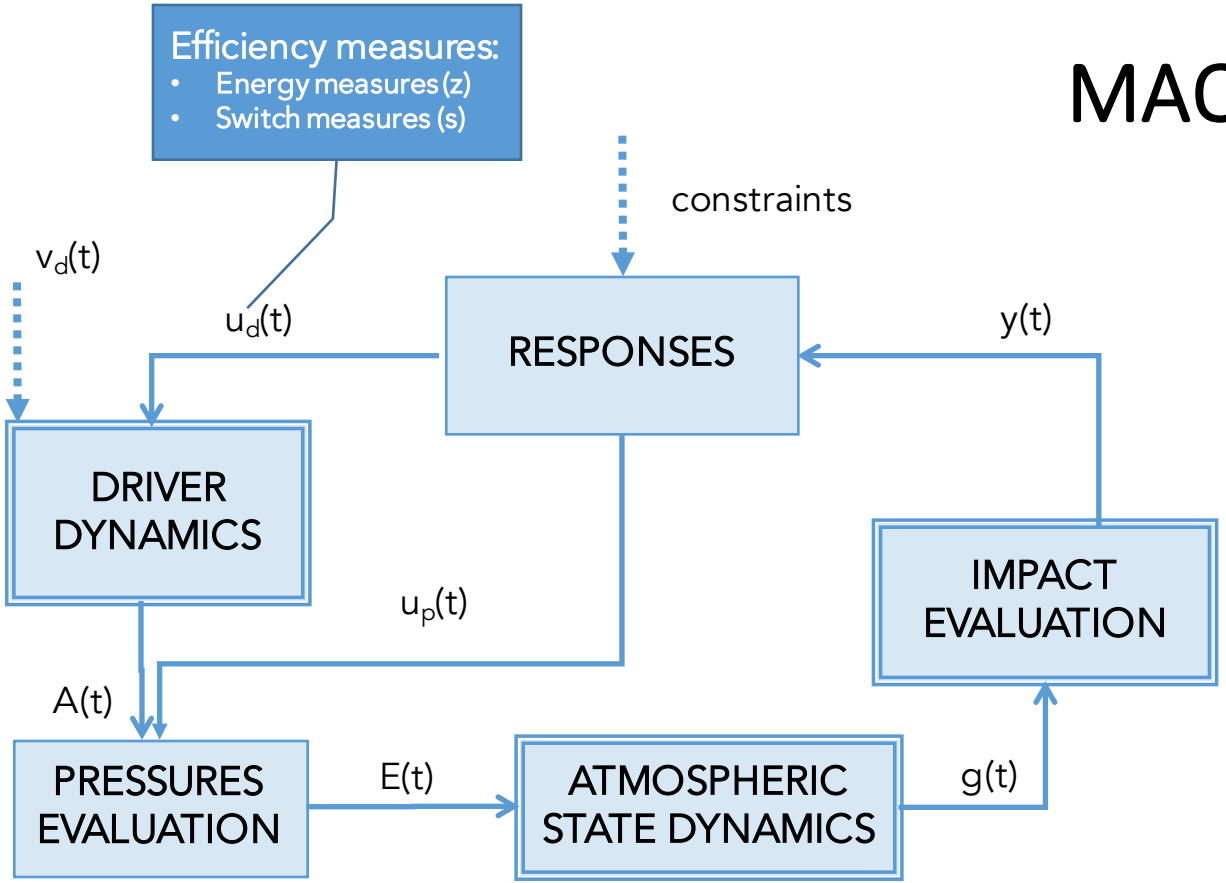
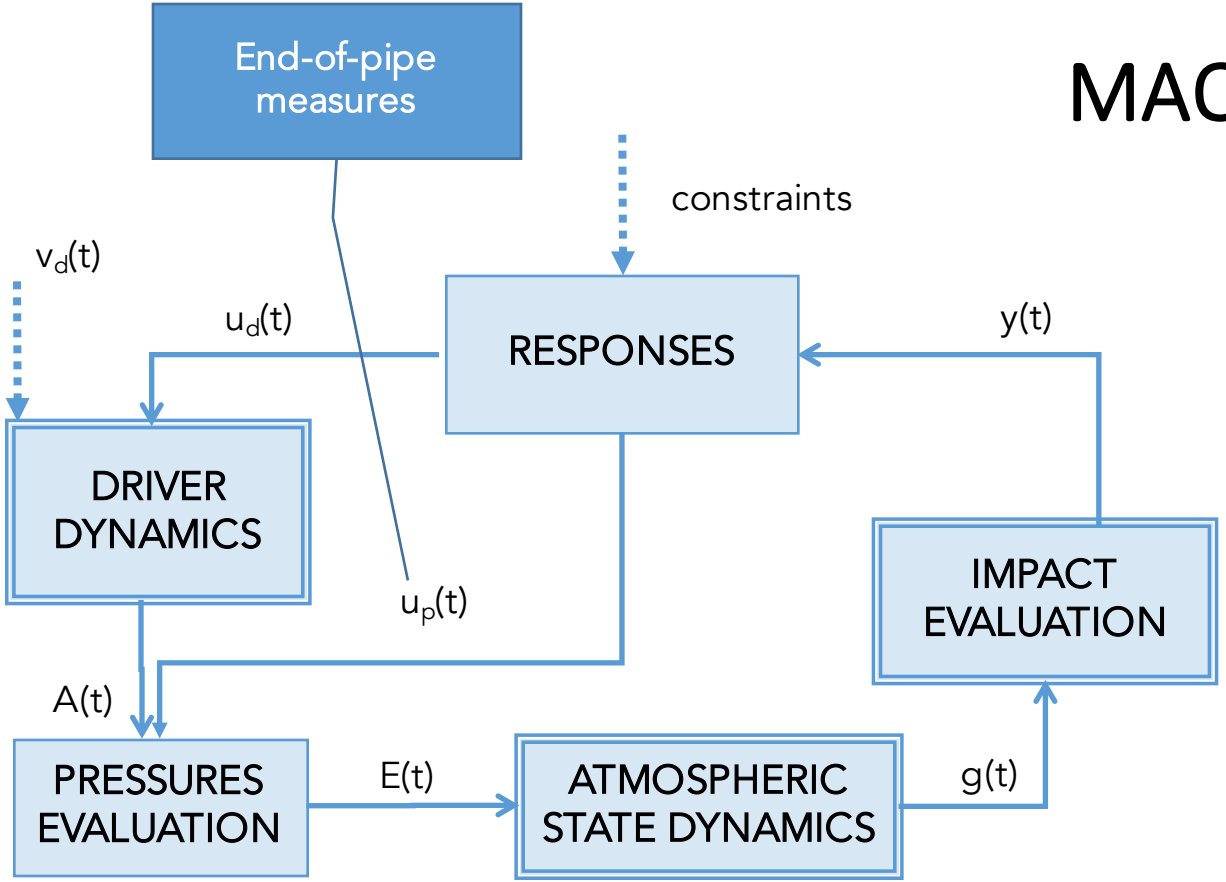
E. Turrini, et al., "A non-linear optimization programming model for air quality planning including co-benefits for GHG emissions," Sci. Total Environ., 621, pp. 980-989, 2018

