



Impatti socio-economici di politiche a favore della mobilità attiva

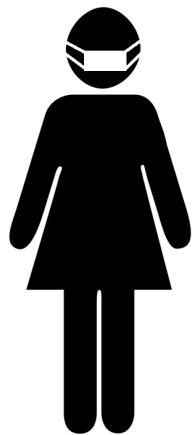
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Università degli Studi di Brescia

Impatti del trasporto privato sulla salute

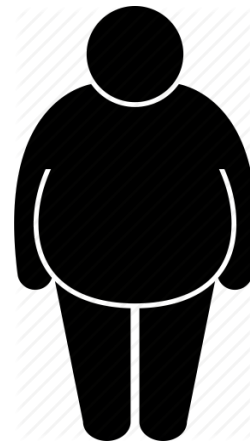
INDIRETTI



(W.H.O. , 2014)

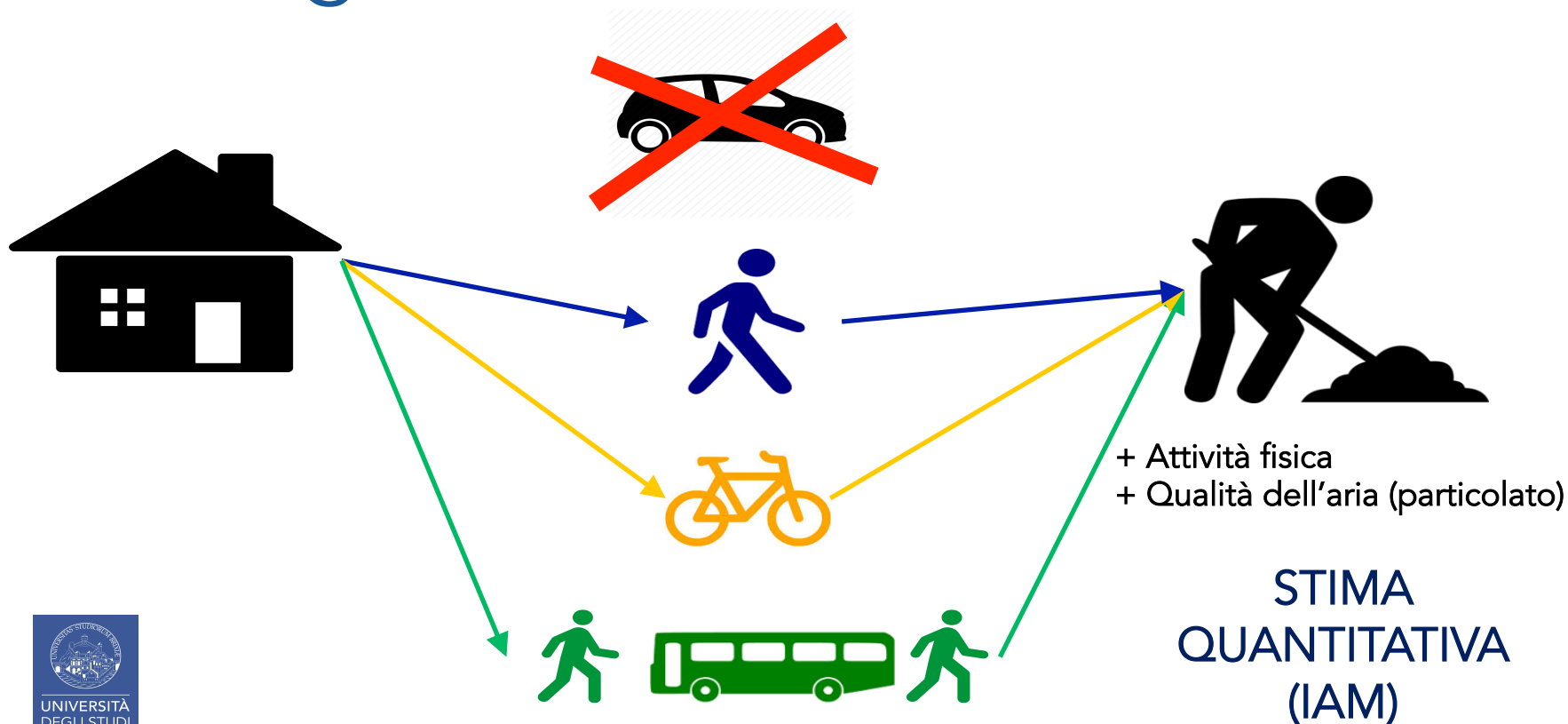


DIRETTI

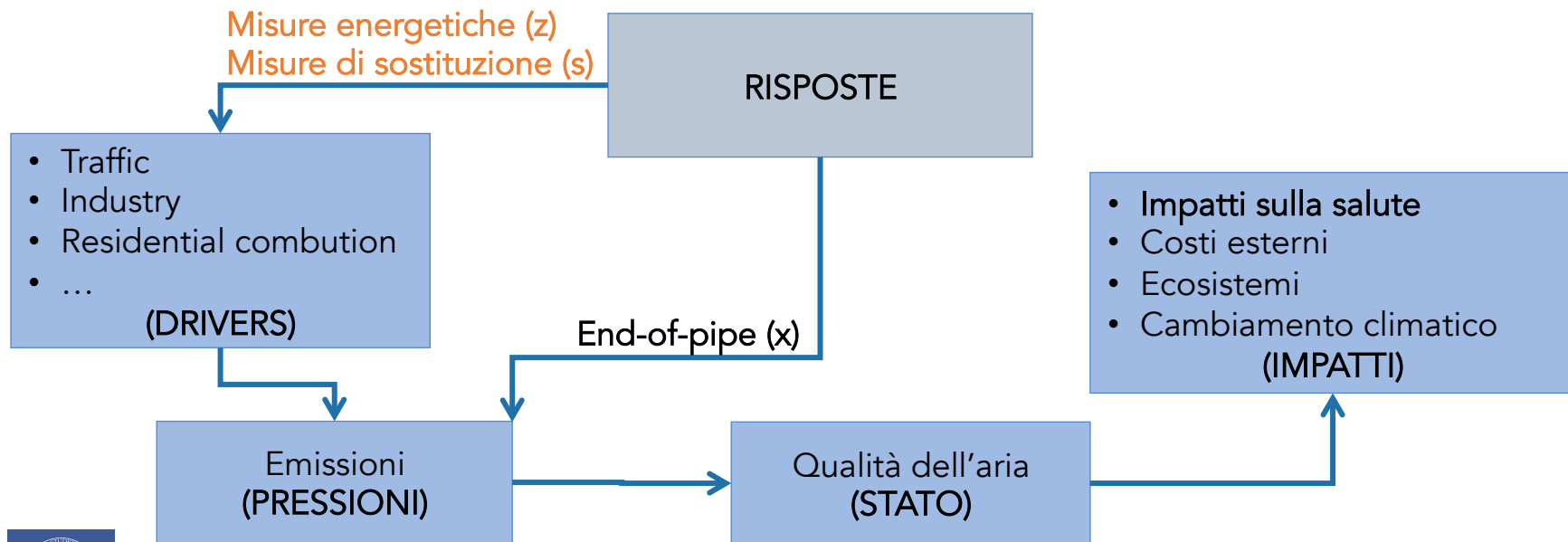


(Wen et al. 2011)

