

RIAT+ and Emilia Romagna Air Quality Regional Plan

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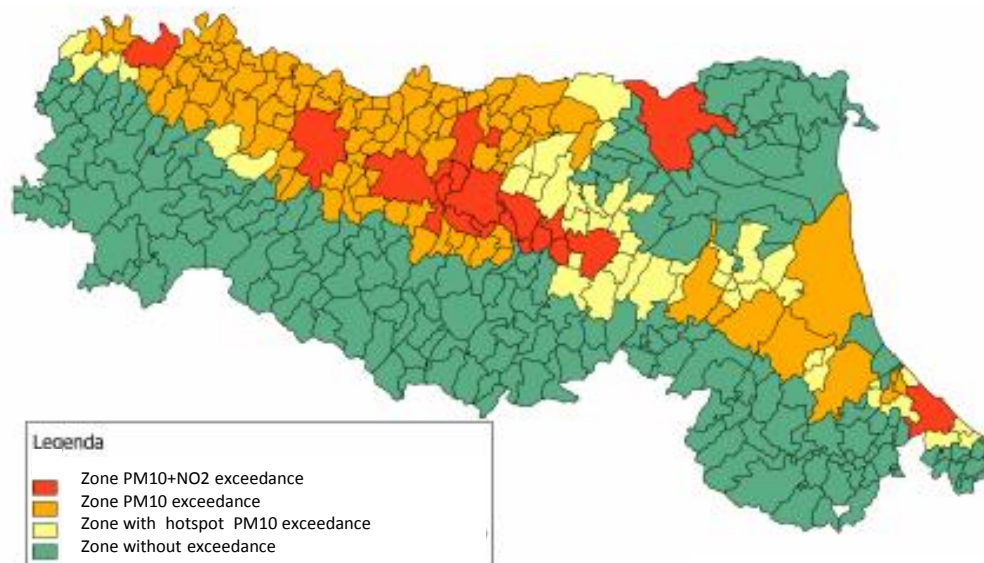
Emilia Romagna region



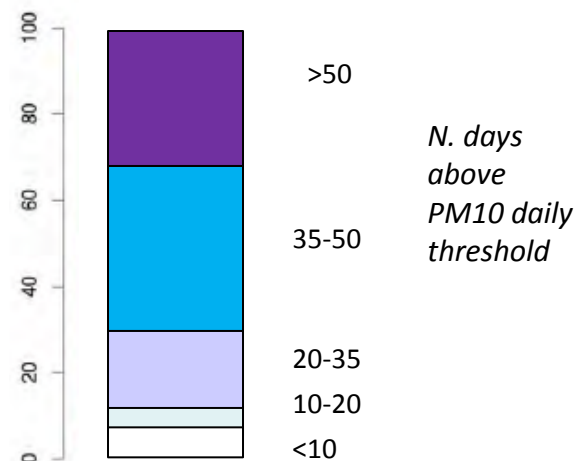
Emilia Romagna region is geographically heterogeneous and complex and includes hills, mountains, valleys, coastal areas and a relevant part of the Po river plain. The Po Valley is surrounded by the Alps in the North, the Apennine mountains in the South and bordered by Adriatic Sea in the East. The frequently stagnation of air masses often leads during winter to very strong air pollution episodes and in summer to high ozone values

Air quality in Emilia Romagna

Exceedance of air quality targets

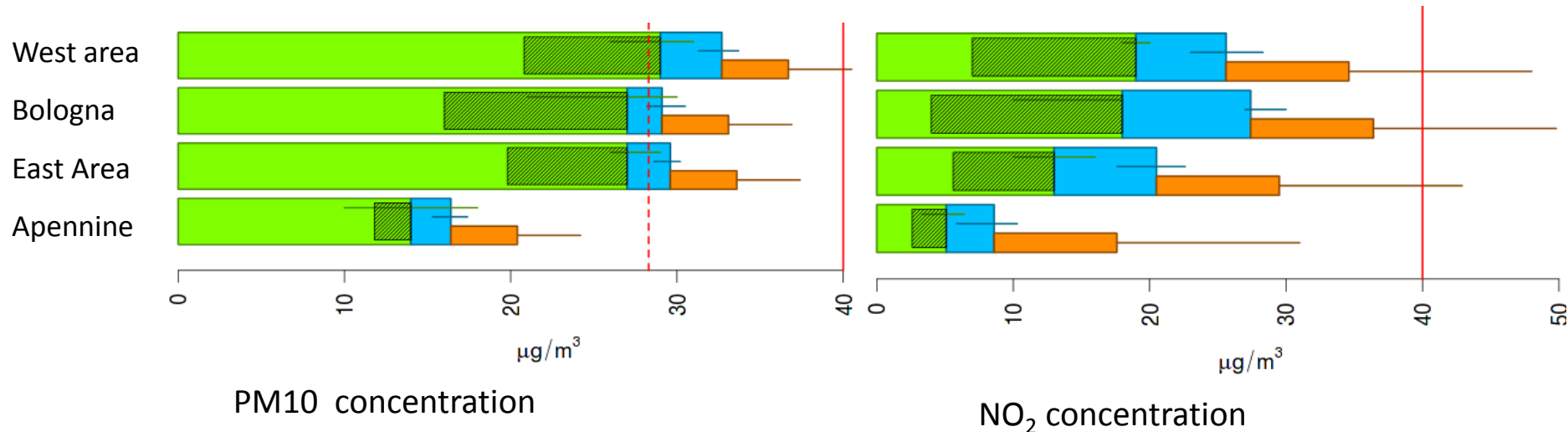


% population
exposed



Contribution to PM10 and NO₂ in Emilia Romagna

- Large scale (average and 25-75th percentile) and
 - Emilia Romagna contribution
 - Urban background (average and 25-75th percentile)
 - Local (50th and 90th percentile)
- Vertical lines are Air quality thresholds



The roadmap to the Air Quality plan (PAIR2020)