MAQ


Efficiency measures:
• Energy measures (z)
• Switch measures (s)
constraints
$v_d(t)$
$u_d(t)$
RESPONSES
y(t)
DRIVER DYNAMICS
IMPACT EVALUATION
$u_p(t)$
A(t)
PRESSURES EVALUATION
E(t)
ATMOSPHERIC STATE DYNAMICS
g(t)

MAQ


End-of-pipe measures
constraints
$v_d(t)$
$u_d(t)$
RESPONSES
$y(t)$
DRIVER DYNAMICS
$u_p(t)$
IMPACT EVALUATION
$A(t)$
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$E(t)$
ATMOSPHERIC STATE DYNAMICS
$g(t)$

RESPONSES
multi-objective problem

$$\min_{x,z,s} J(x,z,s) = \min_{x,z,s} \left[AQI(x,z,s) \quad C(x,z,s) \right]$$

$$x, y, s \in \Theta$$

$$\frac{\partial AQI(x,y,s)}{\partial(x,y,z)} = \frac{\partial AQI(x,y,s)}{\partial E(x,y,z)} \cdot \frac{\partial E(x,y,s)}{\partial(x,y,s)}$$

Surface Response Function:
Artificial Neural Network

RESPONSES
multi-objective problem

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$$E^{d,p} = \sum_{k \in K} A_k^d \cdot ef_k^p$$

Emission factor

Activity level

RESPONSES
multi-objective problem

$$\min_{x,z,s} J(x,z,s) = \min_{x,z,s} \left[AQI(x,z,s) \quad C(x,z,s) \right]$$

$$x, y, s \in \Theta$$

$$E^{d,p}(x) = \sum_{k \in K} \left[A_k^d \cdot ef_k^p \cdot \left(1 - \sum_{t \in T_k} eff_t^p \cdot x_k^t \right) \right]$$

End-of-pipe measures $u_p(t)$

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RESPONSES
multi-objective problem

