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DUALNG

Heavy-duty vehicles retrofitting by Dual Fuel Liquid Natural Gas technology

Final Event 21/02/2024

BM carrozzerie

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C1.2 Valutazione integrata dell'impatto di DUALNG sulla qualità dell'aria e sulle emissioni di GHG in un test case sulla Regione Lombardia (IT)

Marialuisa Volta
marialuisa.volta@unibs.it

Integrated Assessment Modeling and Control Research Group
Dipartimento di Ingegneria Meccanica e Industriale
Università di Brescia

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Obiettivo

Valutazione modellistica dell’impatto della tecnologia DUALNG sulla qualità dell'aria e emissioni di GHG della Regione Lombardia (IT).

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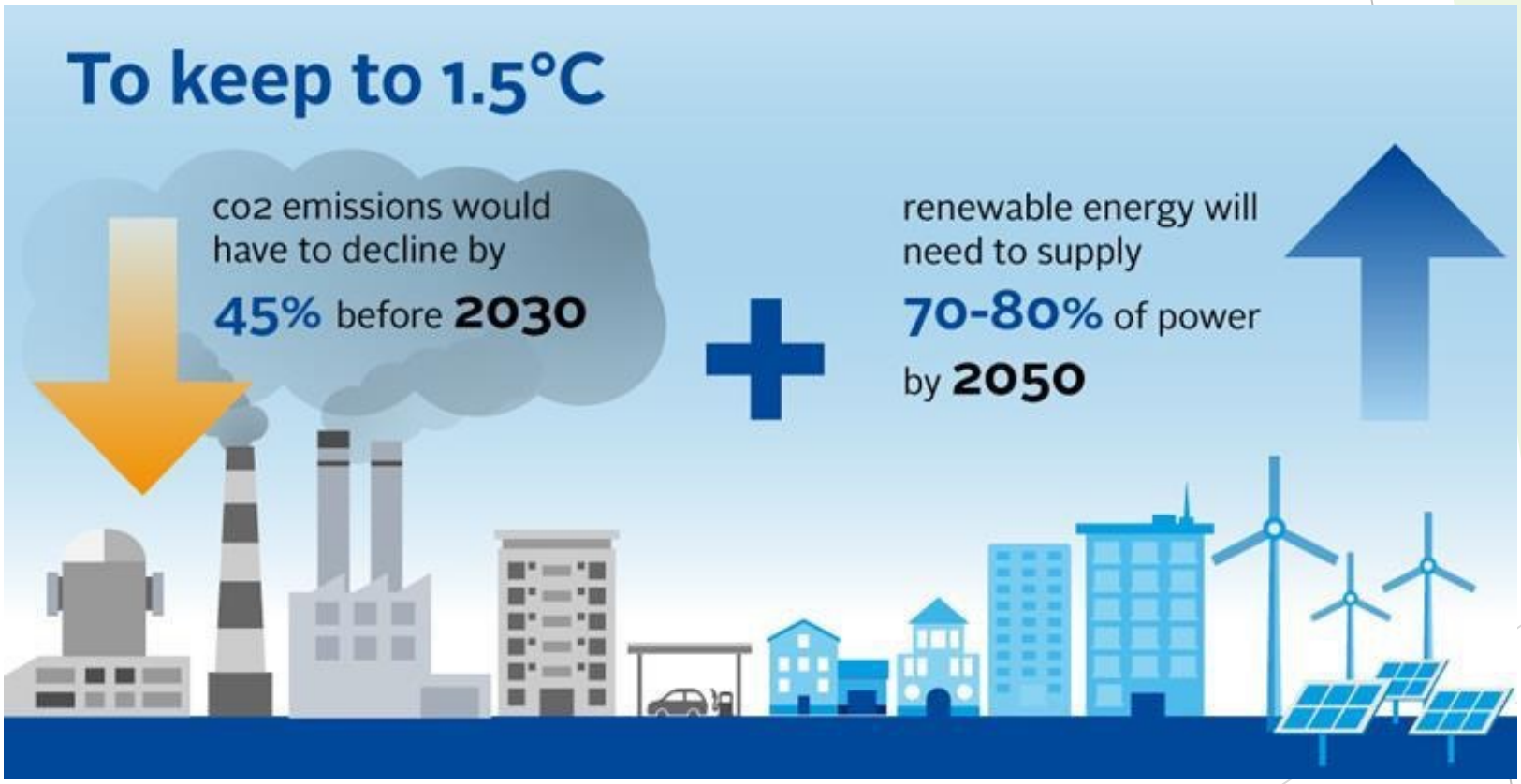
Gas serra

CO2

CH4

N2O

COP21 (2015) - Green Deal (EU 2019)



https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

Inquinamento atmosferico

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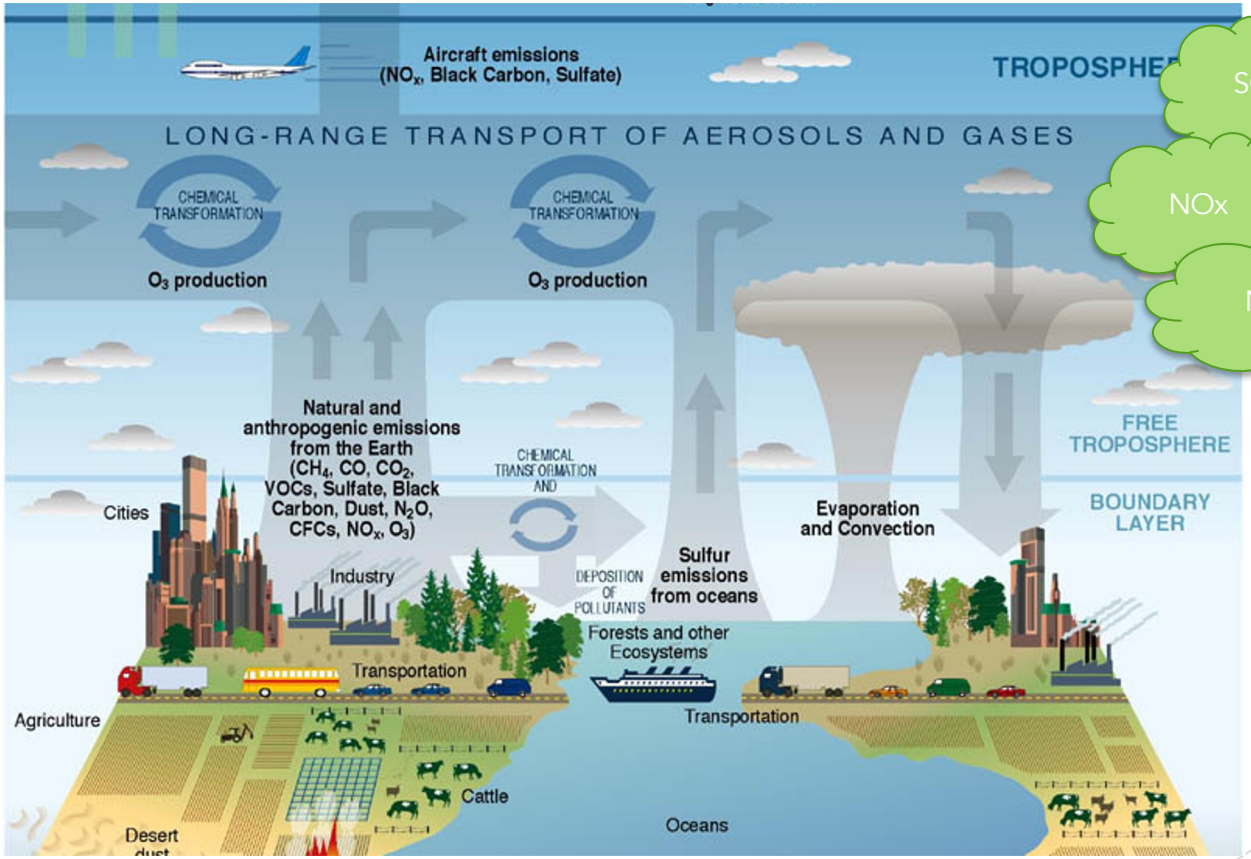