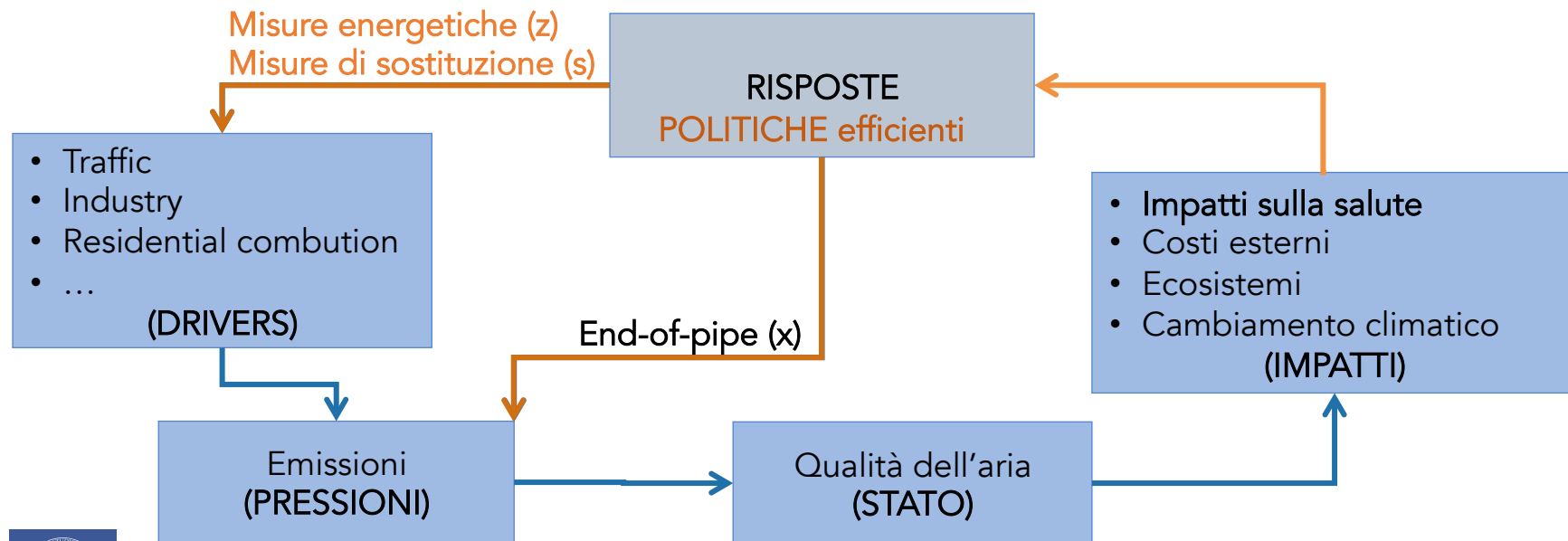
Strategie di mobilità attiva



IAM per l'identificazione di misure efficienti di riduzione delle emissioni



IAM per l'identificazione di misure efficienti di riduzione delle emissioni



Il problema decisionale

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

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

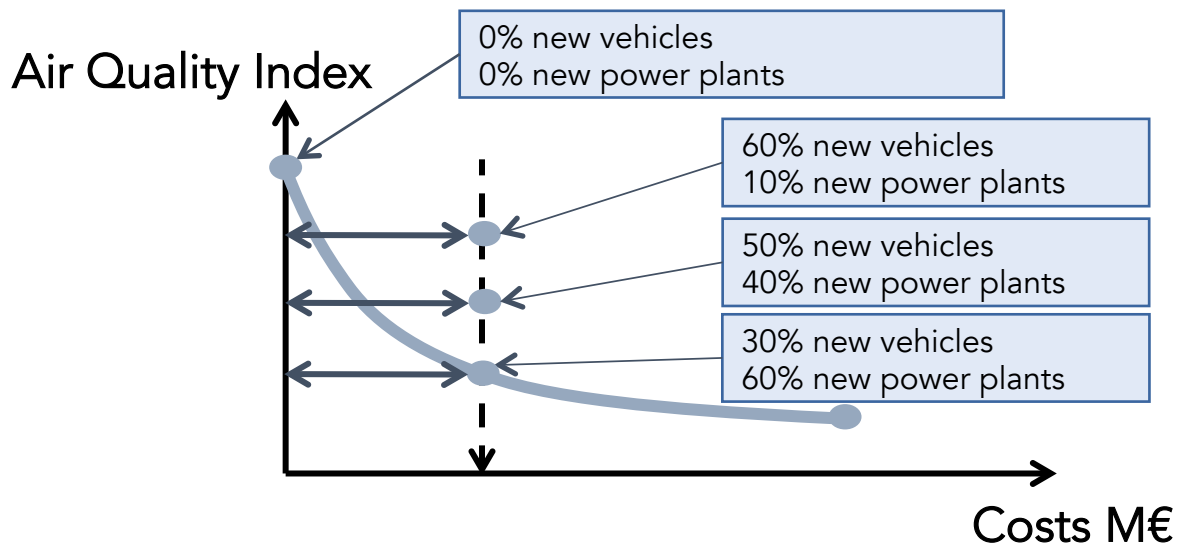
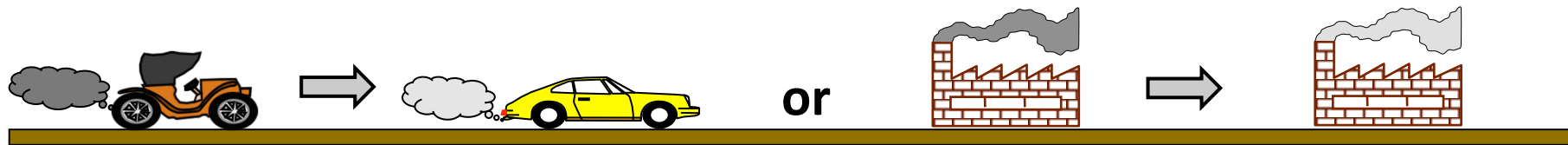
VARIABILI DI CONTROLLO

misure end-of-pipe (x)
misure energetiche (z)
misure di sostituzione (s)