$$\min_{x,z,s} J(x,z,s) = \min_{x,z,s} \left[AQI(x,z,s) \quad C(x,z,s) \right]$$

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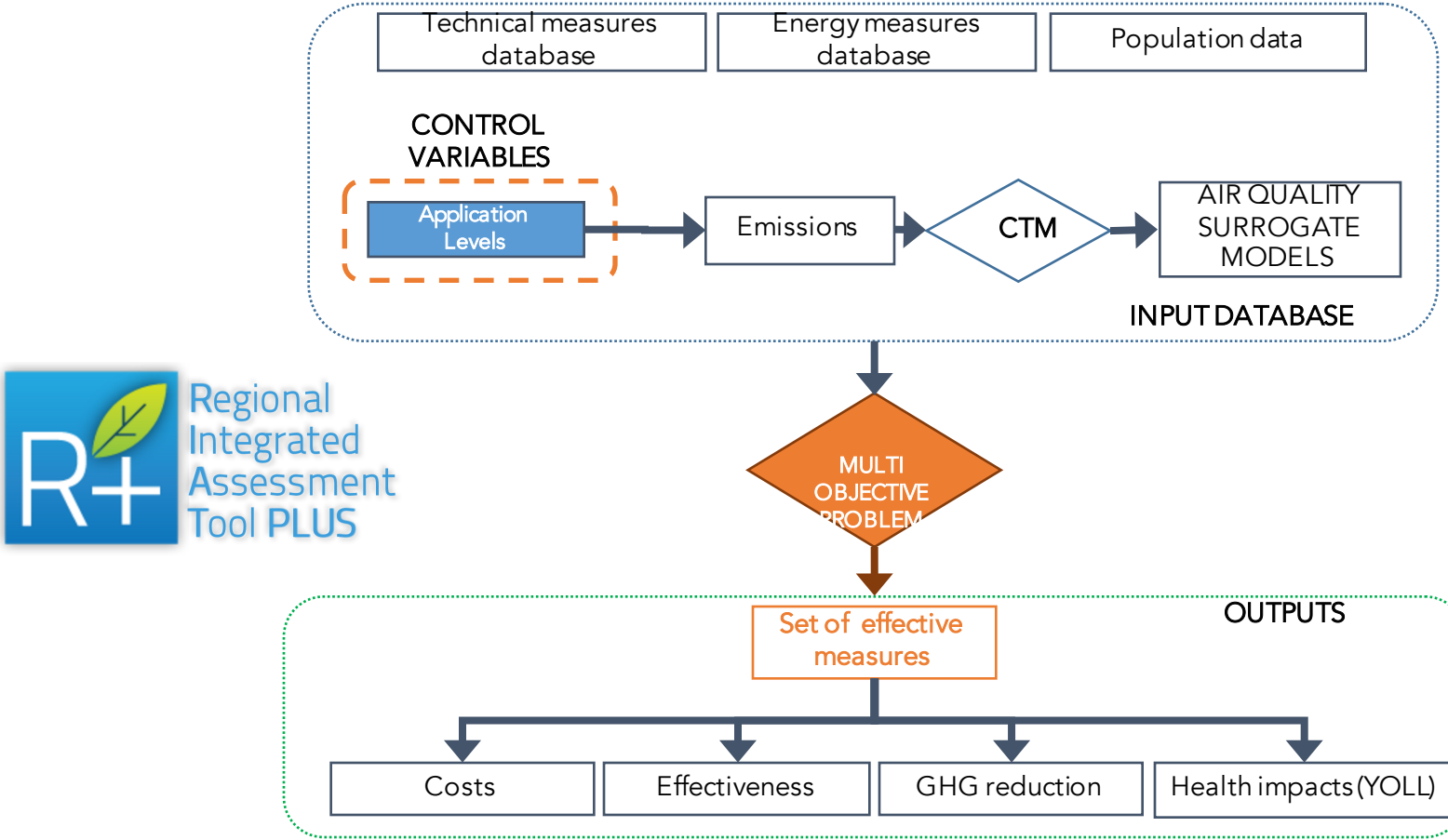
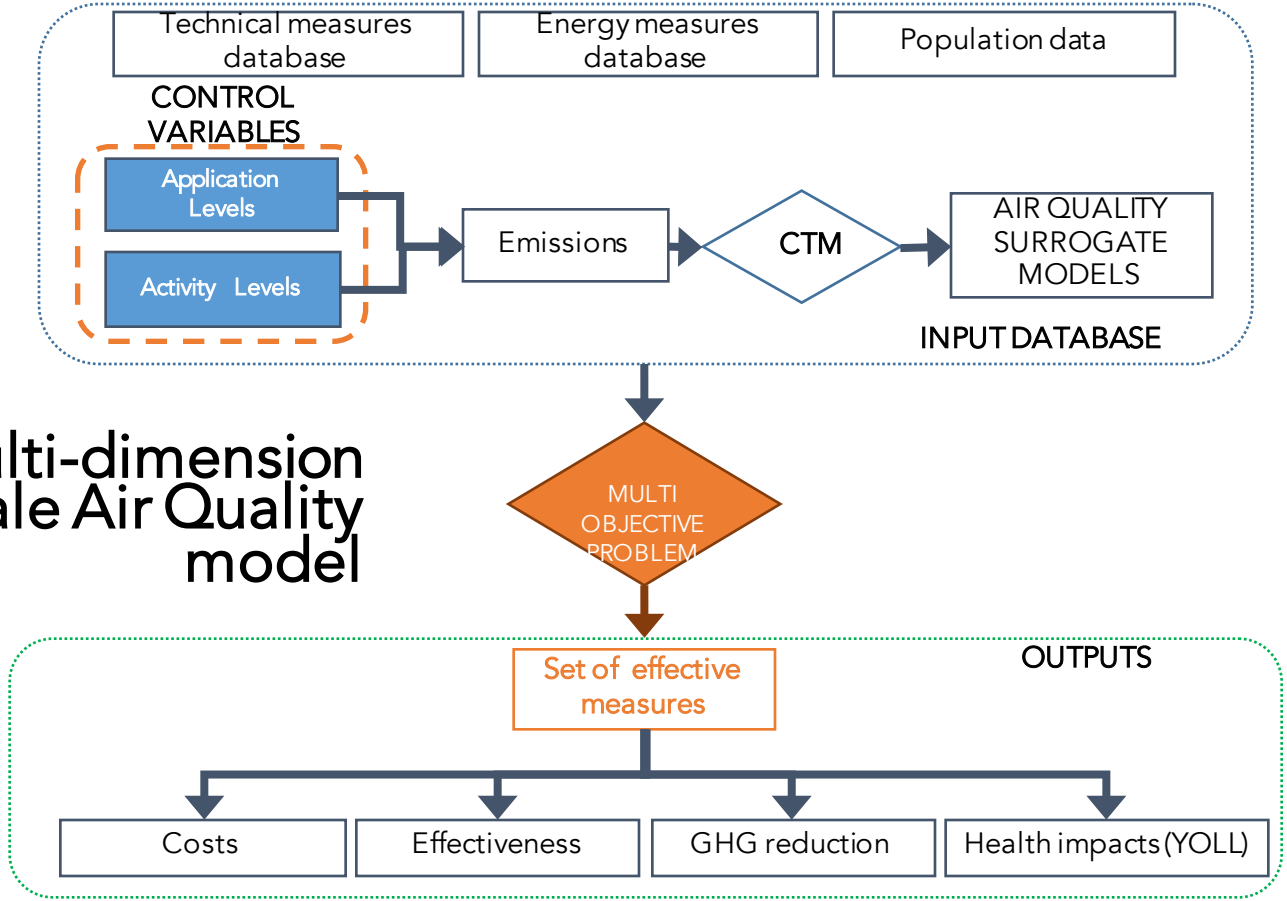
$$E^{d,p}(x,z,s) = \sum_{k \in K} \left\{ \left[A_k^d \cdot (1-(z_k + s_k)) \right] \cdot ef_k^p \cdot \left(1 - \sum_{t \in T_k} eff_t^p \cdot x_k^t \right) \right\}$$