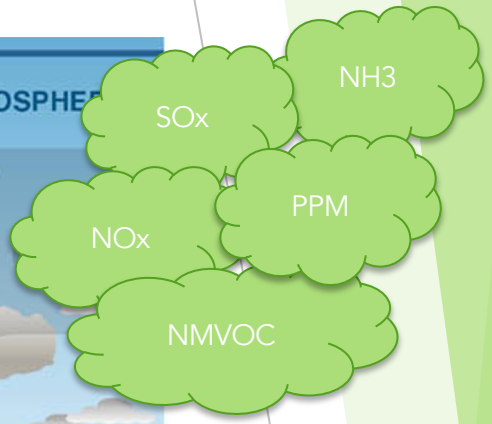

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Inquinamento atmosferico

- Zero pollution action plan (2021): -55% morti premature al 2035 rispetto al 2005
- Nuova direttiva EU per la qualità dell'aria (2024)
  - PM2.5: 10 μg/m3
  - NO2: 20 μg/m3

https://environment.ec.europa.eu/strategy/zero-pollution-action-plan_en

Qualità dell'aria in Lombardia: PM2.5

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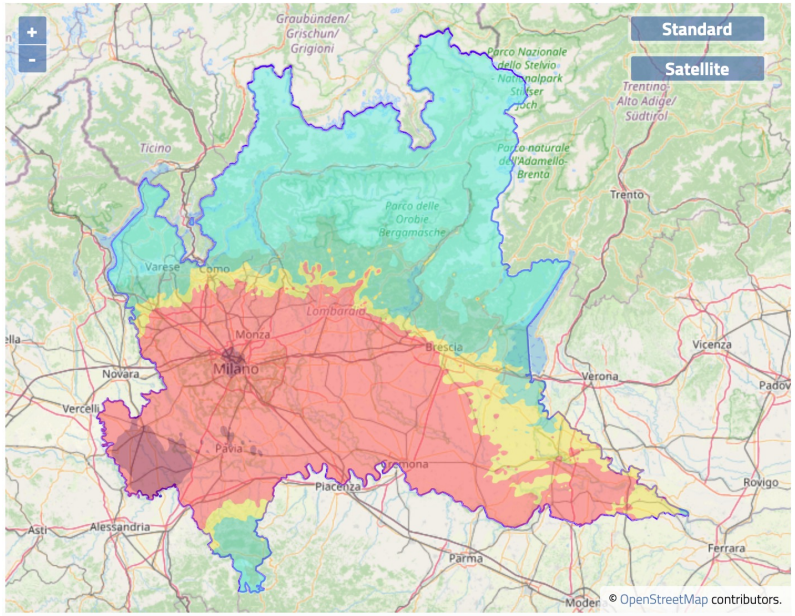
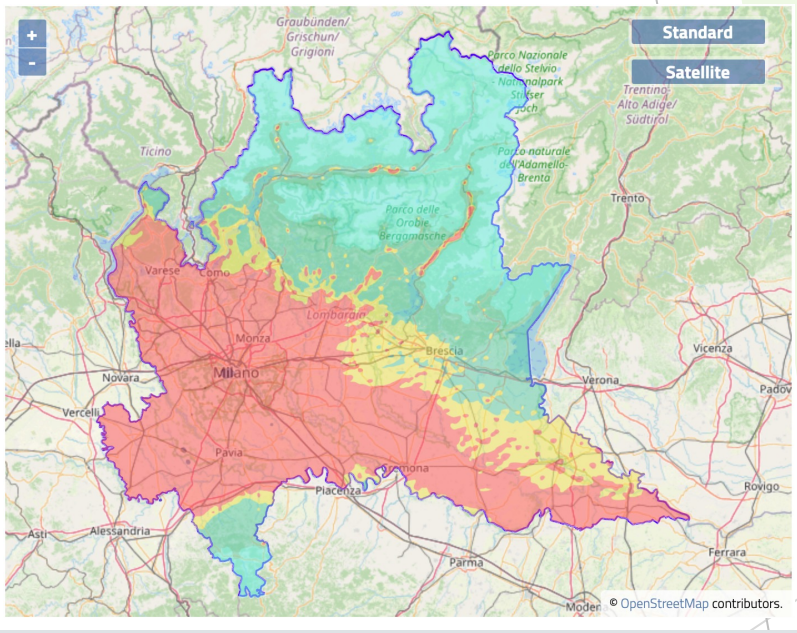
20 febbraio 2024



21 febbraio 2024



Legenda PM2.5 - (µg/m³)

0-10	10-20	20-25	25-50	> 50

https://www.arpalombardia.it/temi-ambientali/aria/mappe-qualita-dellaria/
https://www.arpalombardia.it/temi-ambientali/aria/stime-modellistiche/

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Il particolato secondario

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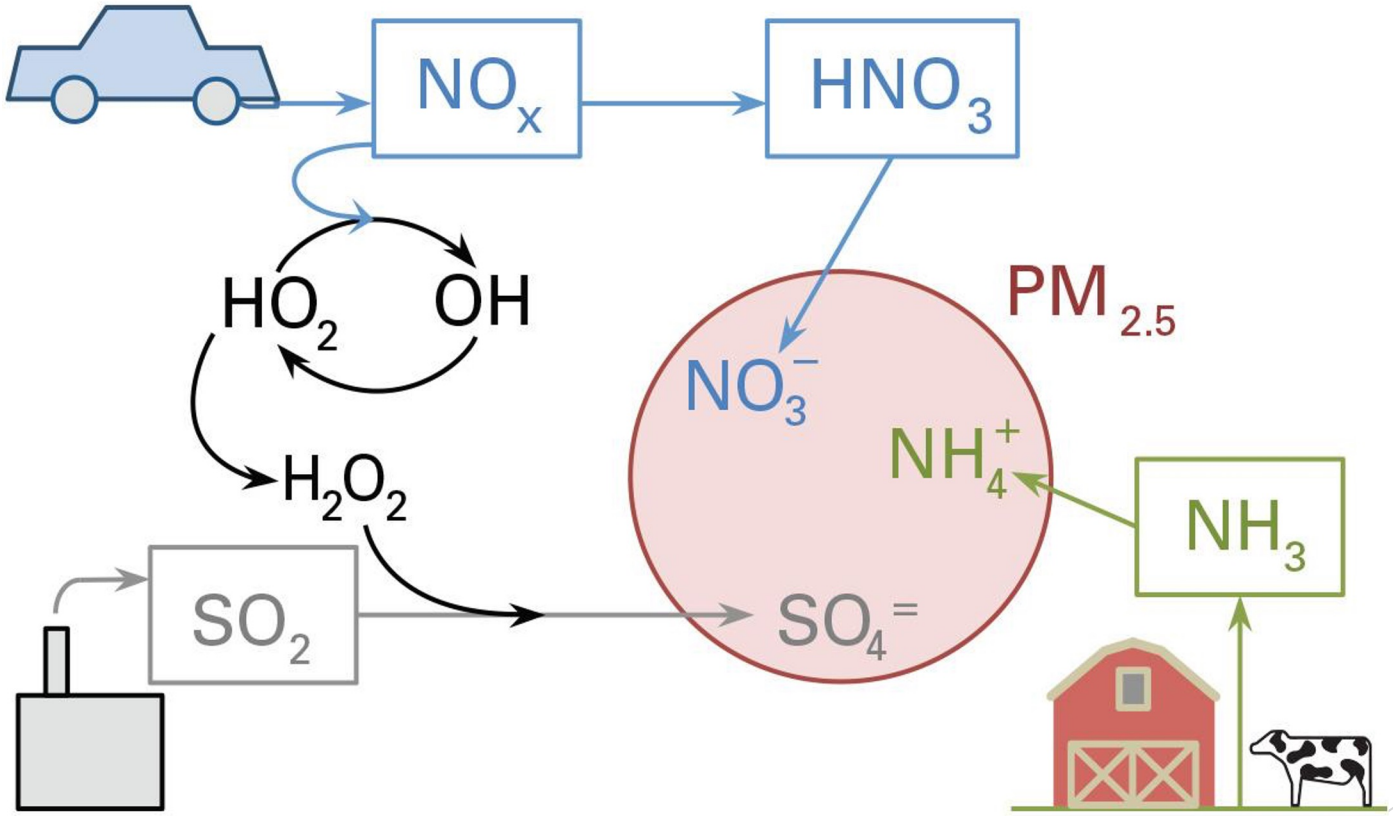