Uno o più obiettivi di
COSTO

Uno o più obiettivi di
QUALITA' DELL'ARIA

Il problema decisionale



Il problema decisionale

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

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

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

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

Emission factor

Activity level

Il problema decisionale

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

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

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

Misure end-of-pipe

Il problema decisionale

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

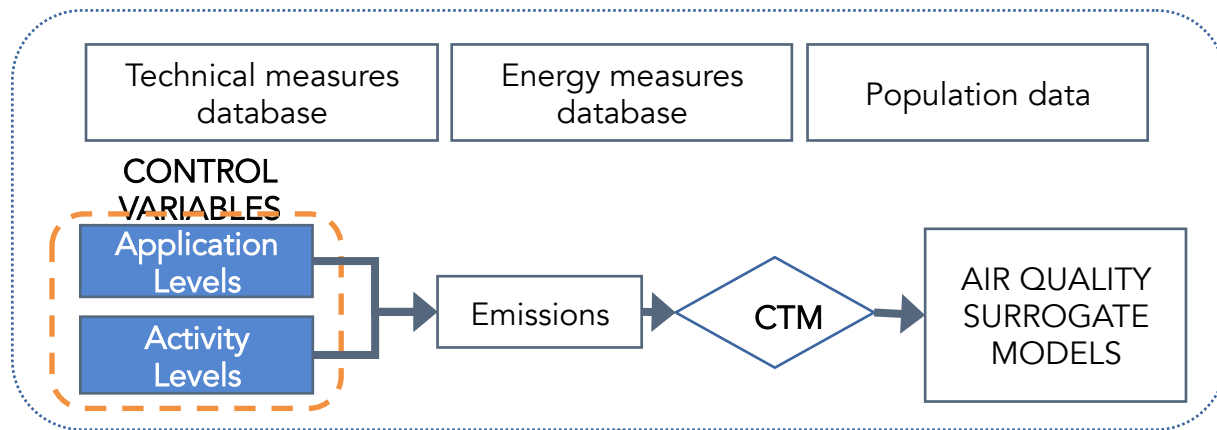
$$x,y,s \in \Theta$$

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

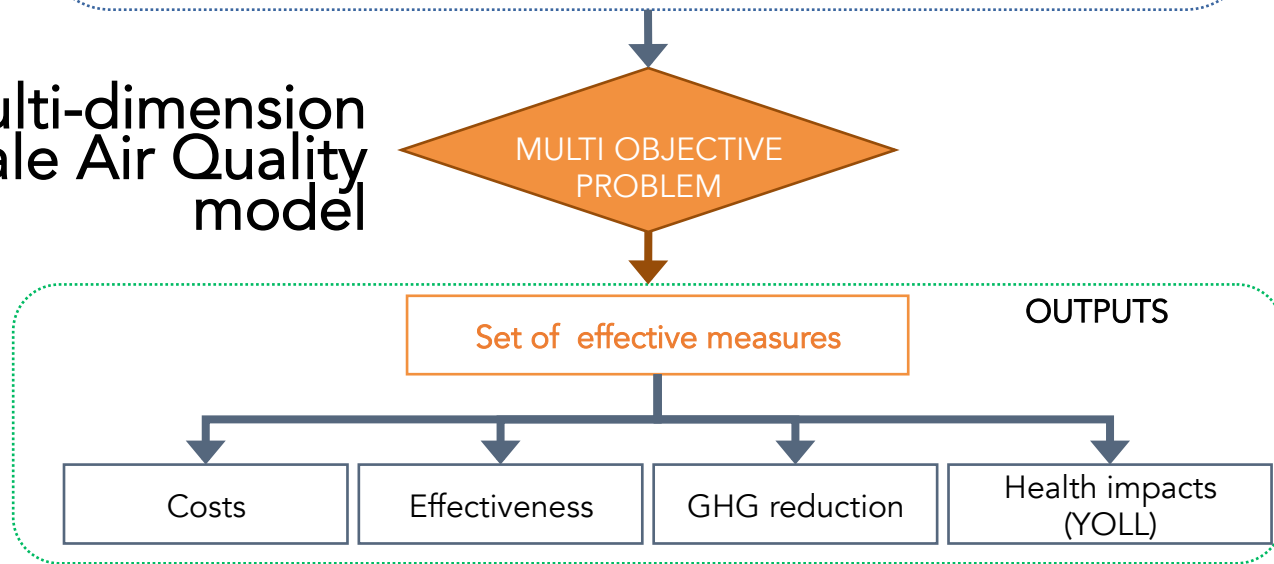
Misure energetiche e di switch

Misure end-of-pipe

INPUT
DATABASE



MAQ: Multi-dimension
multi-scale Air Quality
model



Effetti indiretti sulla salute (Externe)

Impatti sulla salute

$$HI_j^m = \sum_{d=1}^D \gamma_j^m \cdot P_{d,j} \cdot \chi_d$$

- γ_j^m is the incidence of the indicator m on population cohort j;
- $P_{d,j}$ is the population, belonging to the cohort j, exposed to PM_{10} pollution cell d;
- χ_d indicates the mean PM_{10} concentrations, in cell d.