Energy and switch measures $u_d(t)$

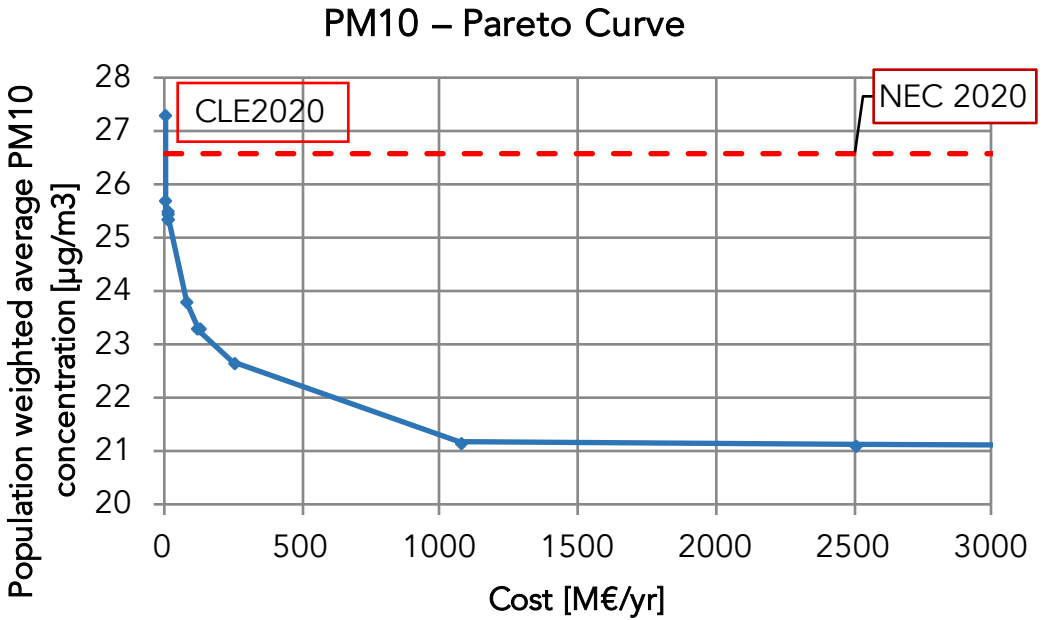
End-of-pipe measures $u_p(t)$


Technical measures database
Energy measures database
Population data
CONTROL VARIABLES
Application Levels
Emissions
CTM
AIR QUALITY SURROGATE MODELS
INPUT DATABASE
Regional Integrated Assessment Tool PLUS
MULTI OBJECTIVE PROBLEM
OUTPUTS
Set of effective measures
Costs
Effectiveness
GHG reduction
Health impacts (YOLL)

MAQ: Multi-dimension multi-scale Air Quality model

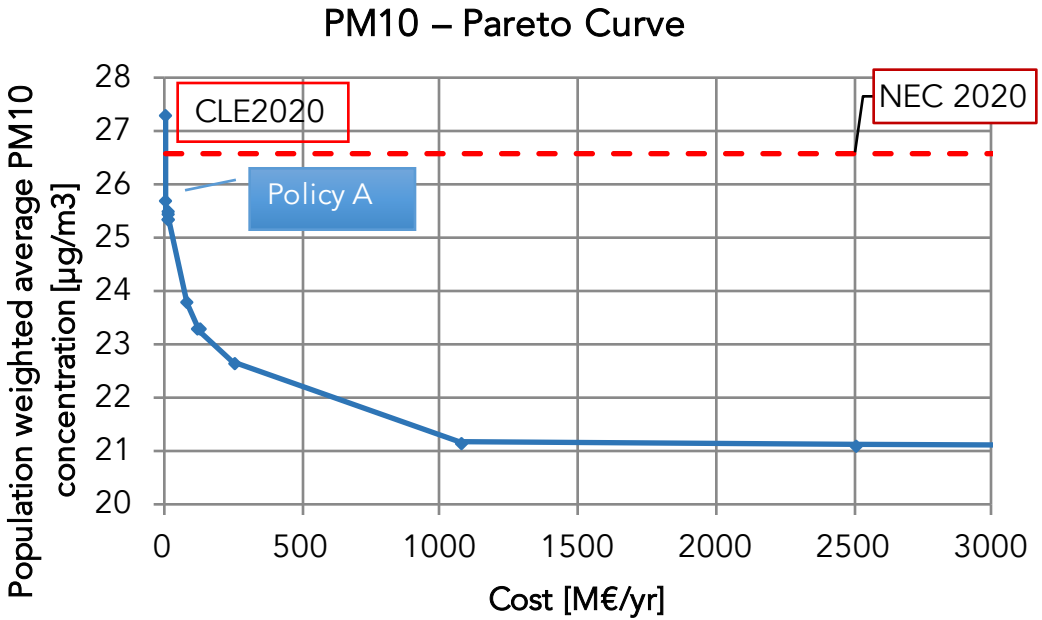


PM10



scenario	costs	NOx	VOC	NH_3	PM2.5	SO_2
CLE2020	baseline	-48%	-14%	8%	-17%	-27%
NECD2020	N/A	-40%	-35%	-5%	-10%	-35%

PM10



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CLE2020	baseline	-48%	-14%	8%	-17%	-27%
POLICY A (NECD2020 PM10)	4 M€/yr	-55%	-20%	-17%	-21%	-28%
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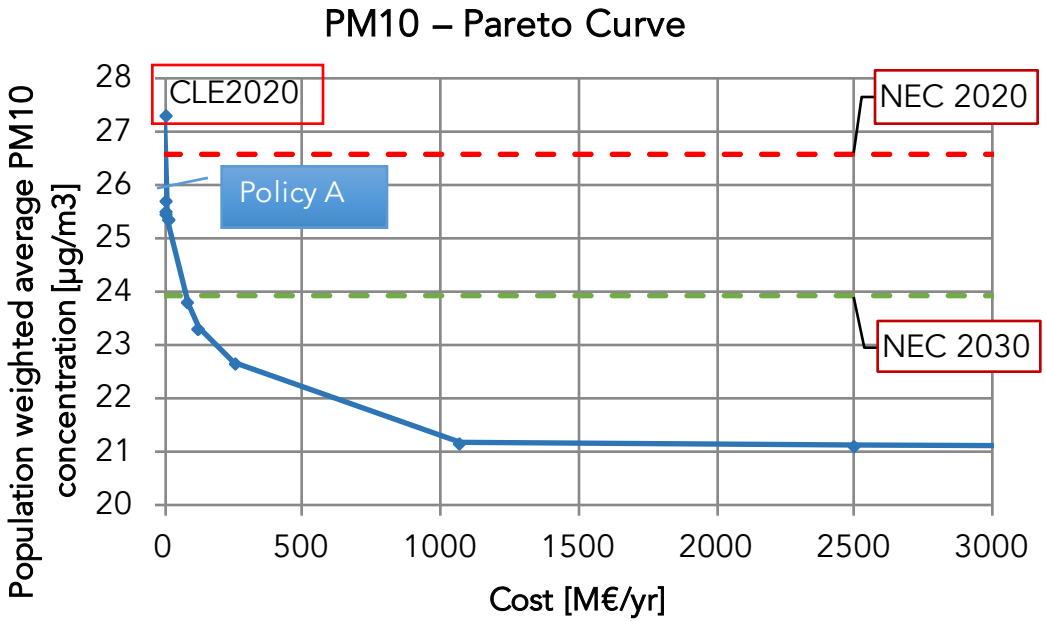
PM10