DOI: 10.1021/acs.est.5b00008
Environ. Sci. Technol. 2015, 49, 4834−4841

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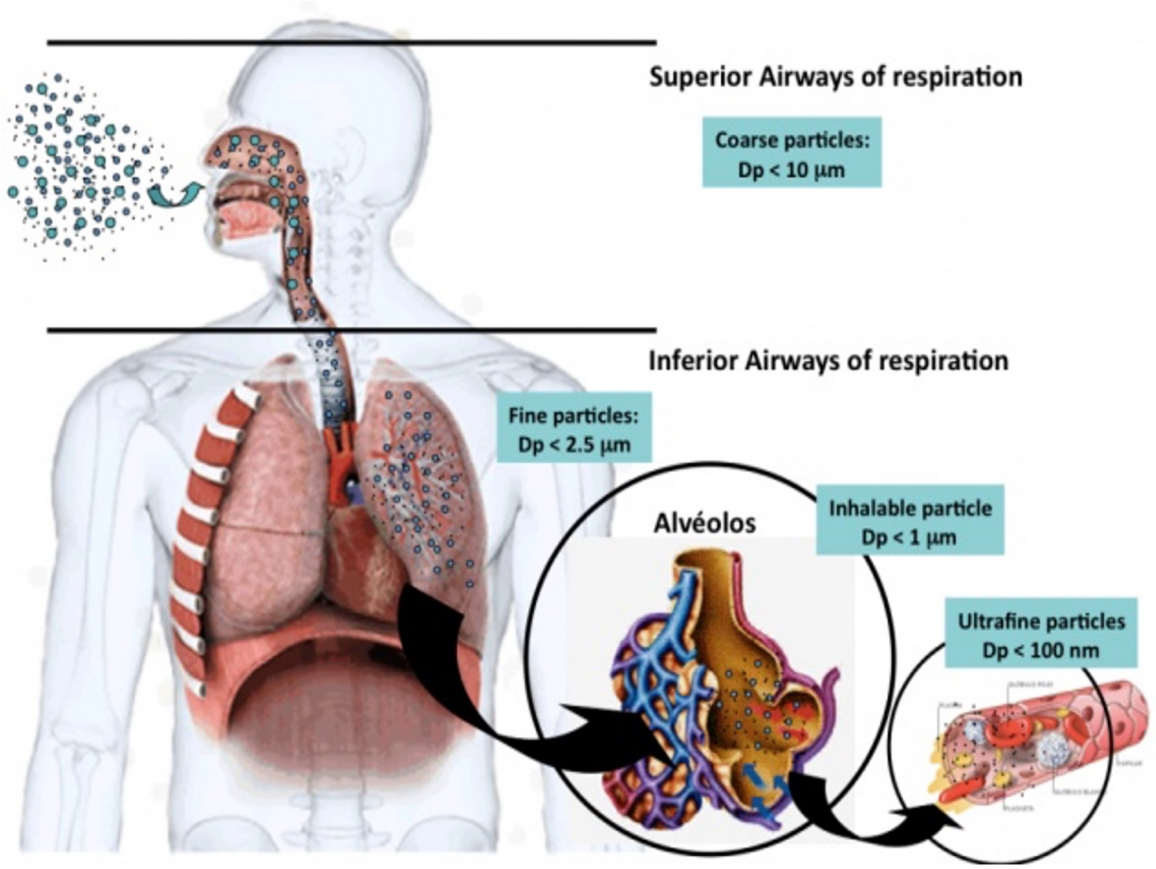
Esposizione e salute



Effetti sul sistema cardio-circolatorio

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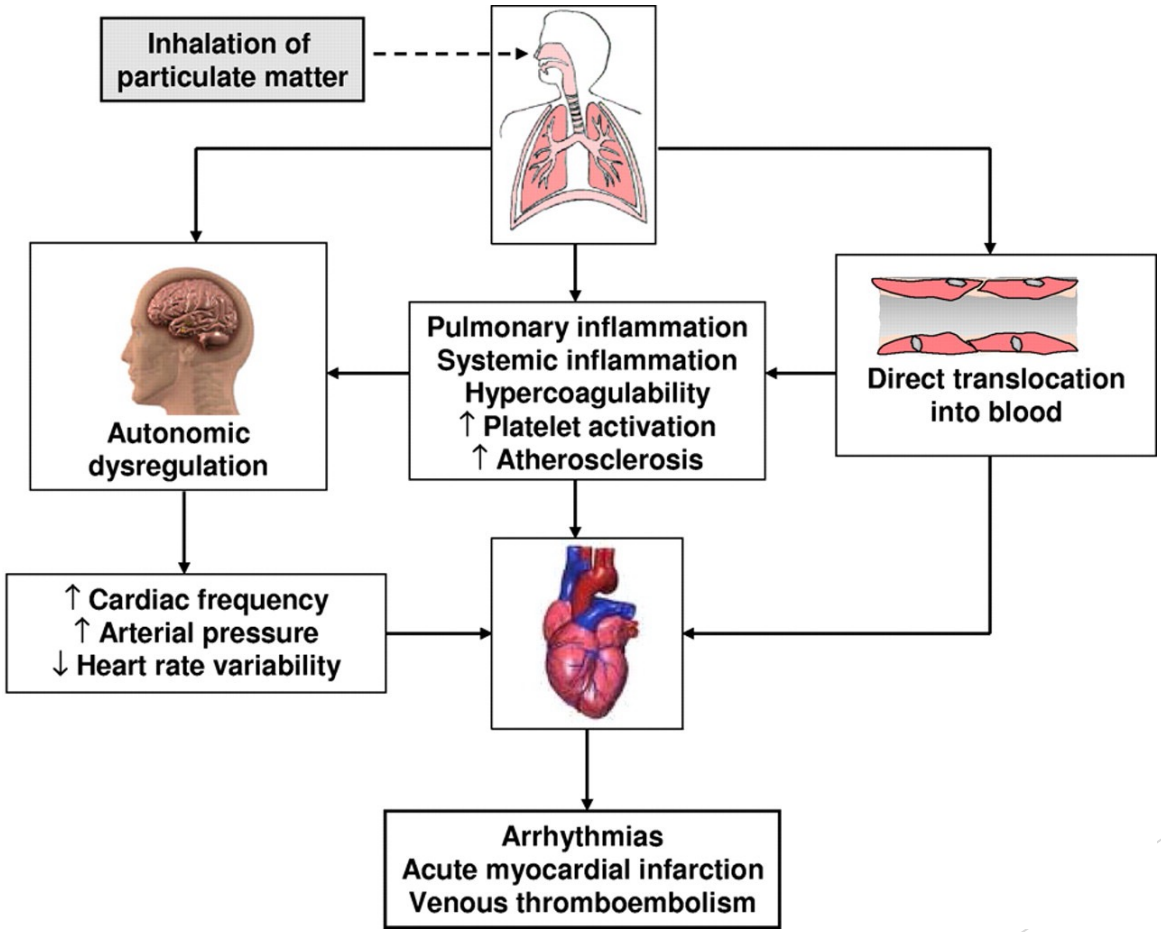

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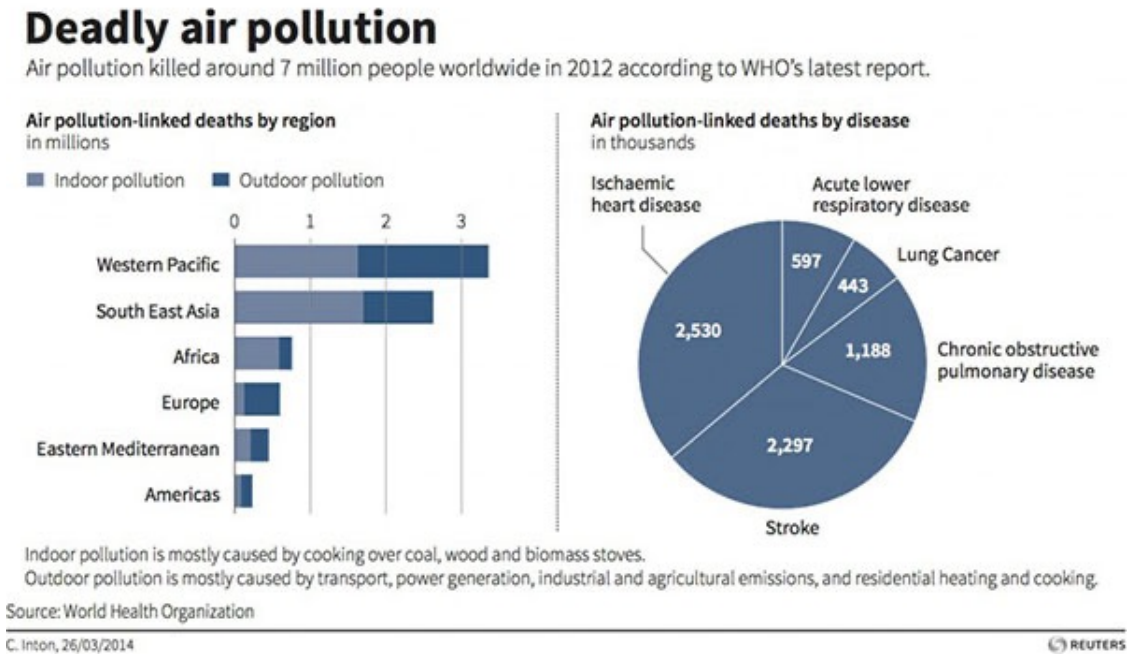
Esposizione e mortalità nel mondo (WHO) e in Italia (EEA)