Costi Esterni

$$HC = \sum_m (\sum_j HI_j^m \cdot ev_j^m)$$

- HC is the health cost;
- ev_j^m is the economic value associated to the indicator m on population cohort j;

receptors	impact indicator
ASTHMATIC	
Adults	
	Bronchodilator usage
	cough
	Respiratory problems
Children	
	Bronchodilator usage
	cough
	Respiratory problems
OVER 65	
	heart attack
CHILDREN	
	chronic cough
ADULTS	
	reduced activity
	chronic bronchitis
TOTAL POPULATION	
	chronic mortality
	hospital admission for respiratory problems
	hospital admission for cardiovascular problems
OVER 30	
	years of lost life

Effetti diretti sulla salute (WHO-HEAT)

1. Anni di vita guadagnati grazie alla riduzione del rischio dovuto all'incremento di **attività fisica**

$$YOLL_d^w = -\frac{y^w}{100} \cdot A \cdot PC_d^w$$

Diagram showing the calculation of PC_d^w and the substitution of y^f and y^b into the main equation:

$$PC_d^w = \min \left\{ \begin{array}{l} \rho \cdot 1.3 \cdot \frac{\sum (AL_d^w \cdot z)}{\sum (AL_d^w \cdot z)} \\ \gamma \cdot P_d \cdot \frac{\sum (AL_d^w \cdot z)}{\sum (AL_d^f \cdot z) + \sum (AL_d^b \cdot z)} \end{array} \right.$$
$$y^f = 0.4586x + 0.0766$$
$$y^b = 0.4627x + 0.5951$$

Effetti diretti sulla salute (WHO-HEAT)

2. Anni di vita persa dovuti all'aumento della frequenza respiratoria

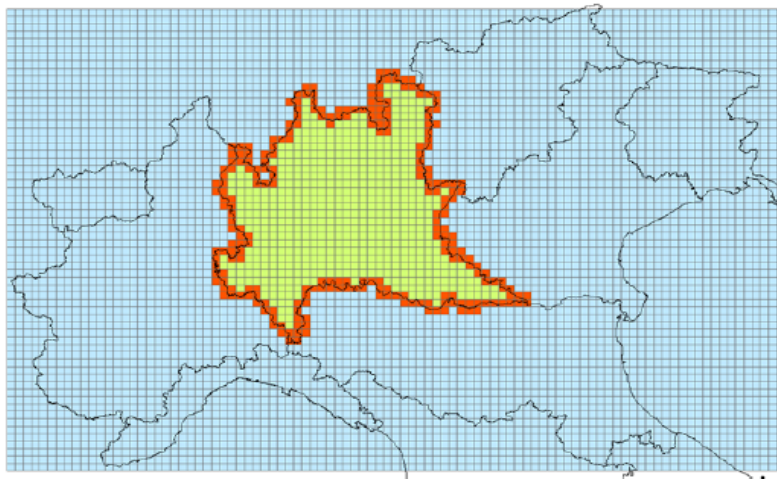
$$YOLL_d^w = (RR_d - 1) \cdot PM_{2.5d} \cdot A \cdot PC_d^w(z)$$

Rischio relativo:

$$RR_d = \exp \left(\underbrace{\ln(RR_{PM_{2.5d}})}_{\text{Dose a riposo}} \cdot \underbrace{\frac{\left(\frac{DPA_d^w}{DNA_d} - 1\right) \cdot PM_{2.5d}}{10}}_{\text{Dose attività fisica}} \right)$$