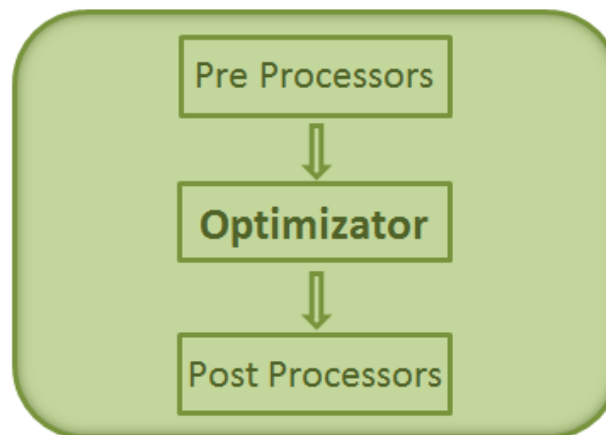
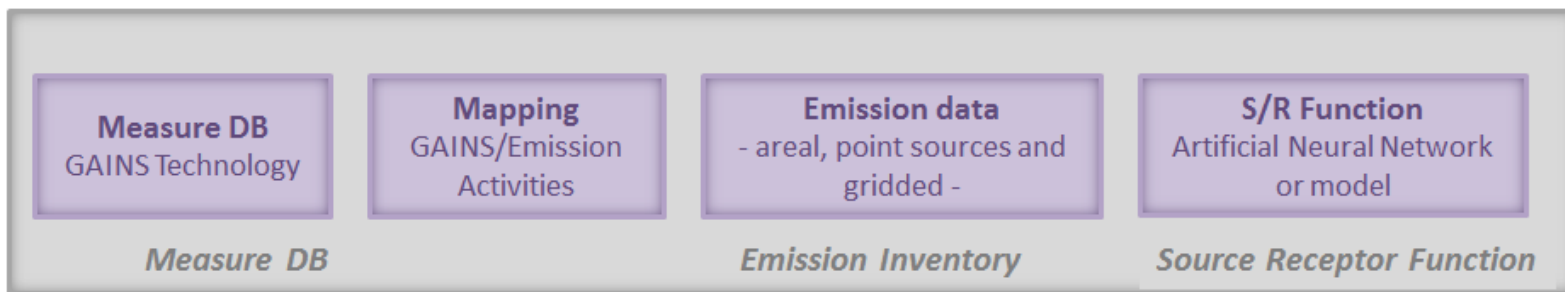
- Issue of the Guidelines by the Regional Government (giunta regionale) (December 2012)
- Institution of a Task force (RER – ARPA) preparing the technical documentation
 1. Framework (quadro conoscitivo)
 2. Preliminary action plan (documento preliminare, july 2013)
 3. Preliminary Environmental assessment and monitoring plan (VAS)
- Presentation and approval of the technical documentation by government (July 2014)
- Submission to the Assembly (assemblea legislativa) end of July 2014)

<http://ambiente.regione.emilia-romagna.it/aria-rumore-elettrosmog/temi/pair2020>

We try to ask to the question

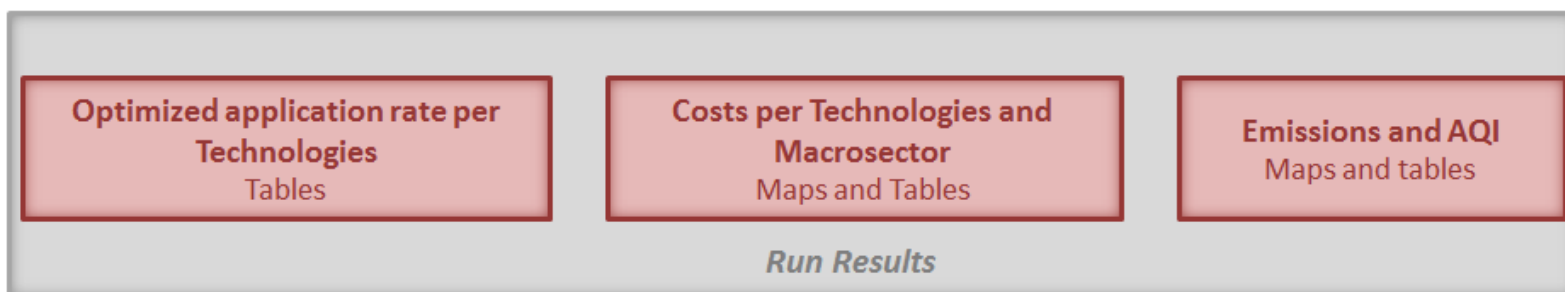
- What are the emissions reductions needed to achieve the air quality target?
- How we can achieve this target?
- Is it possible?