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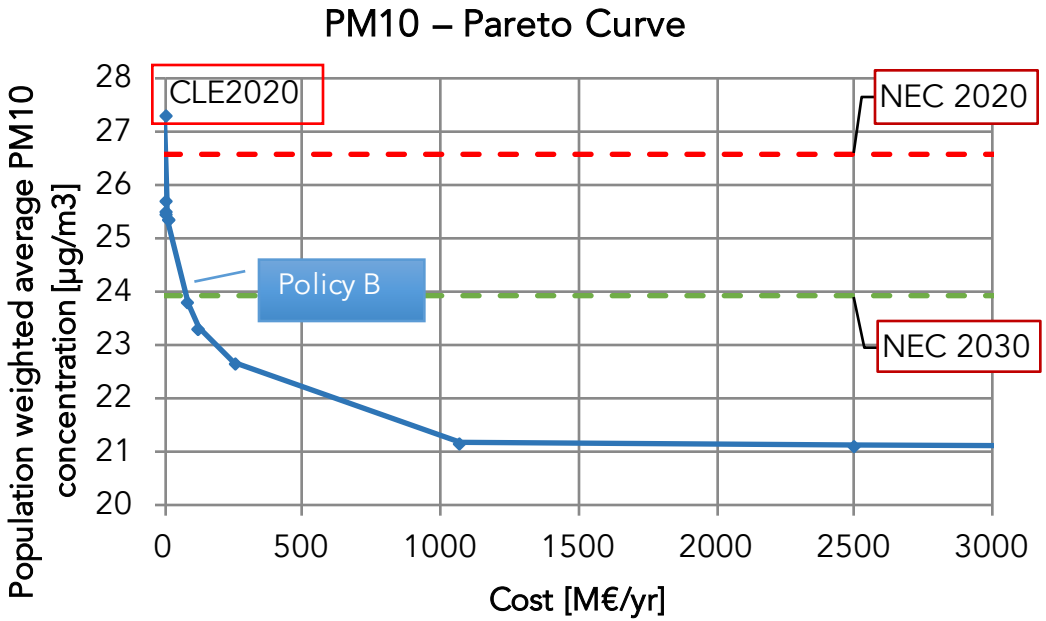
NECD2020	N/A	-40%	-35%	-5%	-10%	-35%
NECD2030	N/A	-65%	-46%	-16%	-40%	-71%

PM10



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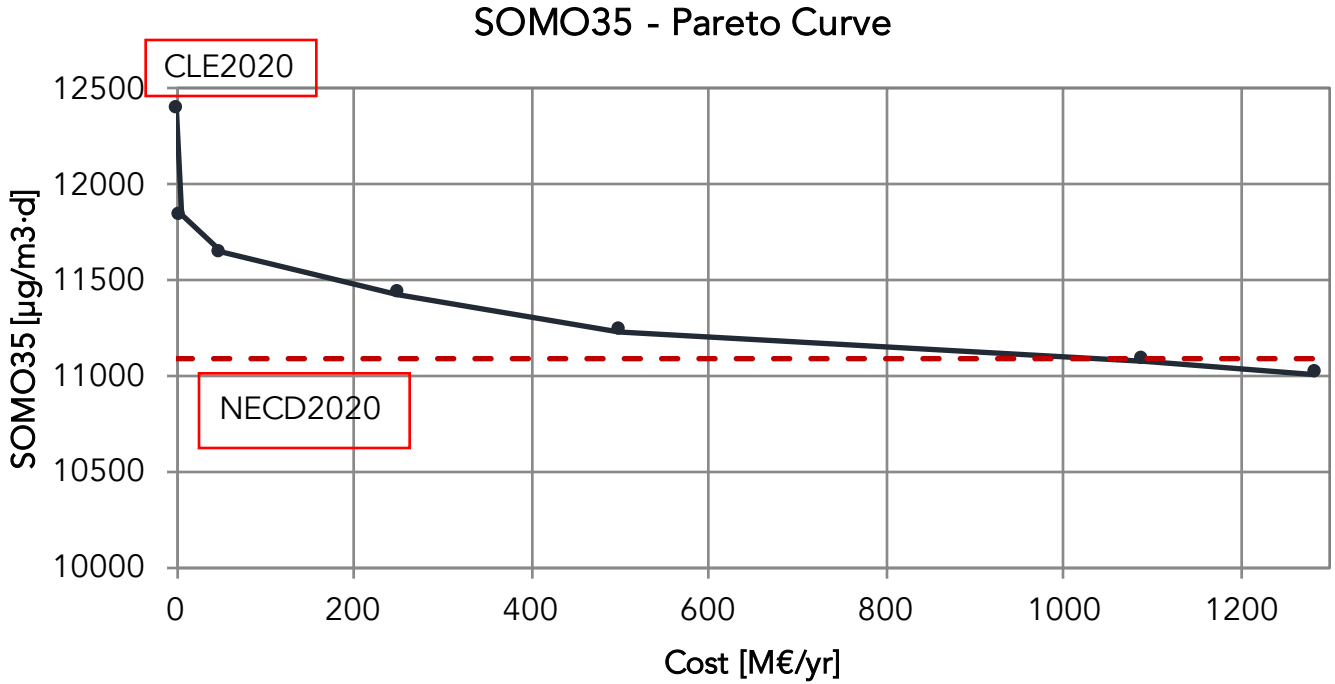
NECD2020	N/A	-40%	-35%	-5%	-10%	-35%
POLICY B (NECD2030 PM10)	120 M€/yr	-61%	-25%	-32%	-47%	-28%
NECD2030	N/A	-65%	-46%	-16%	-40%	-71%