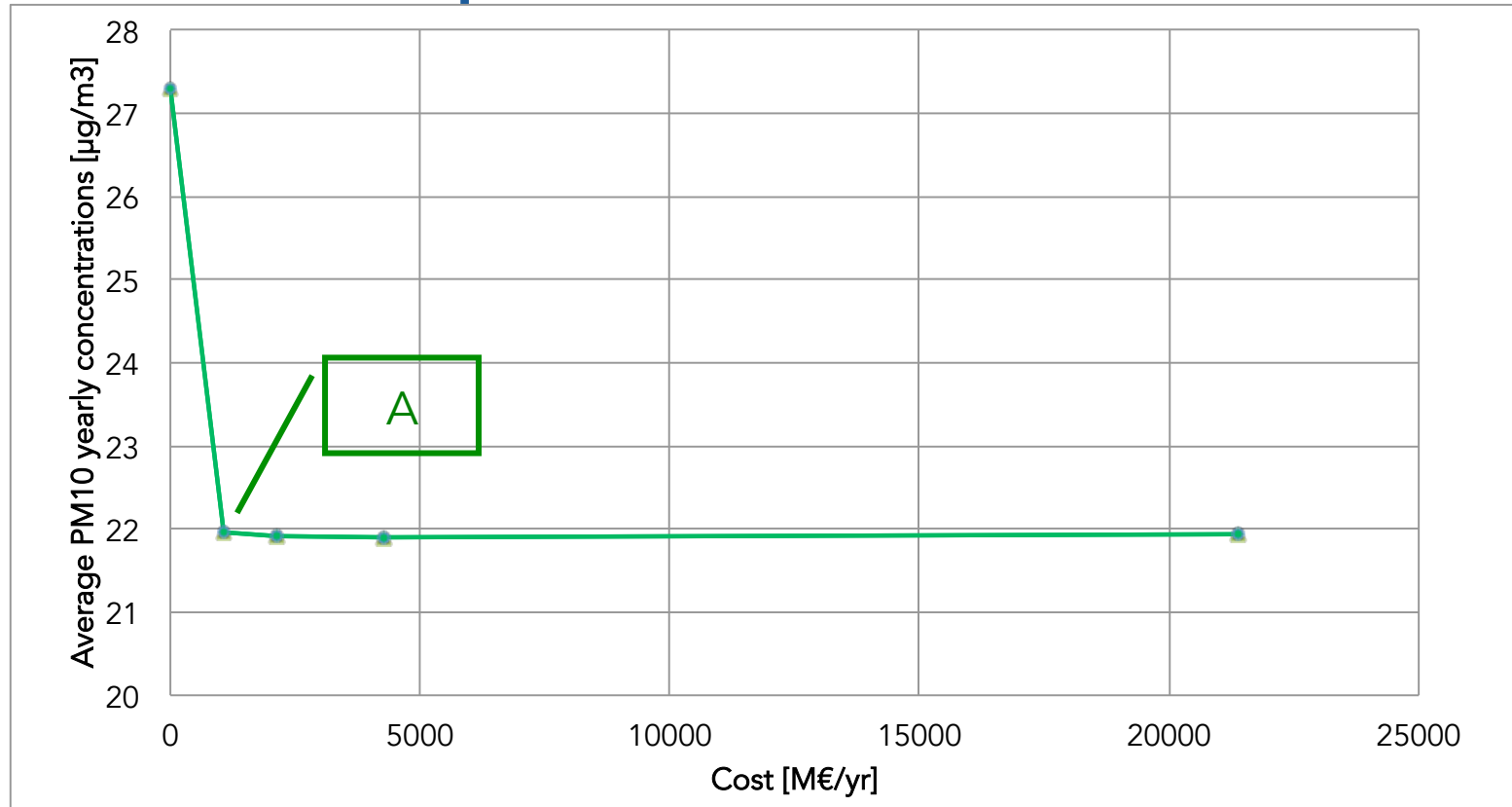
Caso studio: misure di mobilità attiva

DOMINIO

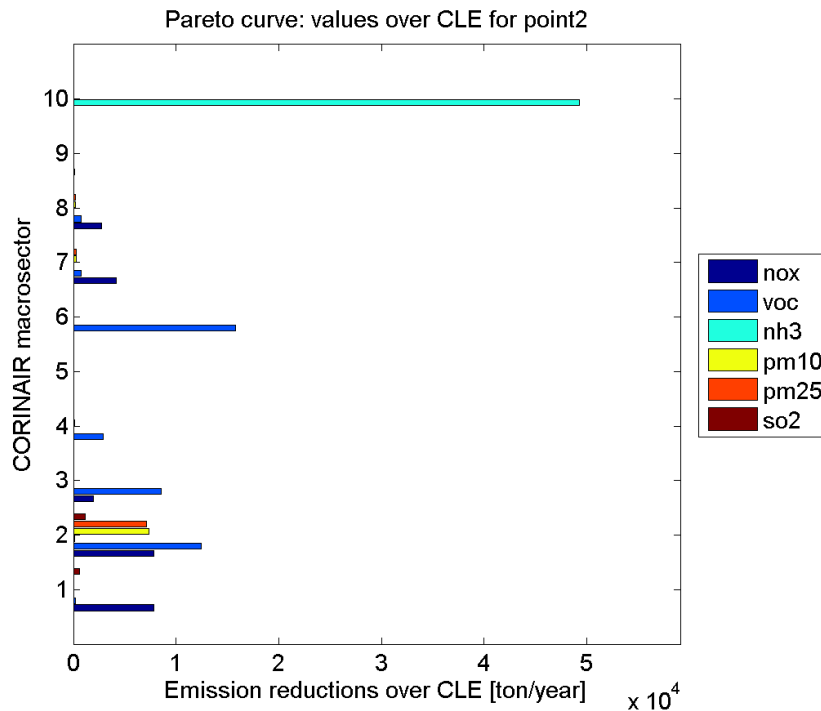
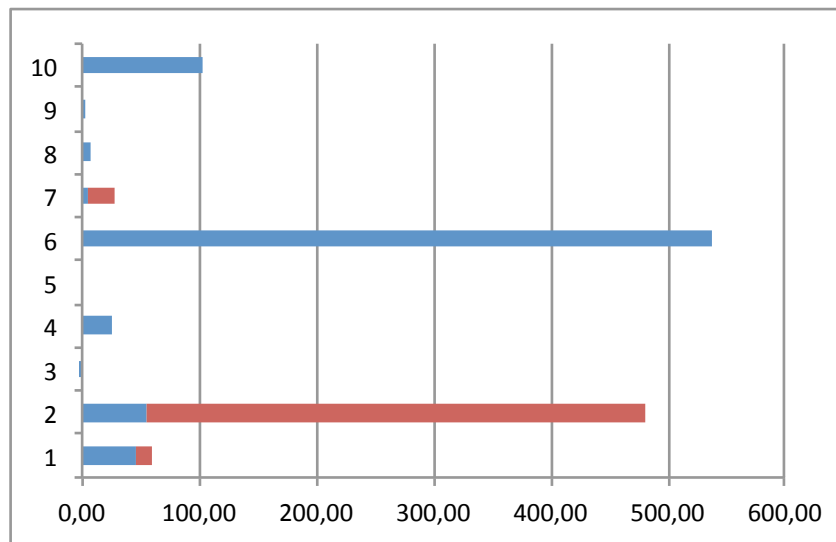


Lombardia Regione Lombardia
95x62 celle di 6x6 Km²

Soluzione del problema decisionale



Politica A: Costi e riduzione delle emissioni



Misure end-of-pipe - traffico

Sector	Activity	Non-technical measures
Light duty vehicles: cars and small buses with 4-stroke engines - Urban	Liquefied petroleum gas	EURO 6 on light duty spark ignition road vehicles (4-stroke engines)
Light duty vehicles: light commercial trucks with 4-stroke engines - Urban	Medium distillates (diesel- light fuel oil; includes biofuels)	EURO 6 on light duty diesel road vehicles
Light duty vehicles: cars and small buses with 4-stroke engines - Urban	Liquefied petroleum gas	EURO 5 on light duty spark ignition road vehicles (4-stroke engines)
Light duty vehicles: cars and small buses with 4-stroke engines - Urban	Liquefied petroleum gas	EURO 4 on light duty spark ignition road vehicles (4-stroke engines)
Light duty vehicles: light commercial trucks with 4-stroke engines - Highway	Medium distillates (diesel- light fuel oil; includes biofuels)	EURO 6 on light duty diesel road vehicles
Light duty vehicles: light commercial trucks with 4-stroke engines - Extraurban	Medium distillates (diesel- light fuel oil; includes biofuels)	EURO 6 on light duty diesel road vehicles