INPUT



RIAT + CORE SYSTEM

OUTPUT



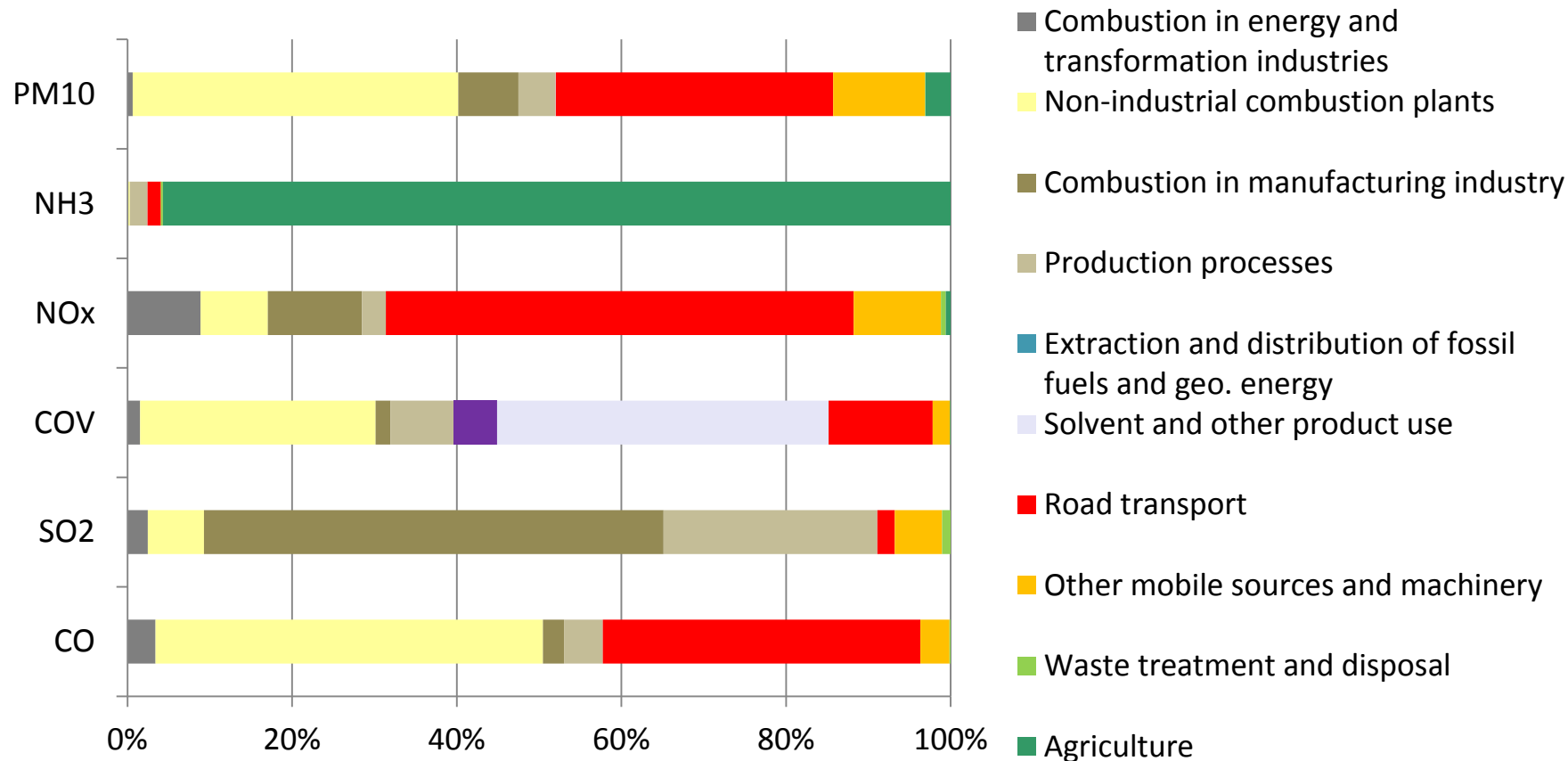
Input data for RIAT+

- Emission inventory with areal and point emissions on the defined domain
- “Mapping” between GAINS database and inventory classification (SNAP)
- Definition of non-technical measures
- Preparation of technical/non-technical measure data base
- Set up of several emission scenarios to define all possible evolutions
- Simulations with chemical transport model (NINFA system)

Regional Emission Inventory

- The regional inventory of atmospheric emissions has been undertaken by ARPA Emilia Romagna on behalf of the Emilia Romagna Region, with reference to the year 2010 using INEMAR
- INEMAR (INventario di EMISSIONi in ARia - Air Emission Inventory) is a database developed in order to carry out an atmospheric emission inventory, that is say, to estimate emissions of different pollutants for different activities (heating, road transport, agriculture, industry, etc.)

Emilia Romagna inventory 2010



”Mapping” between GAINS and SNAP inventory classification

SNAP				GAINS	
MS	SECT	ACT	FUEL	SECT	ACT
...	...	...	...	...	...
Non industrial combustion	Residential	Boiler <50 Kw	Natural gas	DOM	GAS
Agriculture	Organic waste water	Pig	No Comb	AGR_PIG	PL
Road Trasport	Car	Urban	Gasoline	TRA_RD_L D4C_URBA N	GSL

The structure of the “action data base”

2226 actions, of which:

2146 “technical “(GAINS)

80 “non technical/efficiency measure”

For each measure it is defined:

1. The Removal efficiency (RE) for each pollutant (i.e. NO_x, PM₁₀, etc.)
2. The Application rate (AR) for different years (i.e. 2010, 2015, 2020, etc)
3. The Maximum application rate
4. The Unit Cost
5. Several flags useful for the tool

Definition of “non-technical “(energy/efficiency) actions

Domestic:

- thermal insulation (roof and walls)
- Heat pump
- High efficiency boilers
- Solar panels
- Double glass
- Thermostatic valves

Traffic:

- Cycling line
- TLZ
- Velocity Reduction
- Electric car
- Electric bike

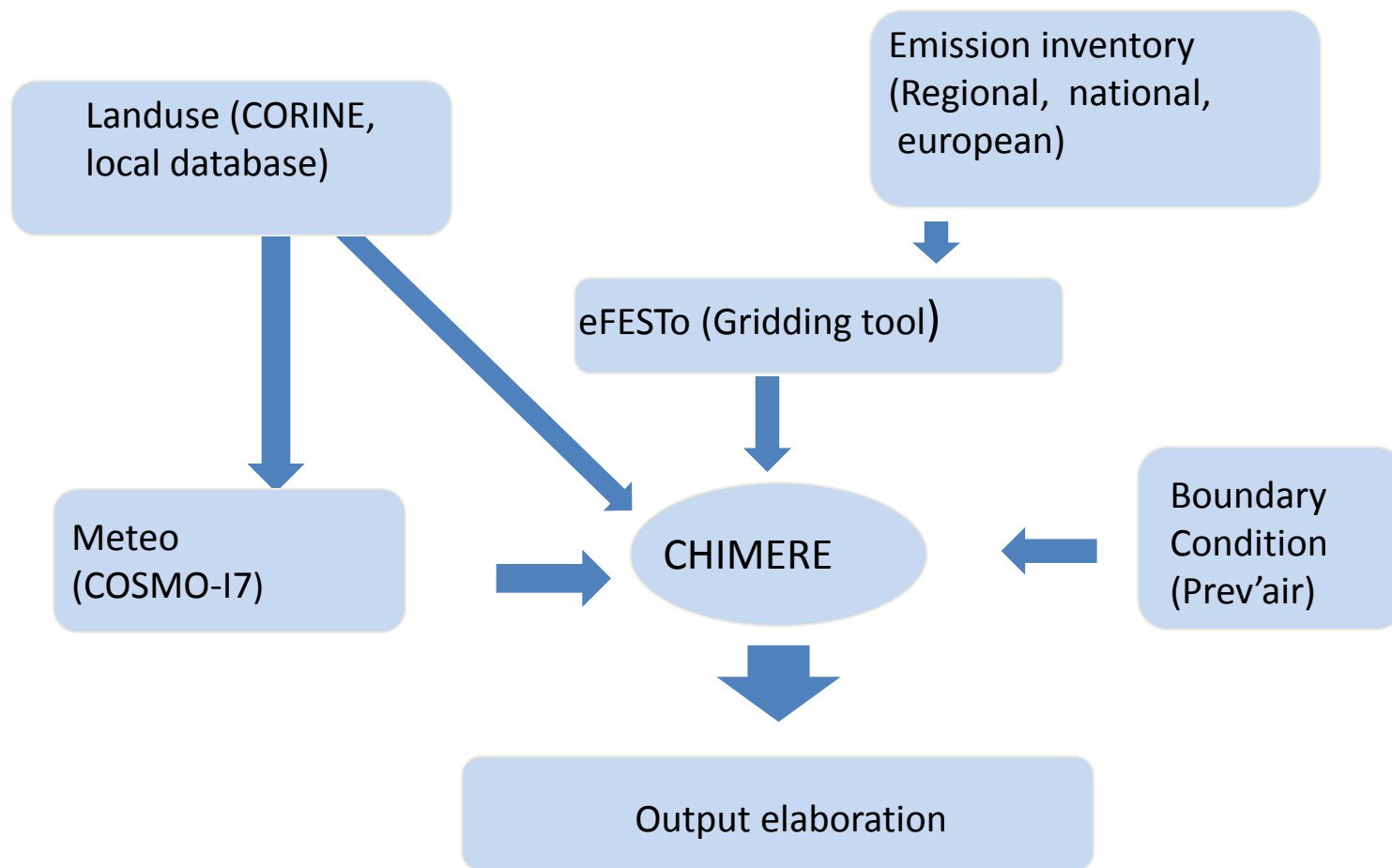
Energy production:

- Hydroelectric
- Wind
- Photovoltaic

Example of measure defined in the data base

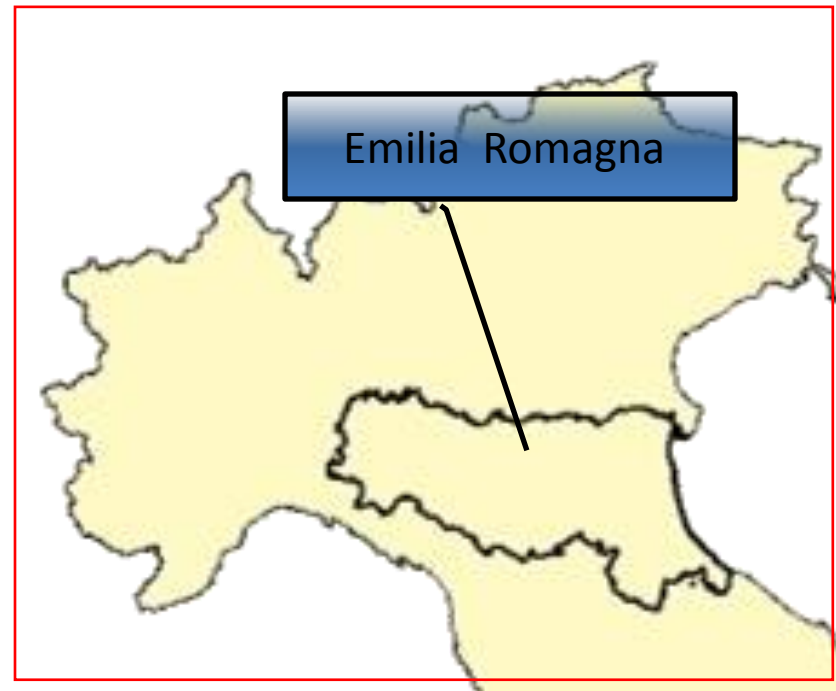
SECT	ACT	TECH
Agriculture:Livestock pigs	Pigs - liquid (slurry) systems	Combination of LNF_BF_CS_LNA
HDV – trucks	Medium distillates	EURO V on heavy duty diesel road vehicles
Industry: Comb. in boilers	Natural gas	No control
LDV: cars and smallbuses	LPG	EURO 6
LDV: light comm. trucks	Medium distillates	EURO 4
Motorcycles with 4-st. en.	Gasoline	Stage 2 control on motorcycles
Ot. Tran.: agriculture	Medium distillates	Stage 3B control
Residential Fireplaces	Fuelwood direct	Fireplace improved
Residential, commercial	Natural gas	Heat pump
Residential, commercial	Natural gas	Insulation of walls and floors
Residential, commercial	Natural gas	Vacuum-sealed solar thermal panels
Residential, commercial	Natural gas	Replacement of single glazing with double glazing

NINFA Air quality system



Model simulation setup for Artificial Neural Network (ANN)

- Meteo: COSMO-I7
- BC: Prev'air CLE 2020
- Emission inventory: Regional Inventory, National Inventory, European Inventory (MACC project)
- CTM:CHIMERE, version 2008c
- Horizontal resolution: 5km
- Vertical level:8
- Domain:128*82



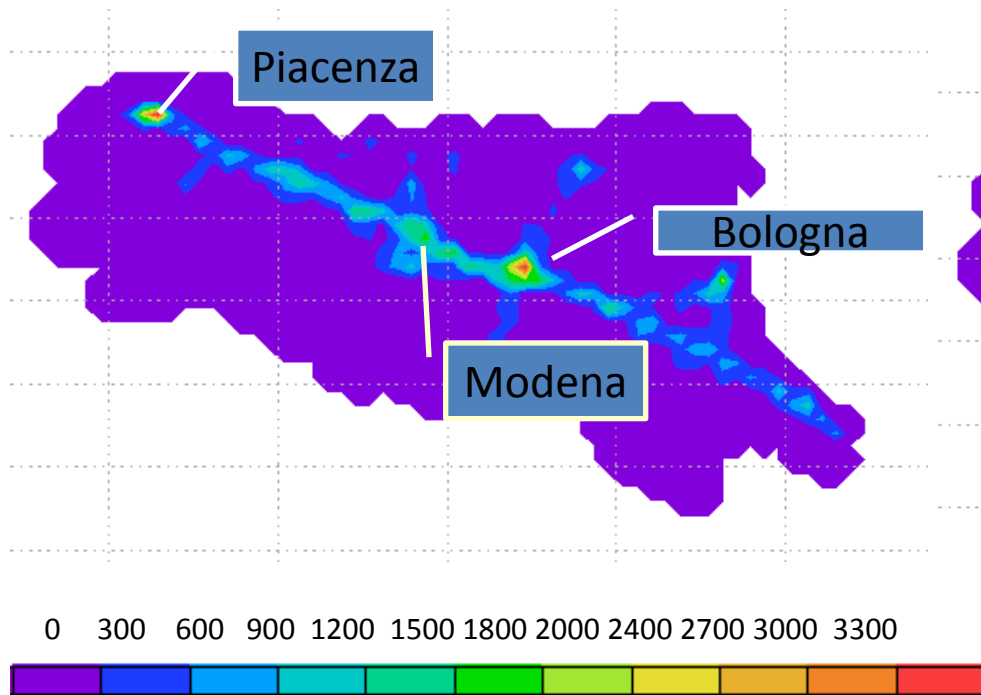
ANNs Emission Scenarios

Applying different emission control strategies (using emissions values varying between CLE - current legislation and MFR – maximum feasible reduction), a number of 12 alternative emission reduction scenarios have been simulated.