L'esposizione al $PM_{2.5}$ sopra il limite di 5 µg/m³ (WHO 2021) ha portato nel 2020 in Italia a:

52300 morti premature

464300 anni di vita persi

775 anni di vita persi ogni 100k abitanti

Metodi/modelli

Integrated Assessment Modeling

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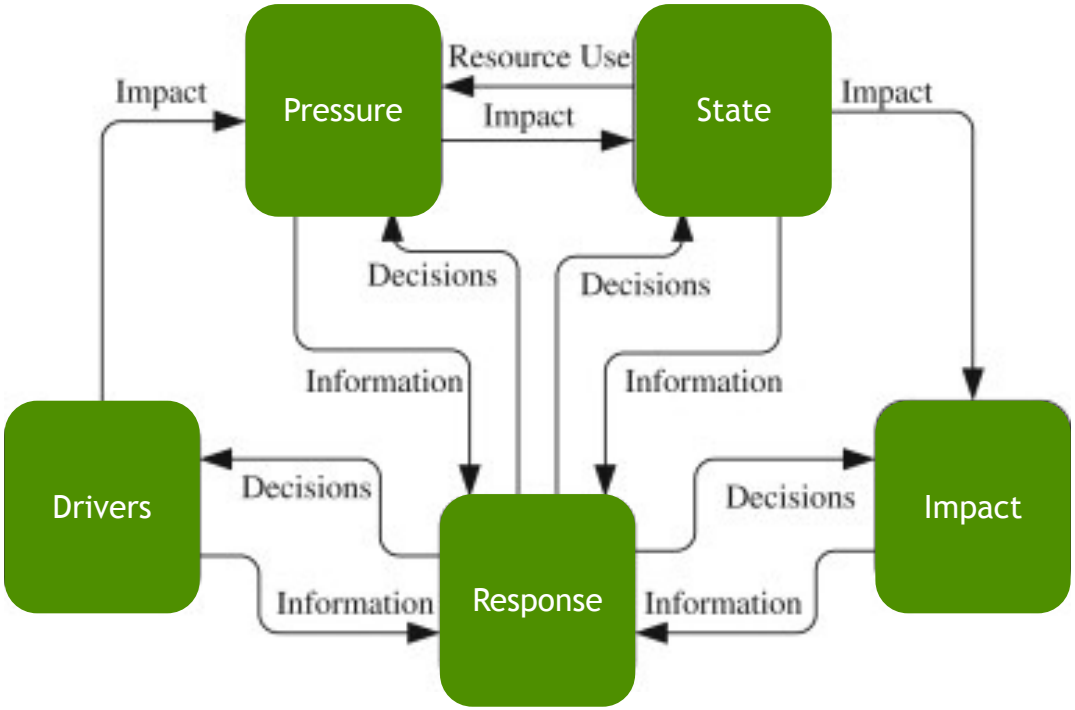

EEA DPSIR framework (1999)

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Data science

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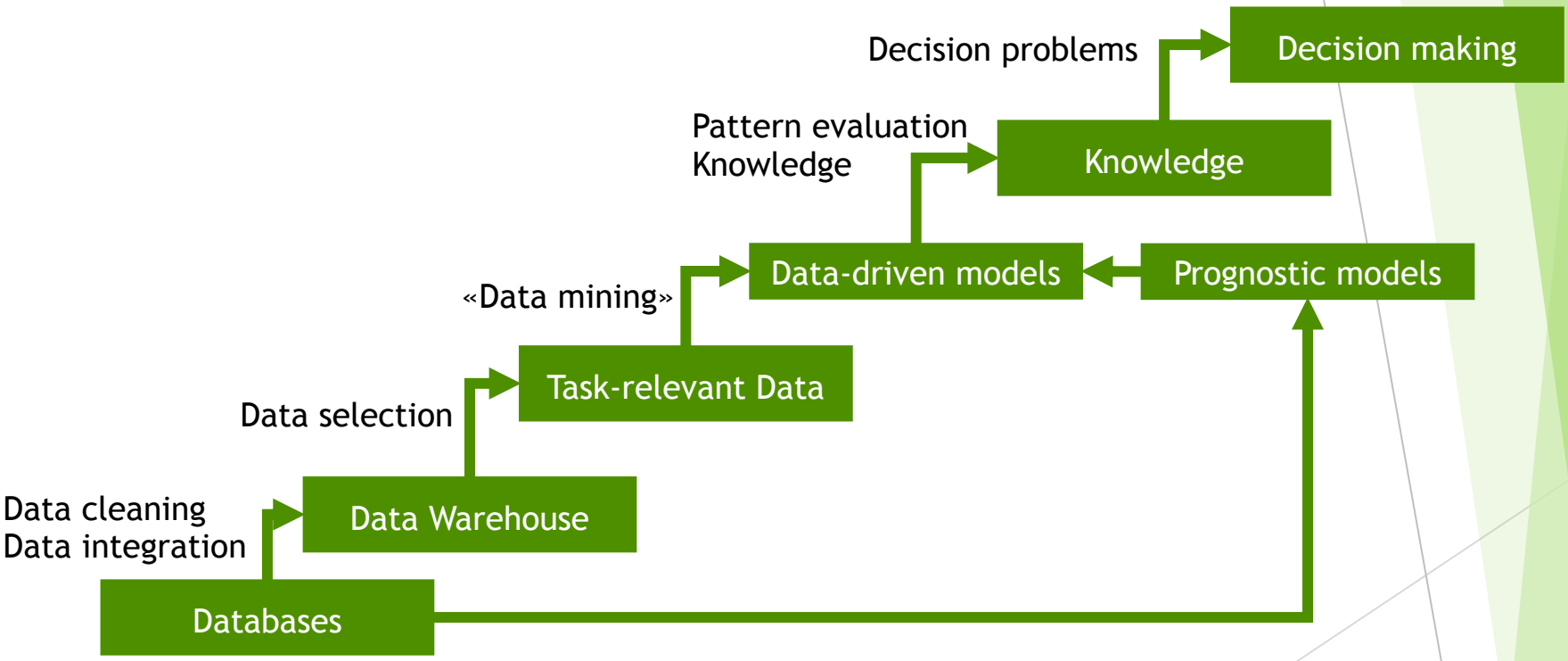