Misure energetiche - traffico

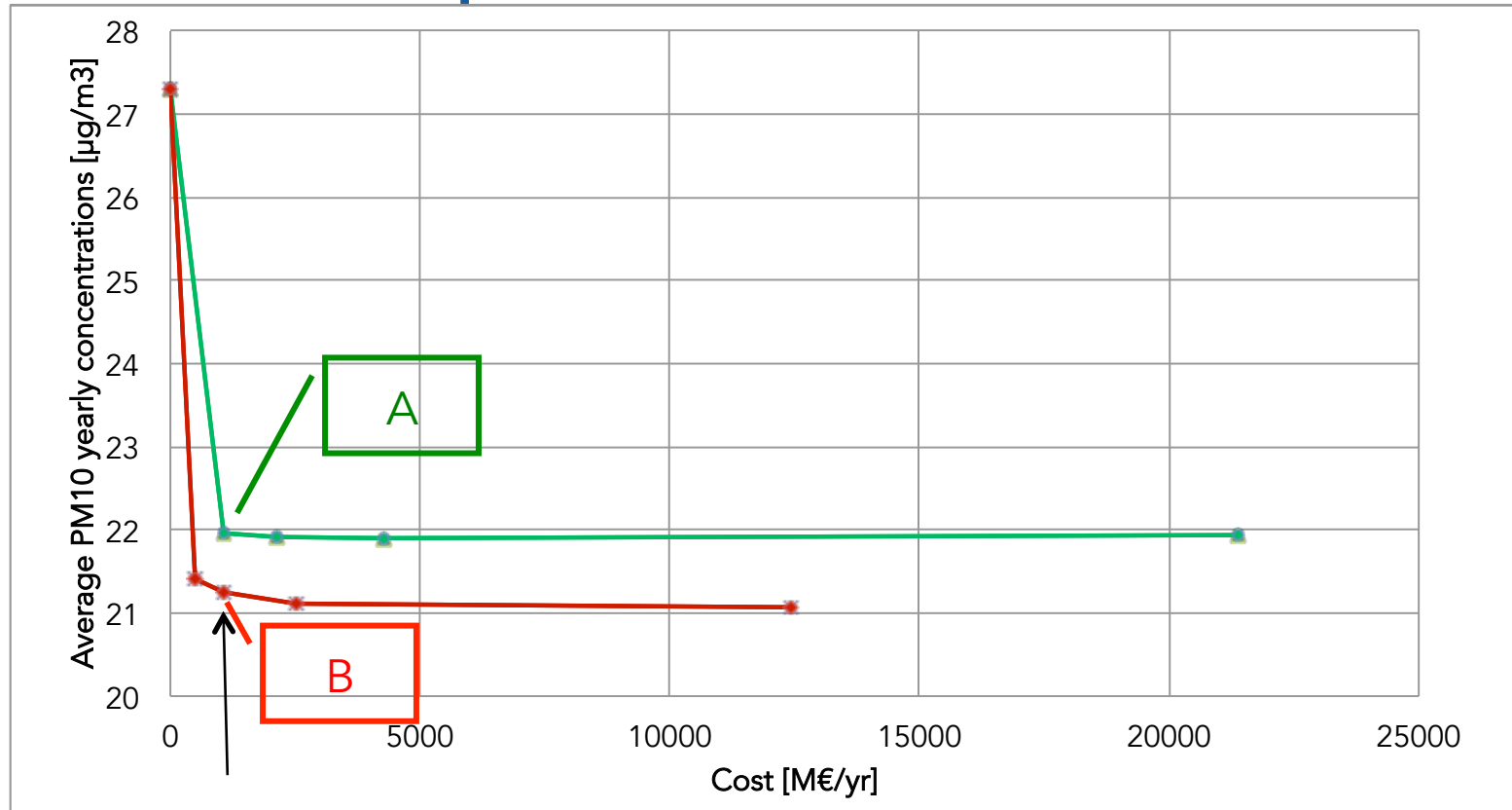
Sector	Activity	Non-technical measures
Heavy duty vehicles - trucks	Medium distillates (diesel- light fuel oil; includes biofuels)	Eco-drive - Applicazione riduzione FE al 50
Heavy duty vehicles - trucks	Medium distillates (diesel- light fuel oil; includes biofuels)	average speed reduction (from 90 km/h to 70 km/h) - euro 1, 2, .. - bus
Evaporative emissions from 4-stroke cars - Urban	Gasoline and other light fractions of oil (includes kerosene and biofuels)	Istituzione ZTL nei Comuni - Riduz 5
Light duty vehicles: light commercial trucks with 4-stroke engines - Urban	Medium distillates (diesel- light fuel oil; includes biofuels)	Istituzione ZTL nei Comuni - Riduz 5
Light duty vehicles: cars and small buses with 4-stroke engines - Urban	Medium distillates (diesel- light fuel oil; includes biofuels)	Eco-drive - Applicazione riduzione FE al 50
Light duty vehicles: cars and small buses with 4-stroke engines - Urban	Gasoline and other light fractions of oil (includes kerosene and biofuels)	Istituzione ZTL nei Comuni - Riduz 5

Mobilità attiva

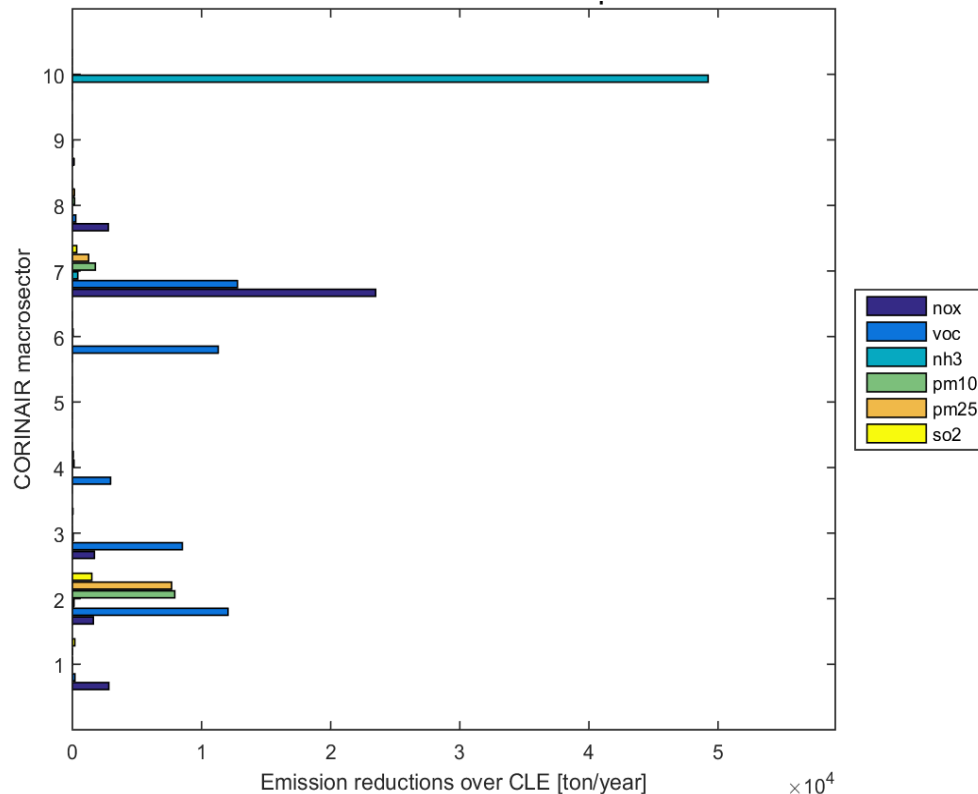
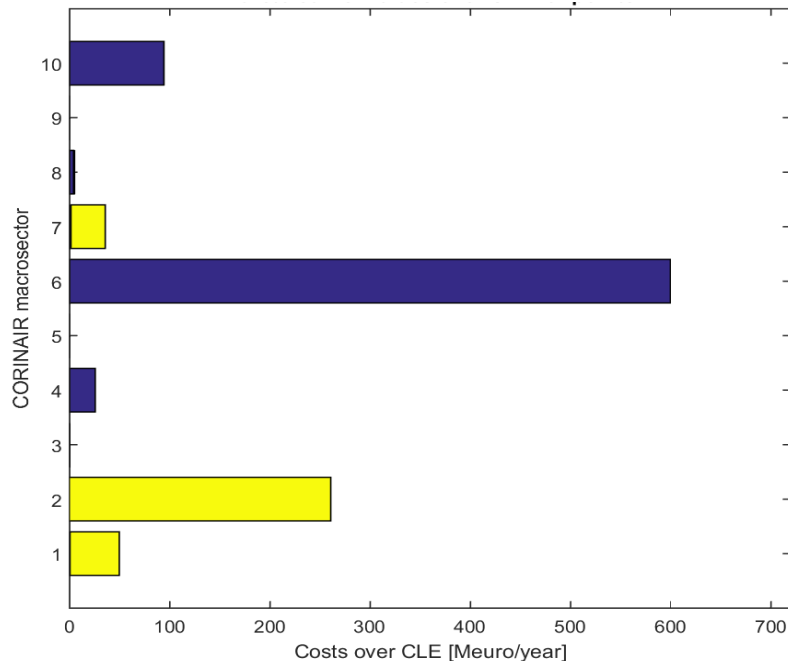