SOMO35



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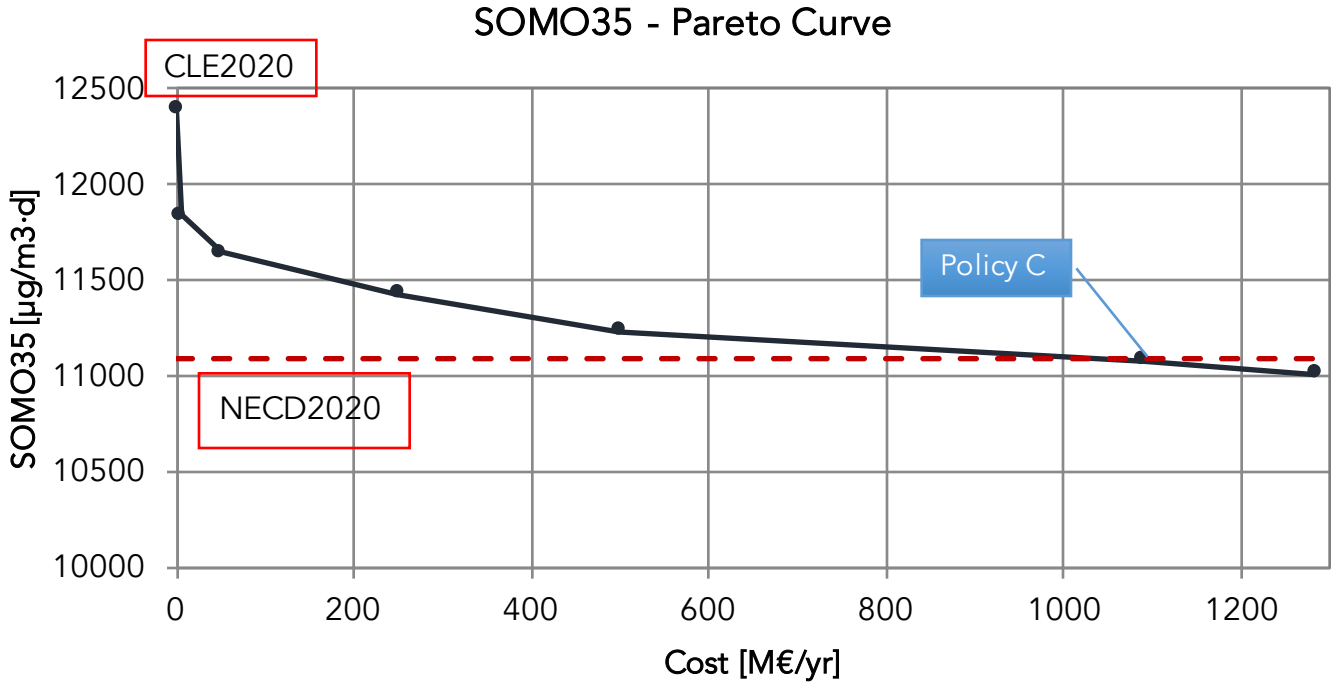
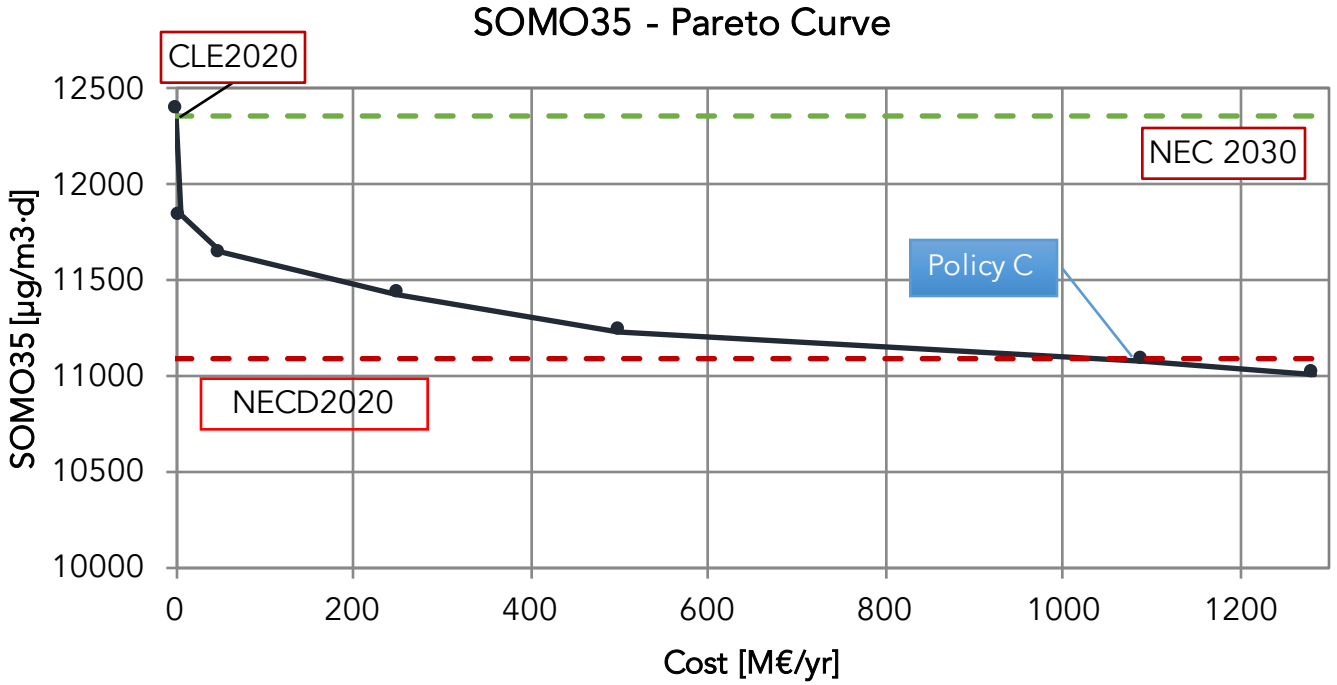
SOMO35