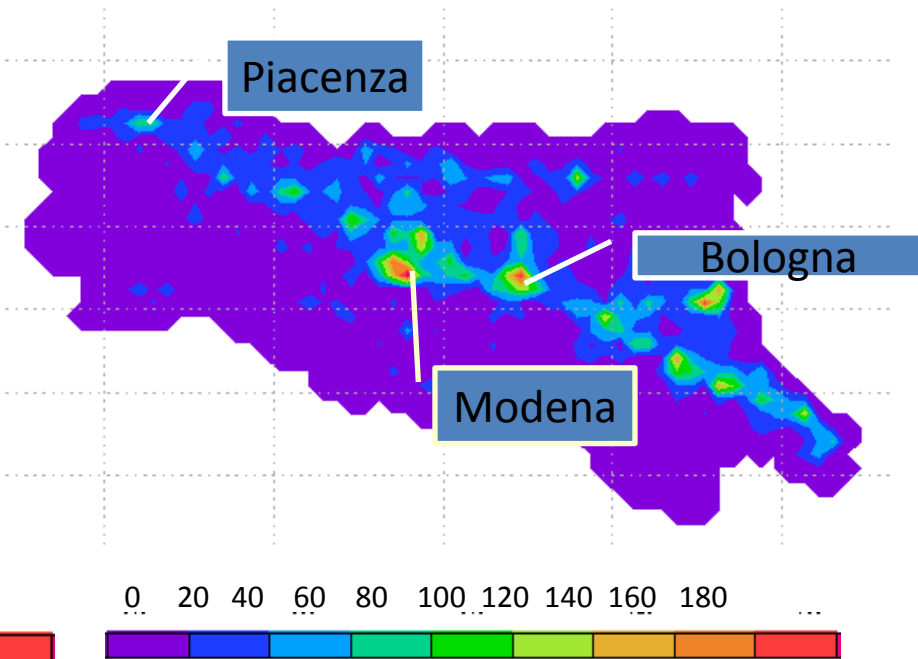
	AREAL AND POINT EMISSIONS					OUTSIDE REGIONAL DOMAIN
SCENARIOS	NOX	VOC	NH3	PM	SO2	
0	B	B	B	B	B	B2 (cle2020)
1	L	L	L	L	L	B2 (cle2020)
2	H	H	H	H	H	B2 (cle2020)
3	H	L	L	L	L	B2 (cle2020)
4	L	H	L	L	L	B2 (cle2020)
5	L	L	H	L	L	B2 (cle2020)
6	L	L	L	H	L	B2 (cle2020)
7	L	L	L	L	H	B2 (cle2020)
8	H	H	L	L	L	B2 (cle2020)
9	H	L	H	H	H	B2 (cle2020)
10	H	L	H	L	L	B2 (cle2020)
11	H	L	H	L	H	B2 (cle2020)

B represents the 2015 CLE legislation incremented of 15%, **H** represents the 2015 MFR reduced of 15%, **L** represents the average reduction between **B** and **H**, and **B2** represents the 2020 current legislation boundary conditions used as input for the Chemical Transport Model

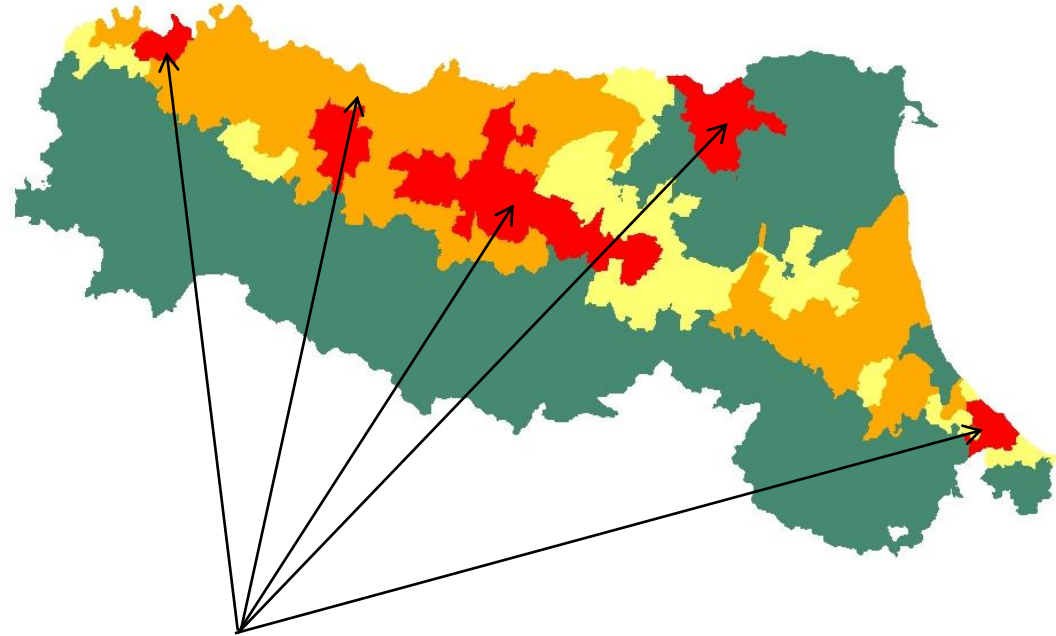
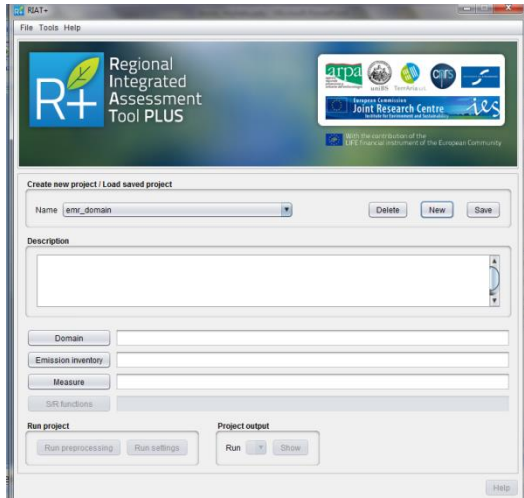
Emissions scenarios



NOx: base scenario-high reduction
scenario (tons/year)



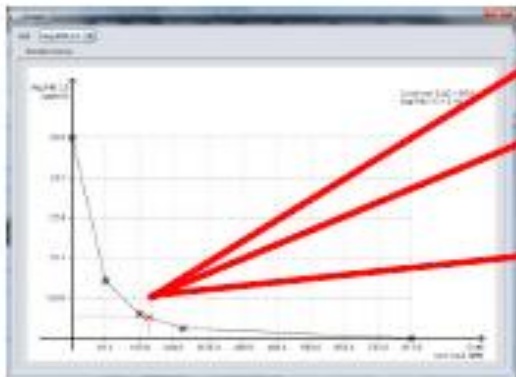
PM10: base scenario-high reduction
scenario (tons/year)