Strategia	Min/giorno
Casa-lavoro a piedi	20 camminata
Casa-lavoro in bici	40 bici
Casa-lavoro in bus	20 camminata

Soluzione del problema decisionale

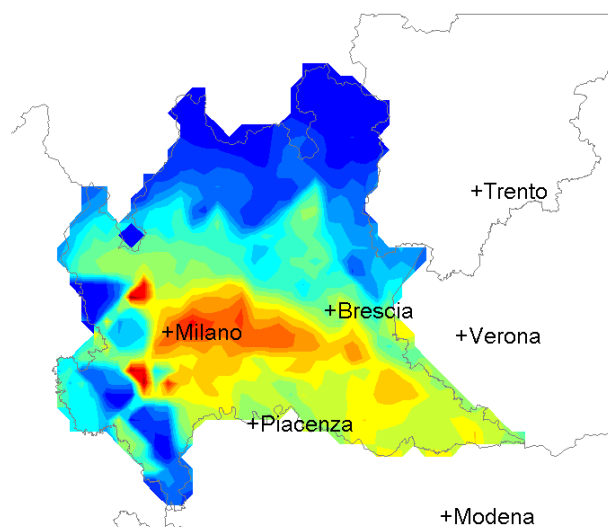
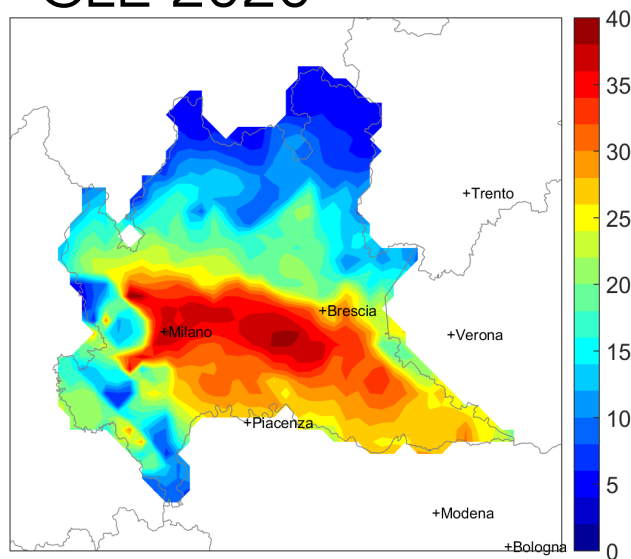


Politica B: Costi e riduzione delle emissioni

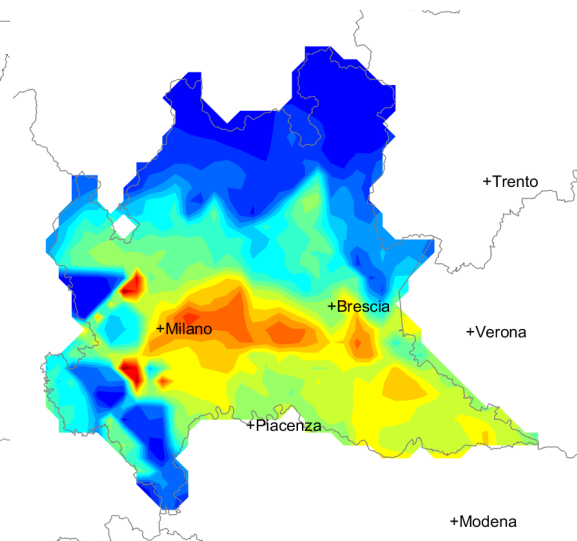


PM10 [$\mu\text{g}/\text{m}^3$]