scenario	costs	NOx	VOC	NH_3	PM2.5	SO_2
CLE2020	baseline	-48%	-14%	8%	-17%	-27%
POLICY C (NECD2020 SOMO35)	1089 M€/yr	-49%	-33%	7%	-48%	-27%
NECD2020	N/A	-40%	-35%	-5%	-10%	-35%

SOMO35



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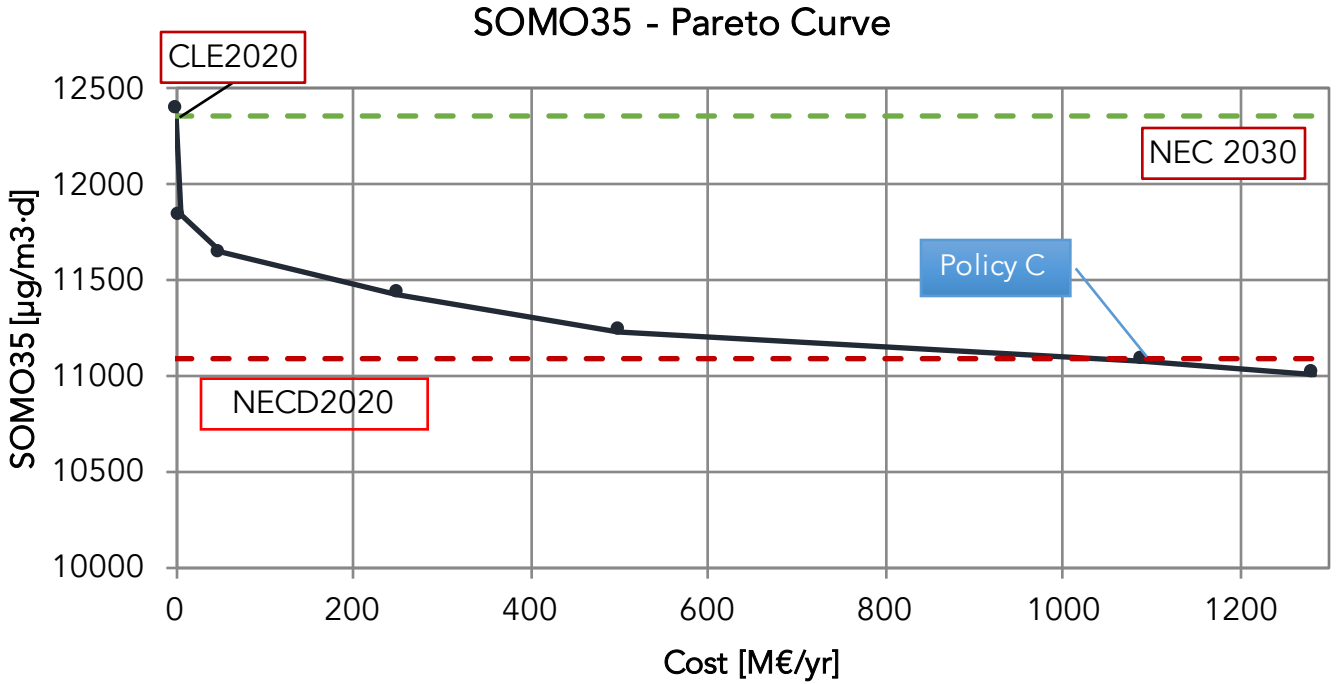
SOMO35



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PM10, SOMO35

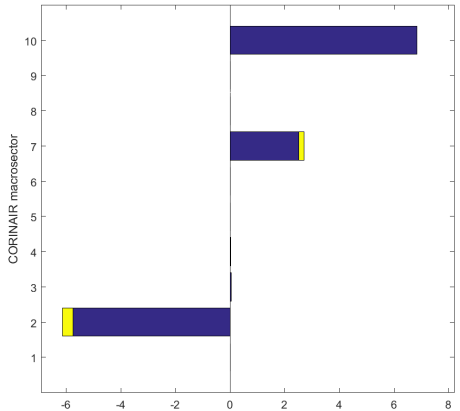
Indicator	CLE2020	NECD2020	POLICY A (PM10, 2020)	POLICY B (PM10, 2030)	POLICY C (SOMO35, 2020)	NEC2030
PM10 [µg/m³] (weighted mean)	27.3	26.6	25.7	23.3	24.6	23.9
PM2.5 [µg/m³] (weighted mean)	21.2	21.1	19.9	18.3	19.5	20.0
AOT40 [µg/m³·h]	95647	87652	97960	99539	88244	93791
SOMO35 [µg/m³·d]	12396	11086	13041	13528	11080	12353
O3 max 8h [µg/m³·h]	101.4	99.5	102.3	103.1	99.2	101.6
NO2 [µg/m³·d] (weighted mean)	33.9	32.0	31.4	28.2	32.3	24.8
CO2 [kt/yr]	29698		30402	29701	29698	
CH4 [kt/yr]	281		278.4	271.2	274.2	
N20 [kt/yr]	0.5		0.4	0.3	0.4	
External Cost Morbidity [M€/yr]	2140	2084	2013.9	1826.1	1928.3	1873.2
External Cost Yoll [M€/yr]	3902	3799.8	3671.4	3329.2	3515.4	3415
Fuel savings [M€/yr]			335.8	13741	11714	