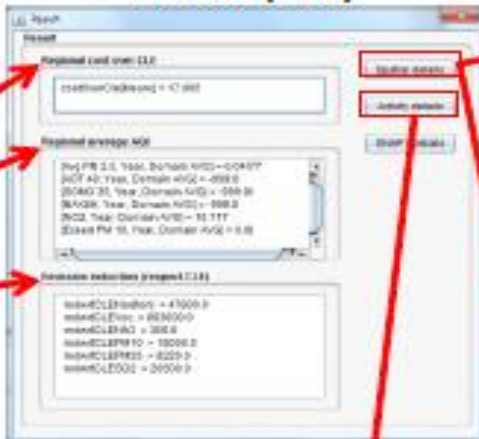
RIAT+ can be apply to different subdomain

RIAT+ output

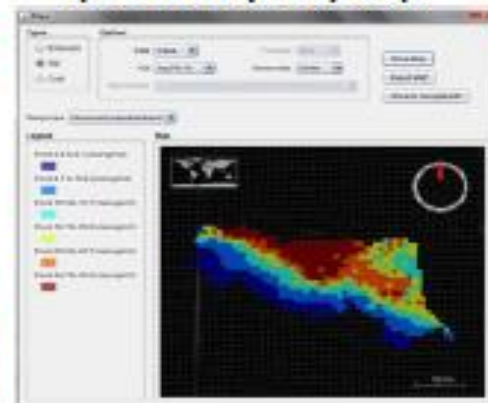
Pareto Boundary



Effective policy



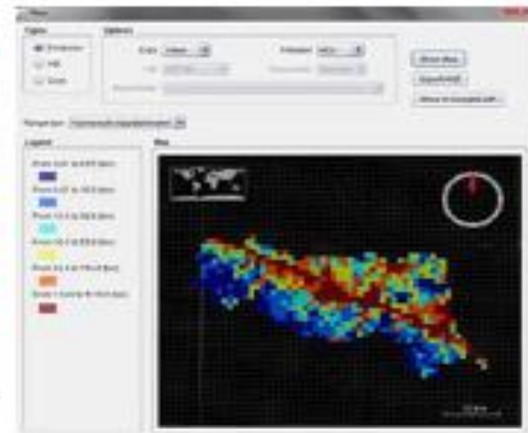
Optimal air quality map



Detailed technologies optimal application

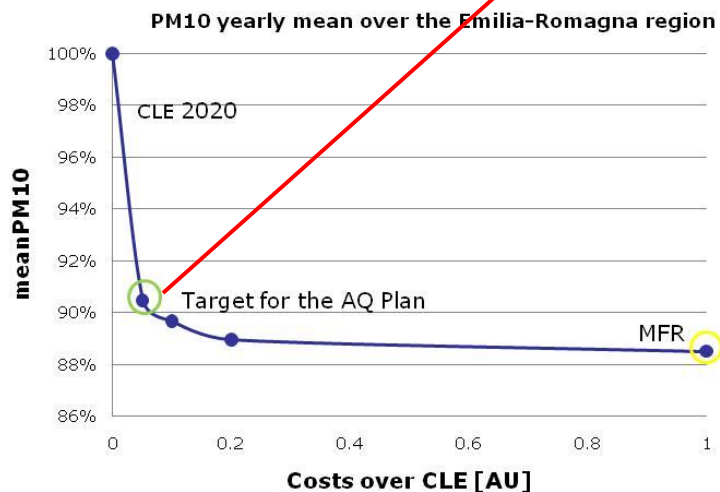
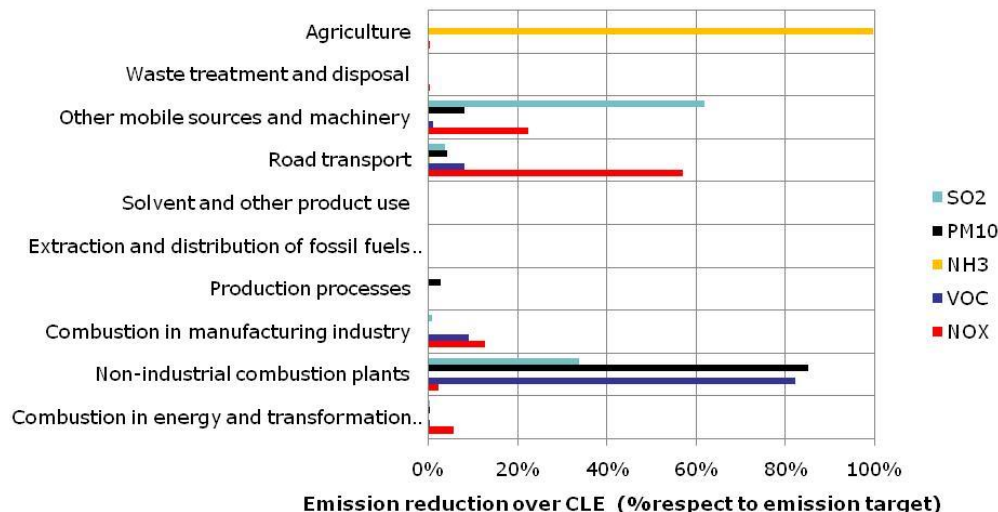