CLE 2020



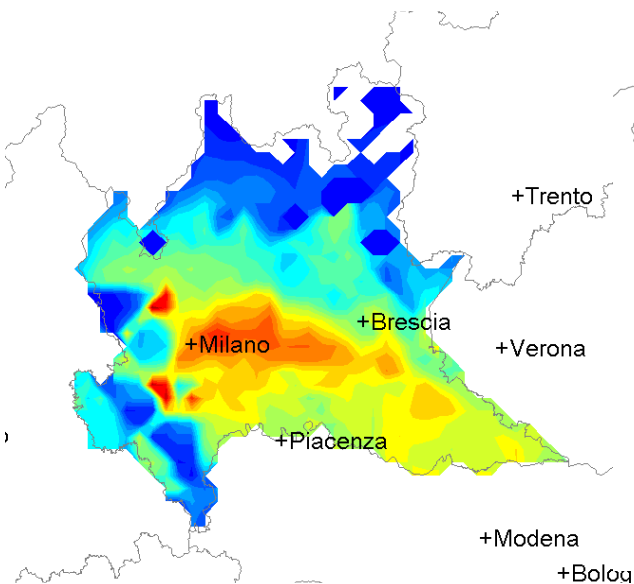
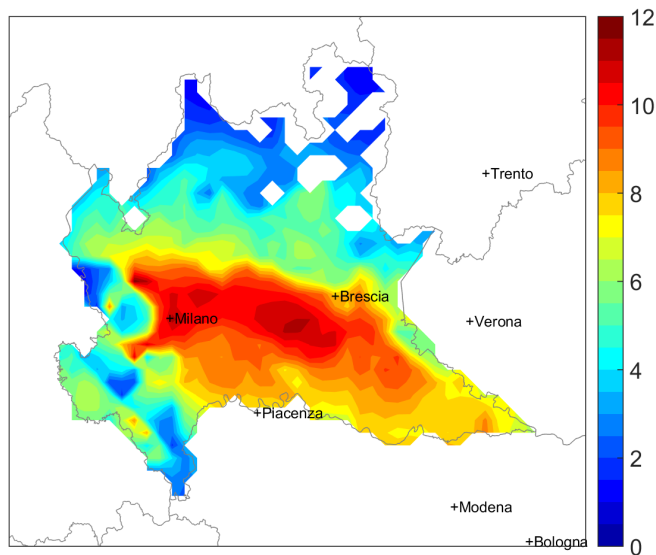
Politica A



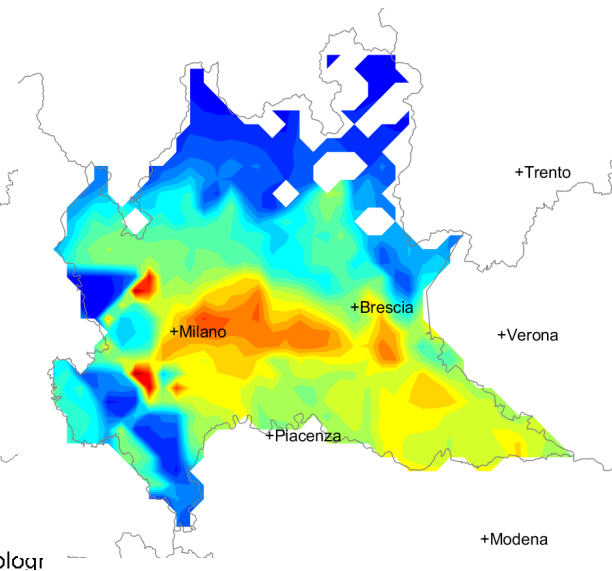
Politica B

YOLL [mesi/uomo]

CLE 2020



Politica A



Politica B

Politica B: Impatti sulla salute

30% dei Km/anno totali

Misura	Veicoli	Km percorsi ridotti [Km/anno]
Casa-Lavoro in bici	Auto benzina - urbano	3.3E+09
	Auto diesel - urbano	3.8E+09
Casa-Lavoro a piedi/in bus	Motocicli a benzina	5.8E+09
	Auto benzina - urbano	4.2E+09
	Auto diesel - urbano	5.4E+09
	Auto benzina - extraurbano	6.6E+09
	Auto diesel - extraurbano	6.1E+10

	Pendolari coinvolti	Costo diretto (tempo pendolare)	Guadagni (fuel)	YOLL indiretti pro-capite	Guadagno diretto di YOLL	Perdita diretta di YOLL
mobilità attiva	Milioni	[M€/anno]	[M€/anno]	[mesi procapite]	[anni/pendolare]	[mesi/ pendolare]
Politica B	1.8	808.5	5730	4.96	2.2 piedi/bus 4.6 bici	0.6 piedi/bus 6.2 bici

(Asensio , J. and Matas, A – 2007)

Misure end-of-pipe - traffico

Sector	Activity	Technology
Light duty vehicles: cars and small buses with 4-stroke engines - Extraurban	Gasoline and other light fractions of oil (includes kerosene and biofuels)	EURO 5 on light duty spark ignition road vehicles (4-stroke engines)
Light duty vehicles: cars and small buses with 4-stroke engines - Highway	Gasoline and other light fractions of oil (includes kerosene and biofuels)	EURO 6 on light duty spark ignition road vehicles (4-stroke engines)
Light duty vehicles: light commercial trucks with 4-stroke engines - Extraurban	Medium distillates (diesel- light fuel oil; includes biofuels)	EURO 6 on light duty diesel road vehicles
Light duty vehicles: light commercial trucks with 4-stroke engines - Highway	Medium distillates (diesel- light fuel oil; includes biofuels)	EURO 5 on light duty diesel road vehicles
Motorcycles- mopeds and cars with 2-stroke engines	Gasoline and other light fractions of oil (includes kerosene and biofuels)	Stage 3 control on motorcycles and mopeds (2-stroke engines)
Motorcycles with 4-stroke engines	Gasoline and other light fractions of oil (includes kerosene and biofuels)	Stage 3 control on motorcycles (4-stroke engines)

Misure energetiche - traffico

Sector	Activity	Non-technical measures
Evaporative emissions from 4-stroke cars - Urban	Gasoline and other light fractions of oil (includes kerosene and biofuels)	commute by bike
	Gasoline and other light fractions of oil (includes kerosene and biofuels)	commute by bus
Light duty vehicles: cars and small buses with 4-stroke engines - Extraurban	Medium distillates (diesel- light fuel oil; includes biofuels)	commute by bus
Light duty vehicles: light commercial trucks with 4-stroke engines - Urban	Medium distillates (diesel- light fuel oil; includes biofuels)	Optimization of urban goods delivery

Politiche a confronto

Scenario	PM10 [$\mu\text{g}/\text{m}^3$]	Morbidity [M€/year]	Yoll [M€/year]
CLE 2020	27.29	2140	3902
Policy A	21.95	1721	3138
Policy B	21.26	1667	3040

Scenario	CO2 [kton/year]	CH4 [kton/year]	N2O [kton/year]
CLE 2020	29698	280,73	0,45491
Policy A	18907	267,85	0,39153
Policy B	27513	259,28	0,27049

Conclusioni

- MAQ: IAM per misure energetiche e end-of-pipe
- Valutazione di misure comportamentali
- Impatti diretti e indiretti sulla salute

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