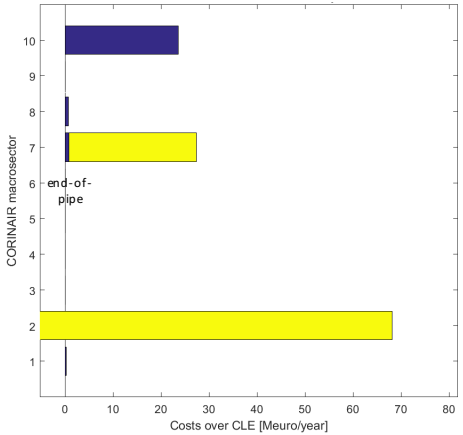
POLICY A (NECD2020 PM10)

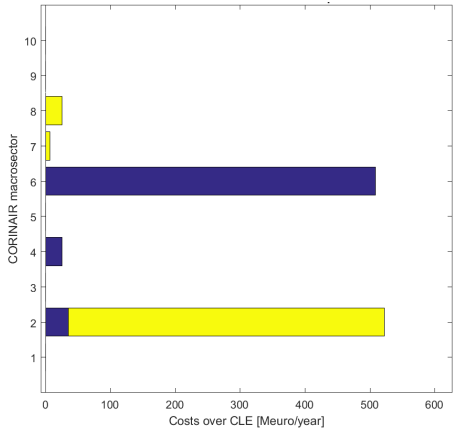
POLICY B (PM10, 2030)

POLICY C (NECD2020 SOMO35)

COSTS (M€/yr)



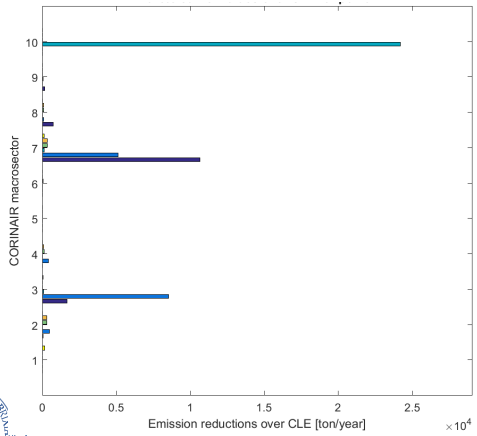


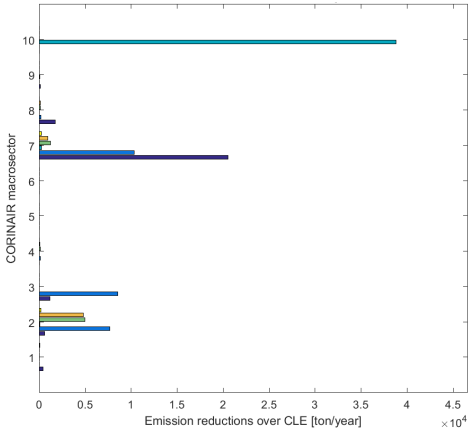


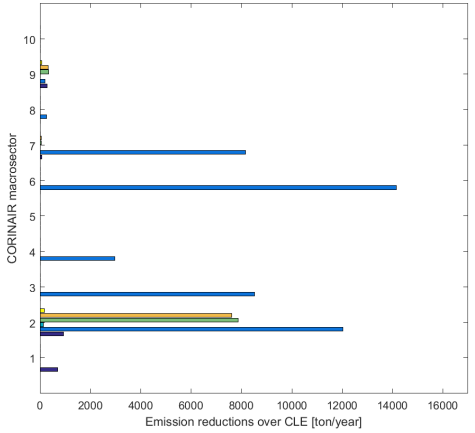
end-of-pipe

efficiency measures

Emission reduction over CLE2020 (ton/yr)







nox

voc

nh3

pm10

pm25

so2

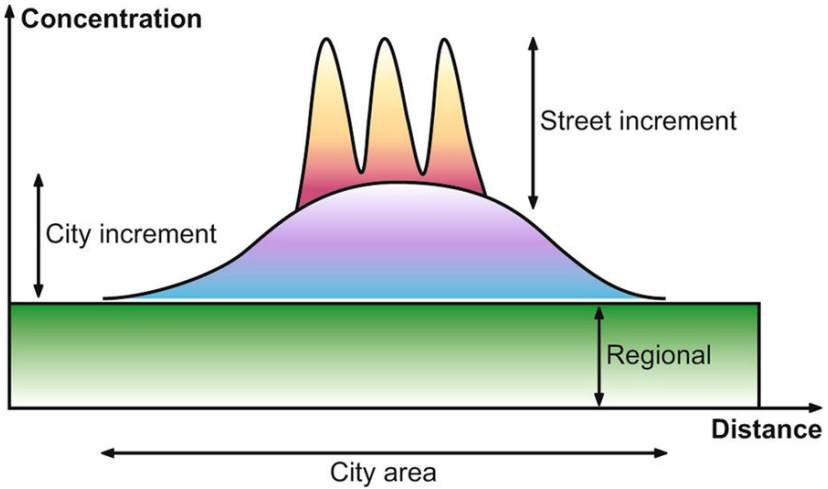
conclusions

NECD on Lombardy region:

- Effective for PM10
- Not effective for ozone in the long term
- Not efficient

conclusions

- Top-down decision process is not efficient, in some cases can be not effective (at regional/local scale)



conclusions

- Top-down decision process is not efficient, in some cases can be not effective, when assessed at regional/local scale
- Effectiveness/efficiency: a bottom-up decision approach ?
- New generation of tools?