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Sistema modellistico MAQ

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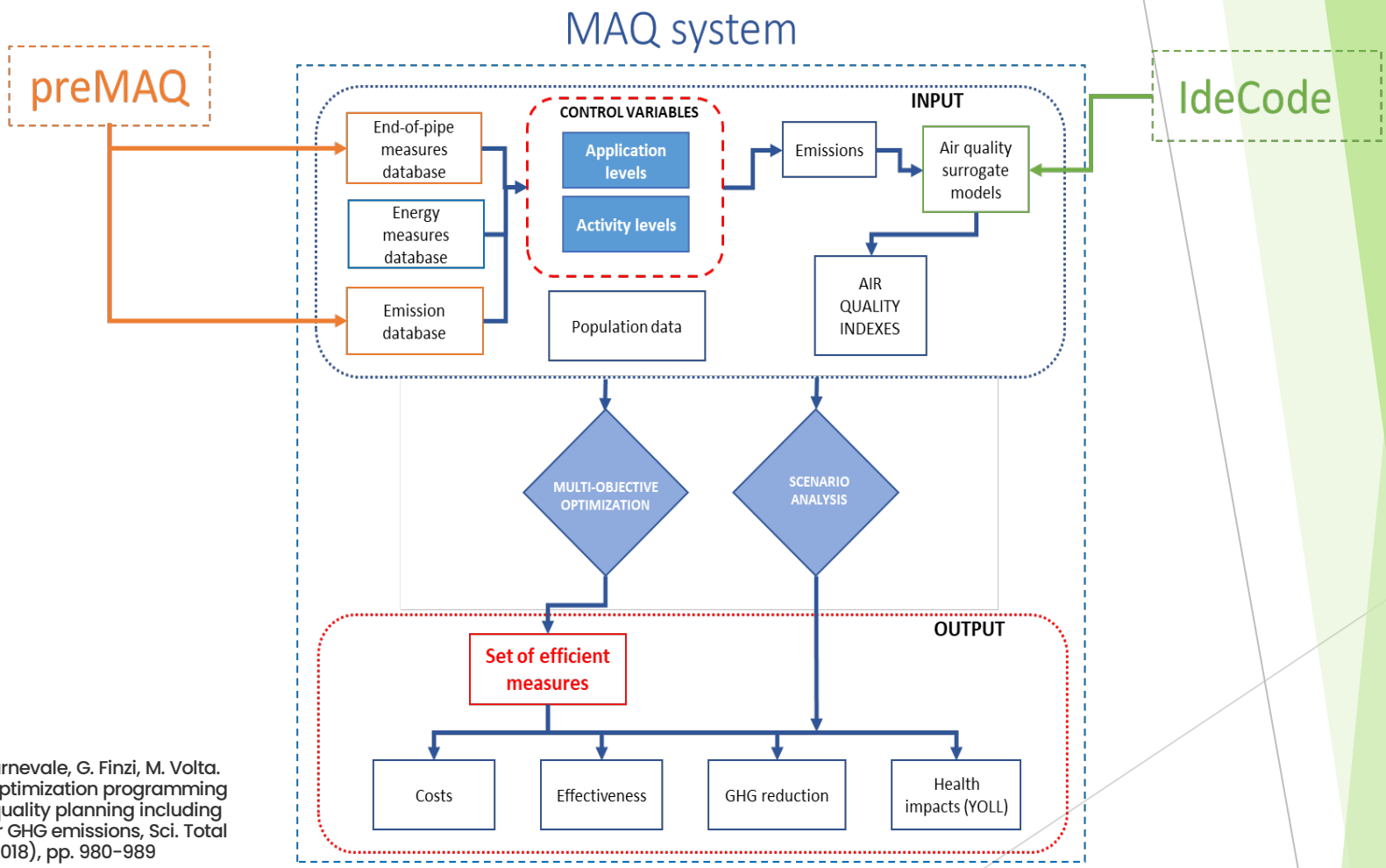

E. Turrini, C. Carnevale, G. Finzi, M. Volta. A non-linear optimization programming model for air quality planning including co-benefits for GHG emissions, Sci. Total Environ., 621 (2018), pp. 980-989

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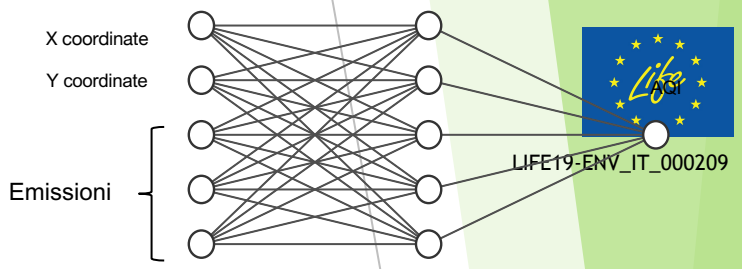
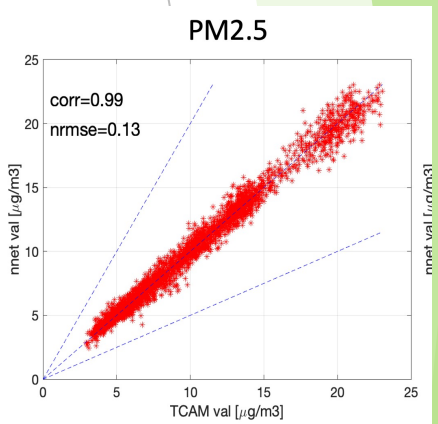
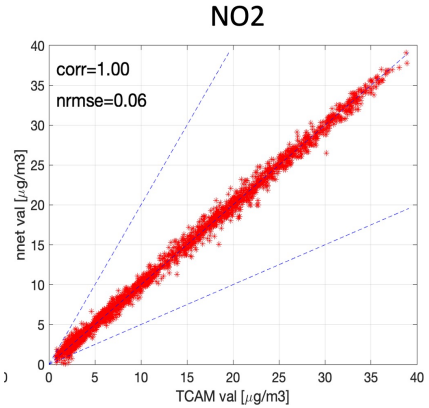
Modelli Source-Receptor



	$PM_{2.5}$ mean	NO_2 mean
Precursors	PM_{10}, NO_X, NH_3, SO_X, VOC	NO_X, VOC
Input nodes	20	8
Layers	2	2
Hidden layer nodes	20	8
f_1	hyperbolic tansig	hyperbolic tansig
f_2	pure linear	pure linear

Index	$PM_{2.5}$ mean	NO_2 mean
Correlation	0.999	0.998
Normalized mean error	0.005	0.026
Explained variation	0.997	0.996
Standard deviation [µg/m^3]	0.106	1.107





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SCENARI CLE2020, CLE2030

Dominio di applicazione: Regione Lombardia

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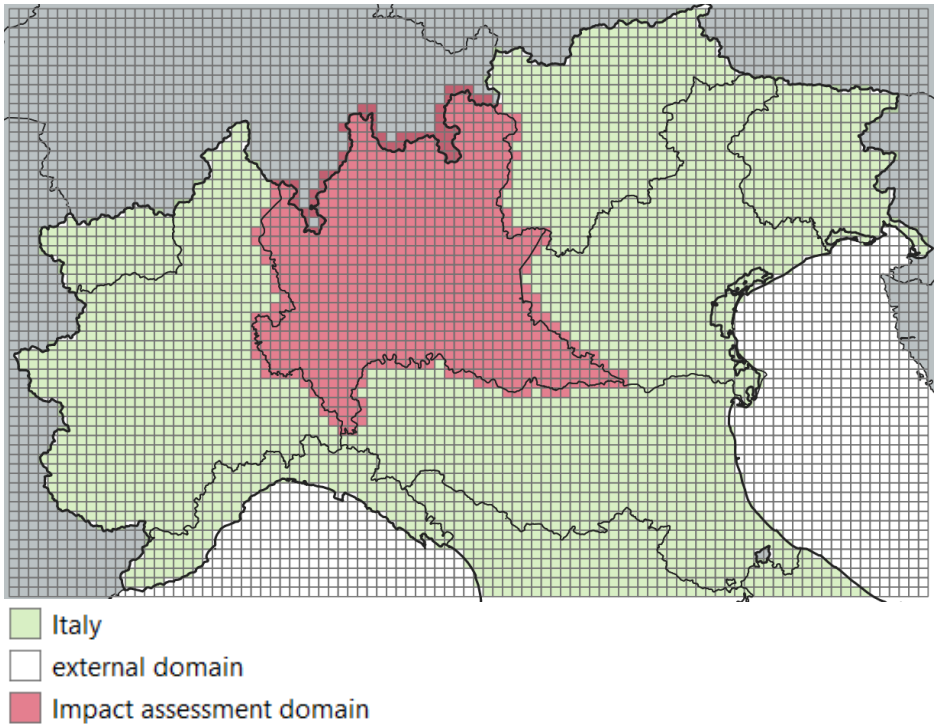
62x95 celle di 6x6 km^2



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Database

- Emissioni (2017: Prepair – Life15 ipe it 013)
- Misure tecnologiche di riduzione delle emissioni (GAINS)
- Popolazione (Istat)
- Morti per tutte le cause
- Numero di capi allevati (Ismea)
- Utilizzo superfici egricole (Ismea-Istat)
- Numero di veicoli circolanti
- Carburante venduto (Copert-UNEM)
- Consumi energetici (TERNA)

Emissioni CLE2020 (kt/anno)