Optimal emission map



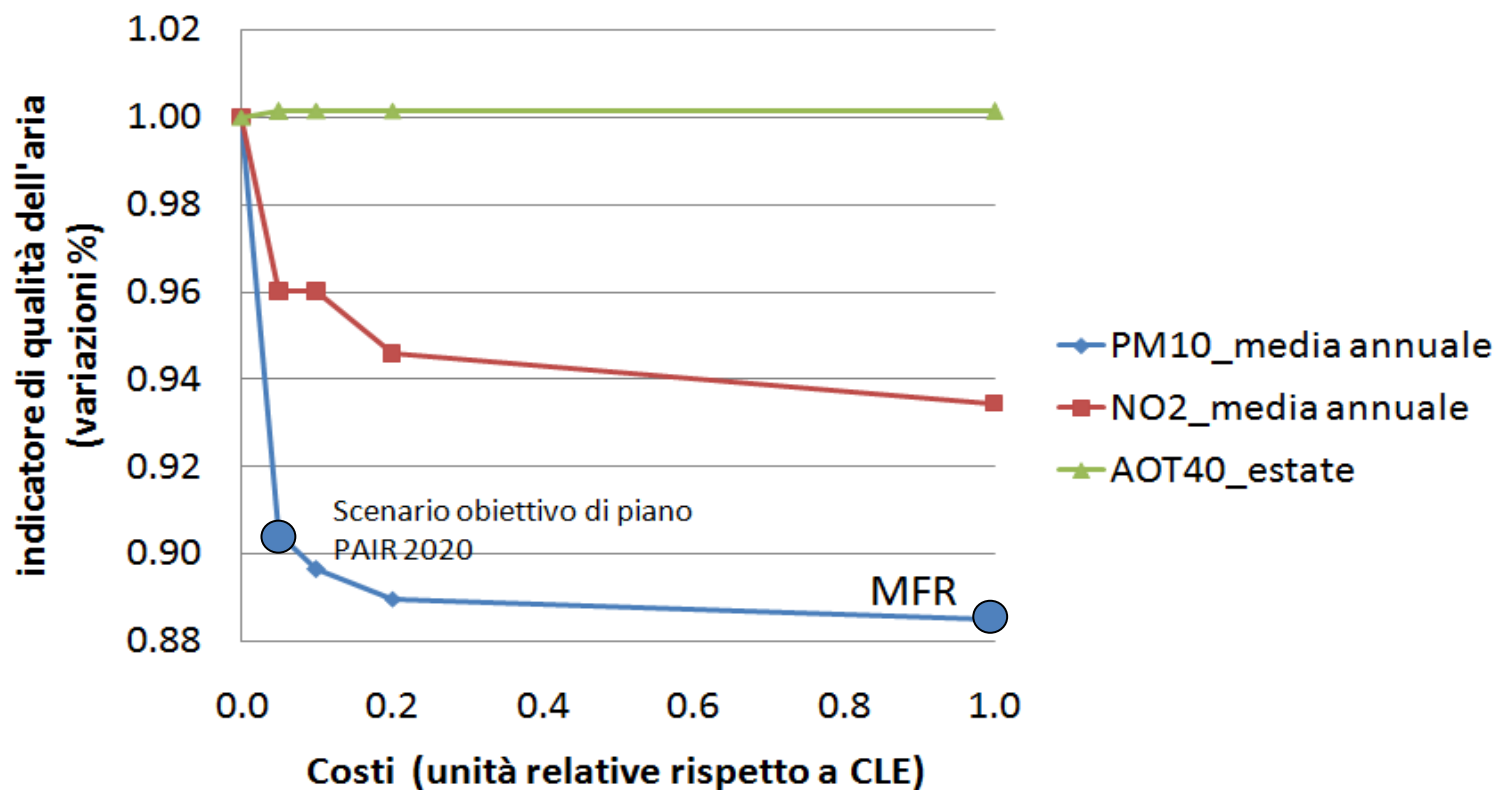
OUTPUT: an example from E-R PAIR2020

Emilia-Romagna A.Q. action plan:
measures per macro-sector for the
target scenario (RIAT+ output)



Emilia-Romagna A.Q. action plan:
identification of the target scenario by the
cost-effectiveness analysis (RIAT+)

The target scenario PAIR2020



Ex. 2 main actions to reduce NOx emissions

1 - Road
transport
and
other
mobile

2- Industry

3 - Energy

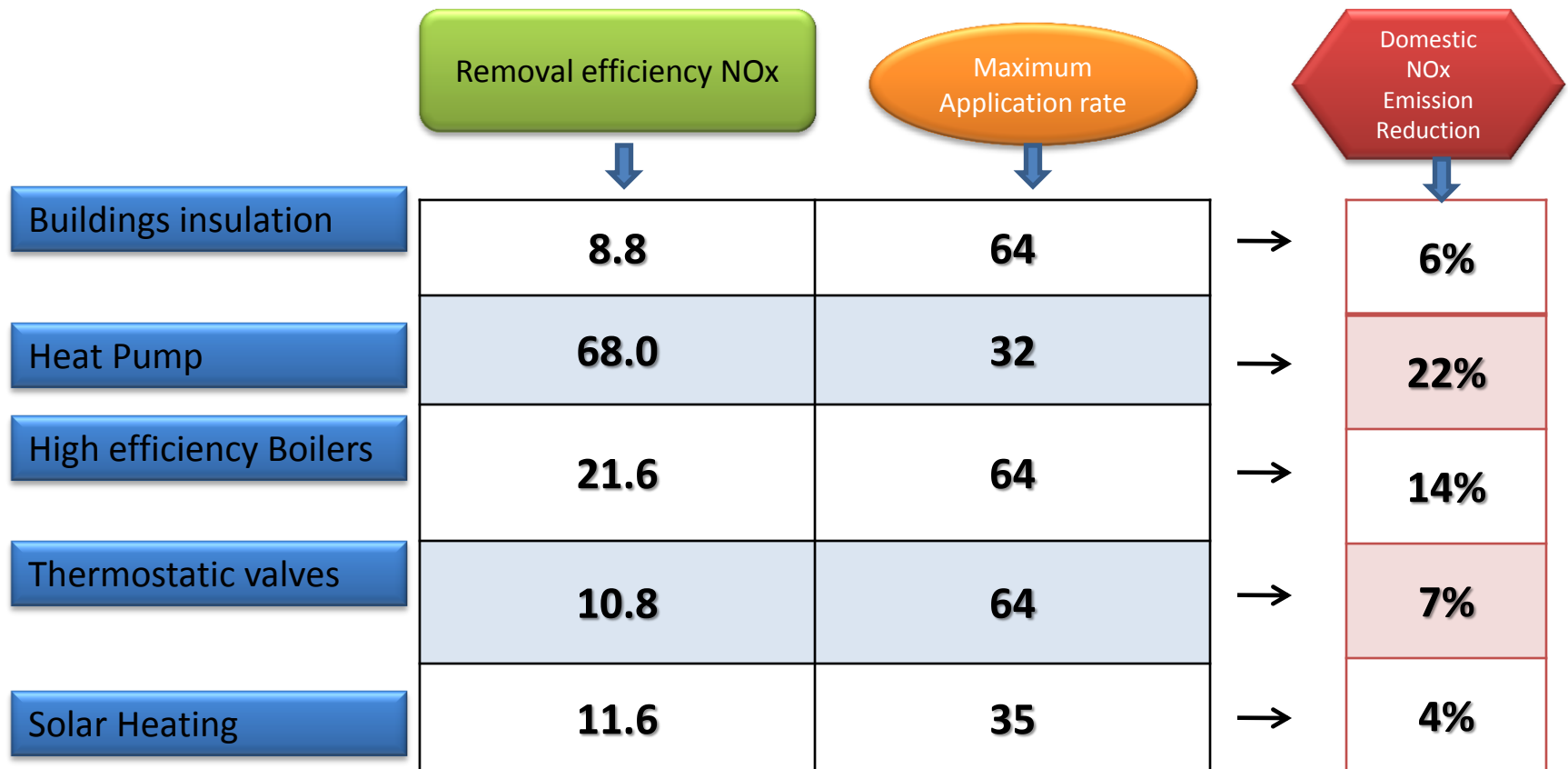
action (road transport)	emission reduction (NOx tons)	% respecto to emission reduction target
Heavy duty vehicles - trucks	2705.2	38%
Light duty vehicles: cars and small buses with 4-stroke engines - Highway	143.7	2%
Light duty vehicles: cars and small buses with 4-stroke engines - Urban	76.8	1%
Light duty vehicles: cars and small buses with 4-stroke engines - Extraurban	563	8%
Light duty vehicles: light commercial trucks with 4-stroke engines	522.5	7%
Motorcycles with 4-stroke engines	14.9	0.2%
Motorcycles, mopeds and cars with 2-stroke engines	6.8	0.1%