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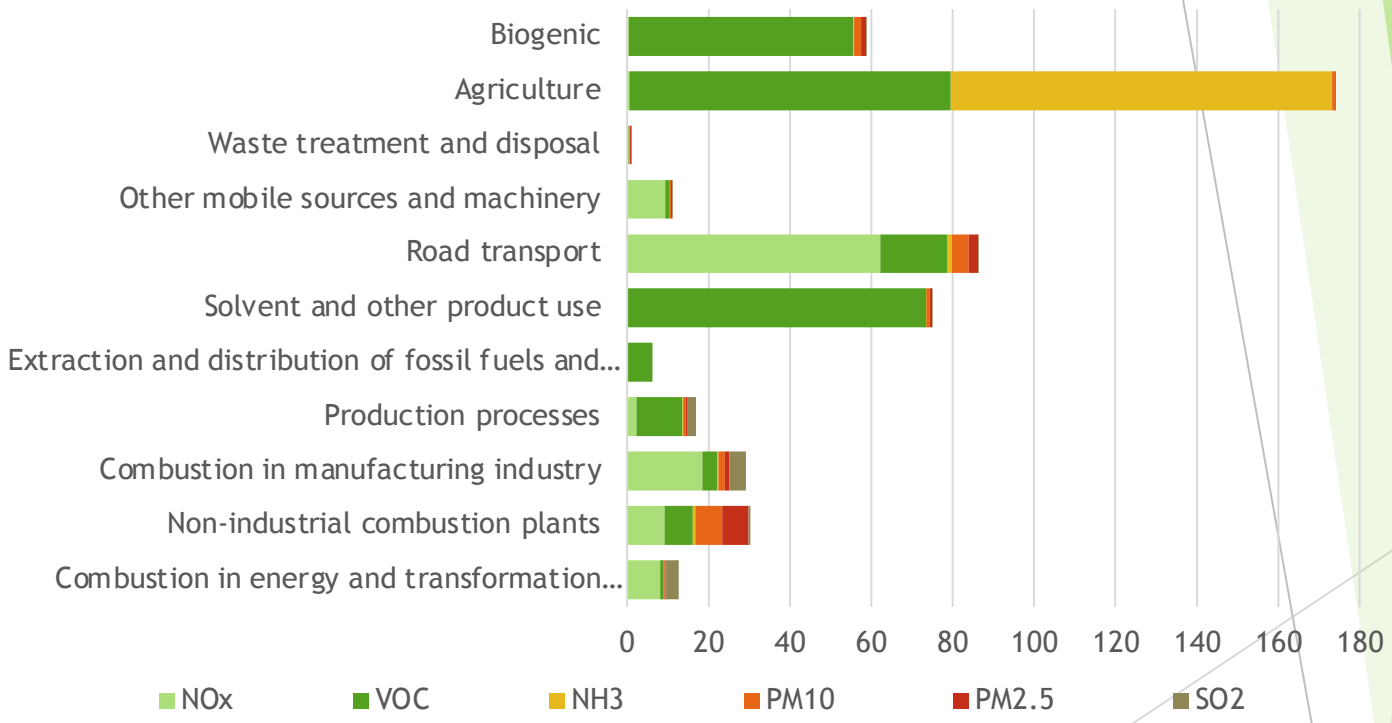

LIFE 15 IPE IT 013

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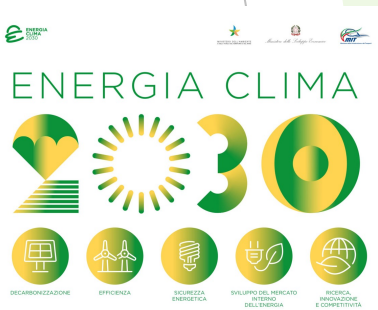
CLE2030



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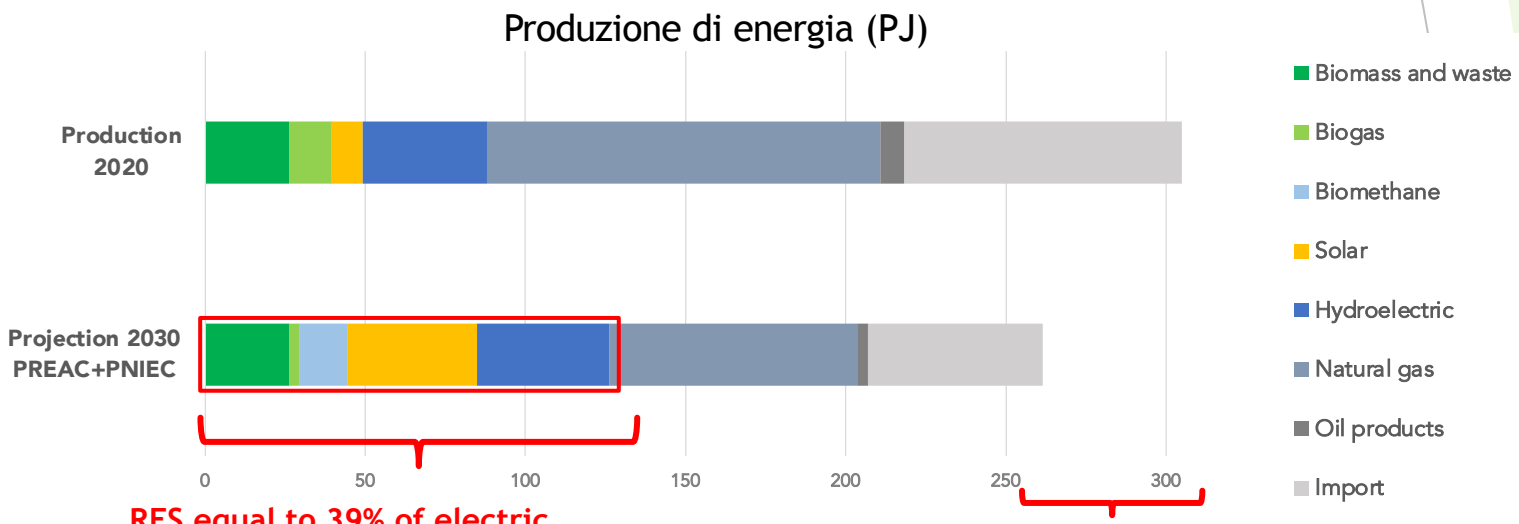

RES equal to 39% of electric production and 56% of thermal

Energy production reduction: 14%

Energy demand

Sector	2019 demand [Mtep]	2030 projection [Mtep]	Variation
Domestic heating	423	293	-31%
Agriculture	17	17	-3%
ETS industry	180	109	-39%
Non ETS industry	121	84	-32%
Transport	201	197	-14%

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CLE2030: riduzione delle emissioni

Emissions variation between CLE2030 and BC2020 [%]					
Macrosettore CORINAIR	NOx	VOC	NH3	PM2.5	CO2
Produzione d'energia	-35%	-34%	-36%	-32%	-44%
Combustione non industriale	-31%	-31%	-31%	-31%	-31%
Industria	-30%	-32%	-35%	-31%	-23%
Estrazione e distribuzione conbustibili	0%	1%	0%	0%	0%
Trasporto su strada	-23%	-21%	-31%	-20%	-26%
Agricoltura	-3%	-3%	-4%	-3%	3%
Totale	-23%	-4%	-5%	-22%	-23%

SCENARI DUALNG2020, DUALNG2030

Stima della riduzione delle emissioni DUALNG

inquinante	Variazione emissioni
CO2	-11,4%
NOx	-19,8 %
PM10	-32,1%

Scenario DUALNG2020

Emissioni

CORINAIR MS	NOx	VOC	NH3	PM10	PM25	SOx	CO2
Trasporto su strada	-9.5%	0%	0%	-3.6%	-6.2%	0%	-4%
TOTALE	-5%	0%	0%	-1%	-1%	0%	-1%

Indicatori di qualità dell'aria

	PM10 [µg/m3]	PM2.5 [µg/m3]	NO_2 [µg/m3]
CLE2020	22.5	14.7	22.1
DUALNG2020	22.4	14.6	21.5

SCENARI 2020: PM2.5 [µg/m3]

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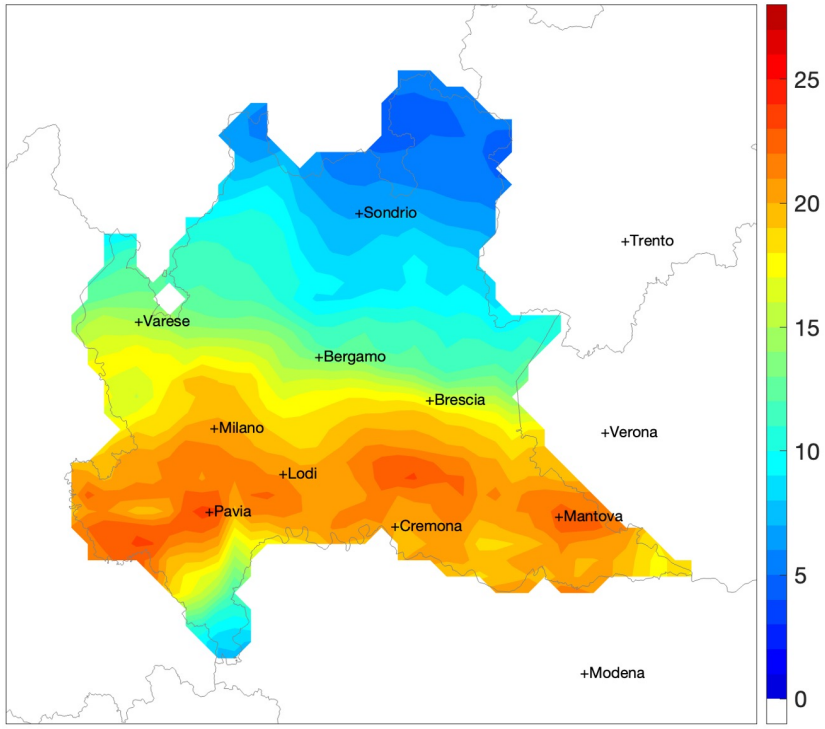
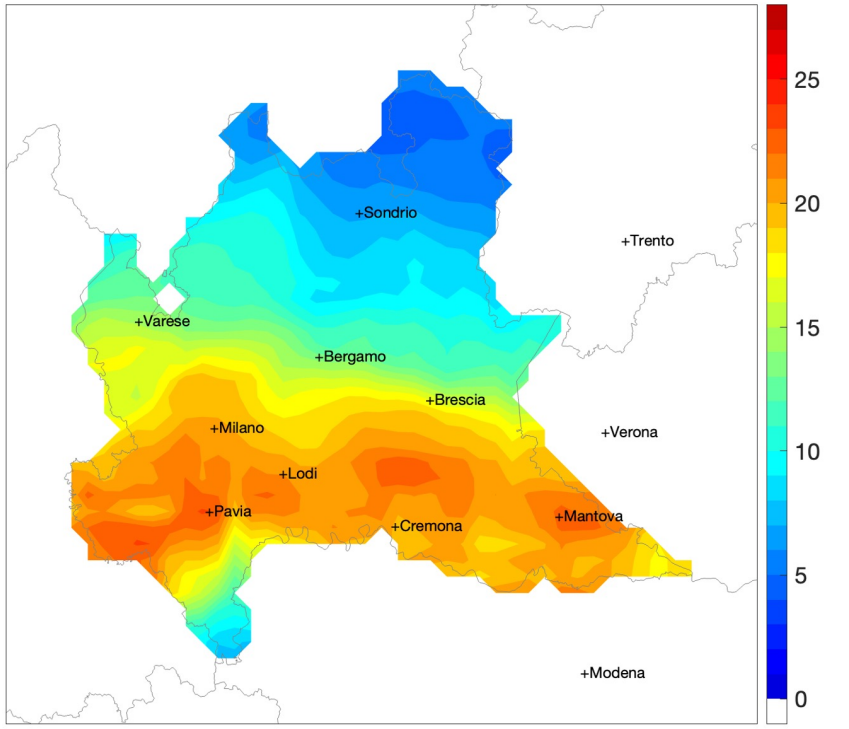
CLE2020



DUALNG2020



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SCENARI 2020: NO2 [µg/m3]

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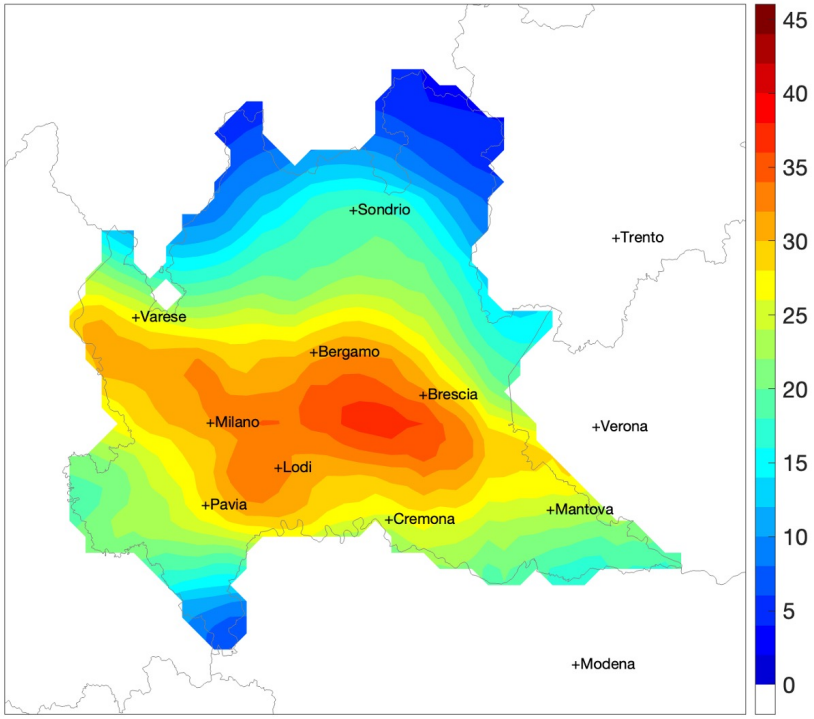
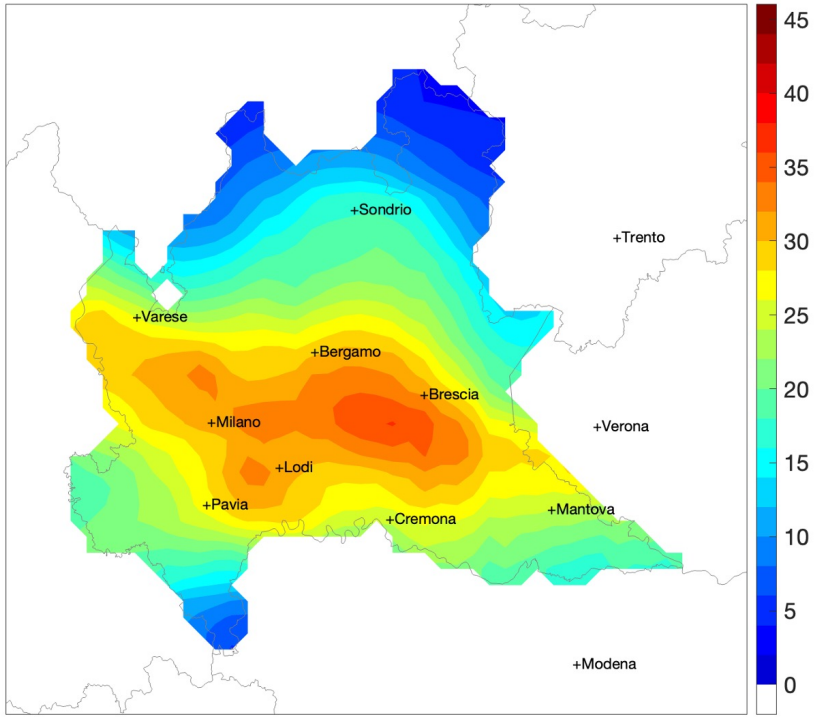
CLE2020



DUALNG2020



EU newtarget to 2030

WHO treshold

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Scenario DUALNG2030

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Emissioni

CORINAIR MS	NOx	VOC	NH3	PM10	PM25	SOx	CO2
Trasporto su strada	-10.2%	0%	0%	-3.6%	-6.3%	0%	-4.5%
TOTAL	-6%	0%	0%	-1%	-1%	0%	-2%

Indicatori di qualità dell'aria

	PM10 [µg/m3]	PM2.5 [µg/m3]	NO_2 [µg/m3]
PREAC	21.2	13.5	19.4
DUALNG2030	21.1	13.4	18.8

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SCENARI 2030: PM2.5 [µg/m3]

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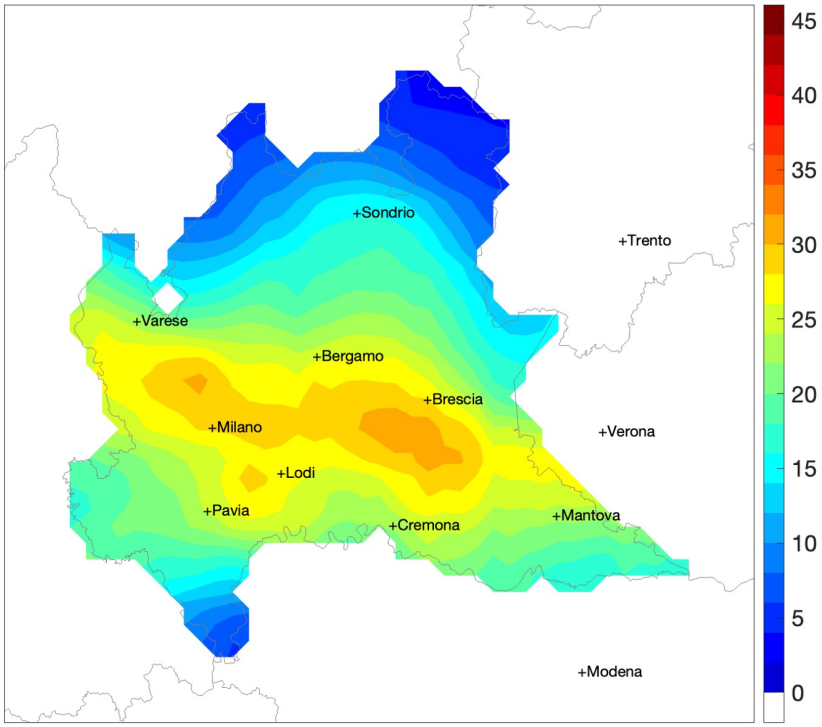
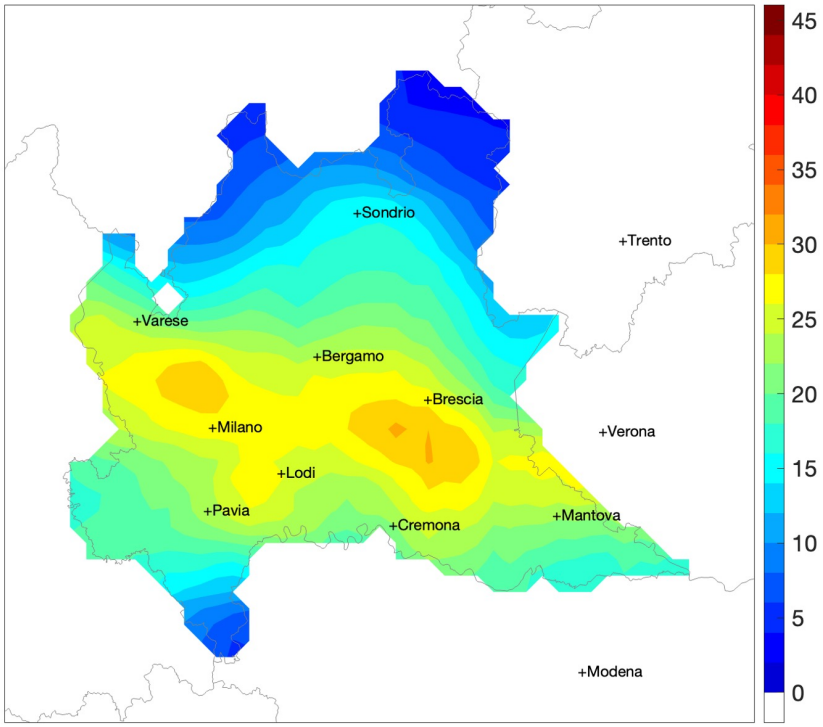
CLE2030



DUALNG2030



EU target

WHO threshold

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SCENARI 2030: NO2 [µg/m3]

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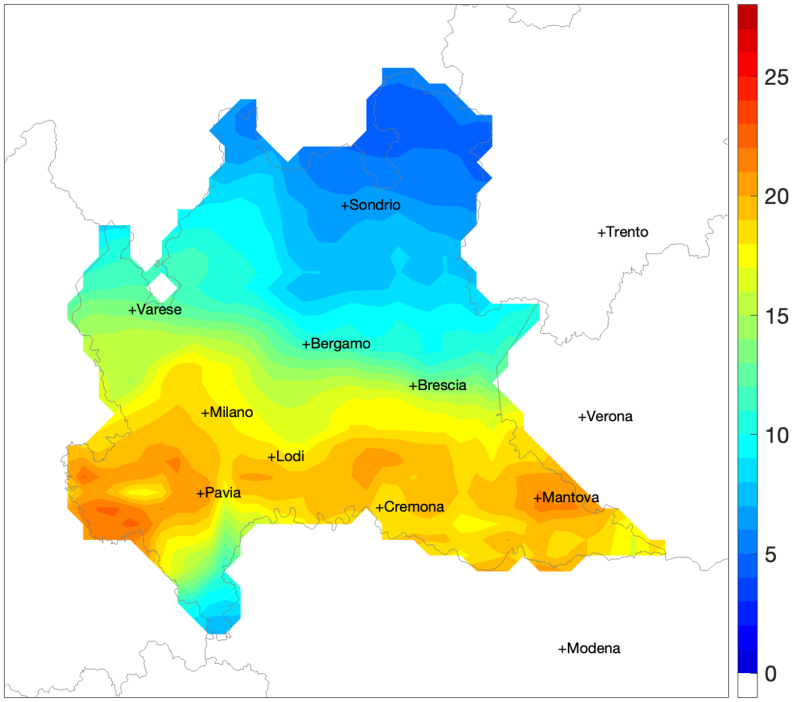
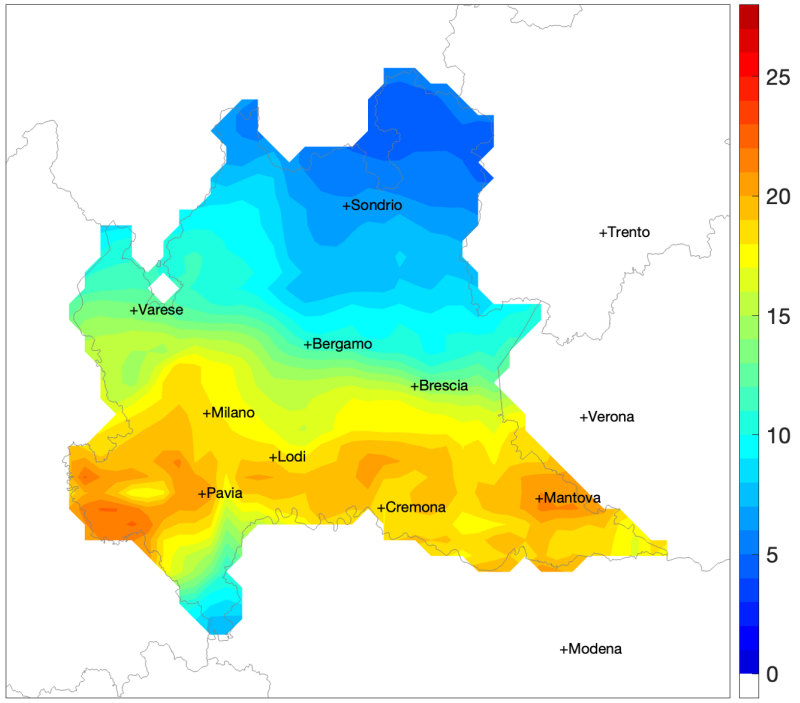
CLE2030



DUALNG2030



EU target

WHO threshold

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Impatti sulla salute

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Morti attribuibili alla esposizione al PM2.5 per 100k abitanti				
NUT3	CLE2020	DUALNG2020	PREAC2030	DUALNG2030
Varese	75 (61-88)	74 (61-87)	66 (54-77)	65 (53-76)
Como	85 (69-100)	83 (69-98)	74 (61-87)	72 (59-85)
Sondrio	29 (23-34)	28 (23-33)	23 (19-27)	22 (18-26)
Milano	106 (87-124)	106 (89-125)	99 (82-116)	97 (80-114)
Bergamo	66 (54-77)	65 (54-77)	53 (44-63)	53 (44-63)
Brescia	94 (77-111)	94 (78-110)	79 (65-93)	78 (64-92)
Pavia	137 (113-161)	137 (114-160)	132 (110-155)	132 (108-154)
Cremona	112 (92-131)	112 (93-131)	94 (77-110)	93 (76-109)
Mantova	126 (103-148)	125 (104-146)	114 (94-134)	113 (93-132)
Lecco	70 (57-83)	69 (58-82)	61 (50-71)	60 (49-70)
Lodi	116 (96-136)	116 (97-135)	102 (85-120)	101 (83-118)

Conclusioni

- Approccio modellistico
- Raccolta database per la stima degli scenari base al 2020 e 2030
- Stima delle emissioni con DUALNG
- Stima impatto sulla qualità dell'aria ed esposizione di DUALNG
- DUALNG tra le tecnologie per compiere la transizione zero-pollution e zero-GHG-emissions

Grazie

Integrated Assessment Modeling and Control research group
Marialuisa Volta, Laura Zecchi, Michele Arrighini, Claudio Marchesi

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DUALNG

Heavy-duty vehicles retrofitting by Dual Fuel Liquid Natural Gas technology

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