Ex. 1 Main actions to reduce NH3 emissions

action	emission reduction (NH3 tons)	% respecto to emission reduction target
Agriculture: Livestock - dairy cattle		
Dairy cows - liquid (slurry) systems		
Combination of LNF_CS_LNA	3318.8	14%
Combination of LNF_SA_LNA	949.3	4%
Agriculture: Livestock - other cattle		
Other cattle - solid systems		
Low ammonia application; high efficiency	1711.3	7%
Agriculture: Livestock - pigs		
Pigs - liquid (slurry) systems		
Combination of LNF_BF_CS_LNA	4613.9	20%
Agriculture: Livestock - poultry		
Laying hens		
Combination of LNF_BF_CS_LNA	652.1	3%
Other poultry		
Combination of LNF_SA_LNA	1842	8%
Fertilizer use - urea		
No fuel use		
Urea substitution	9846.5	43%

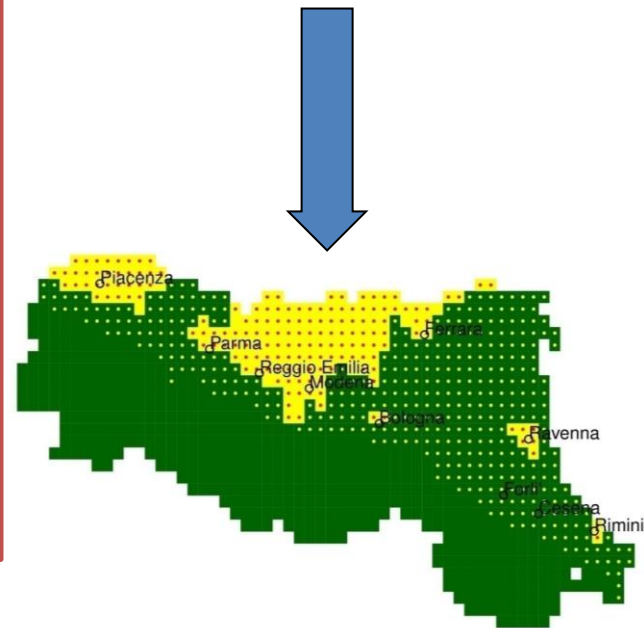
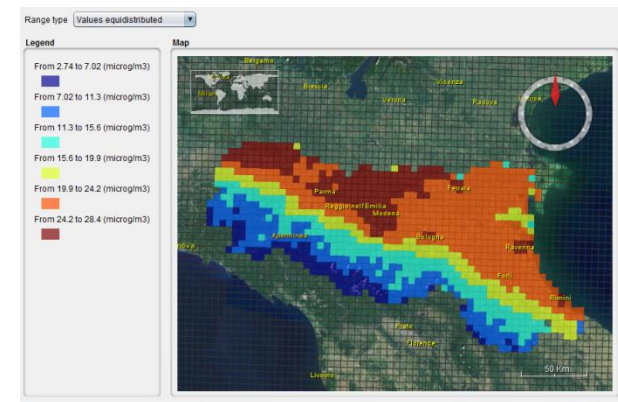
LNF low nitrogen feed
 CS Covered outdoor storage of manure; mean efficiency
 LNA low ammonia applictaion mean efficiency
 BF bio filtration
 SA animal house adaption

Domestic sector (NTM)



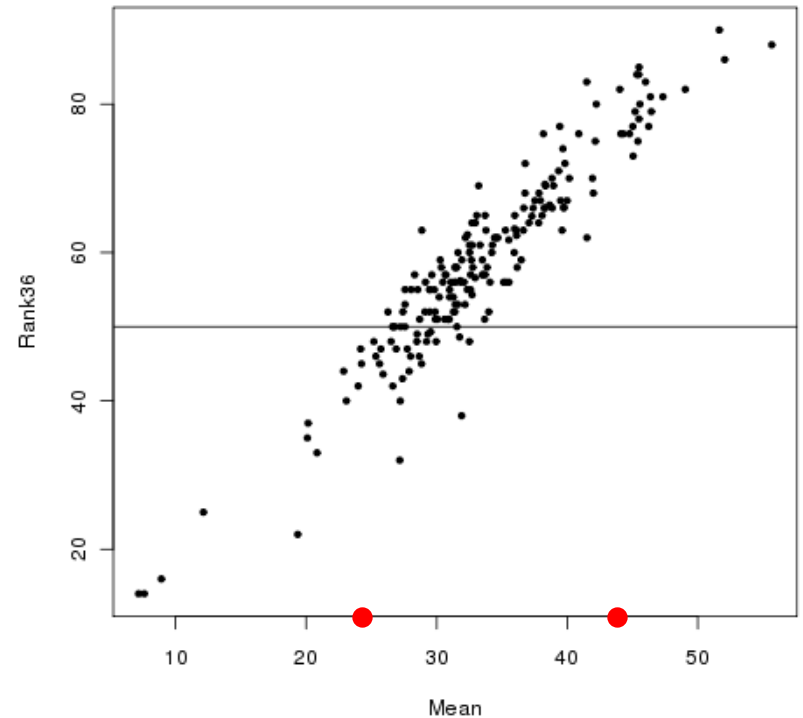
Postprocessing PM10 output

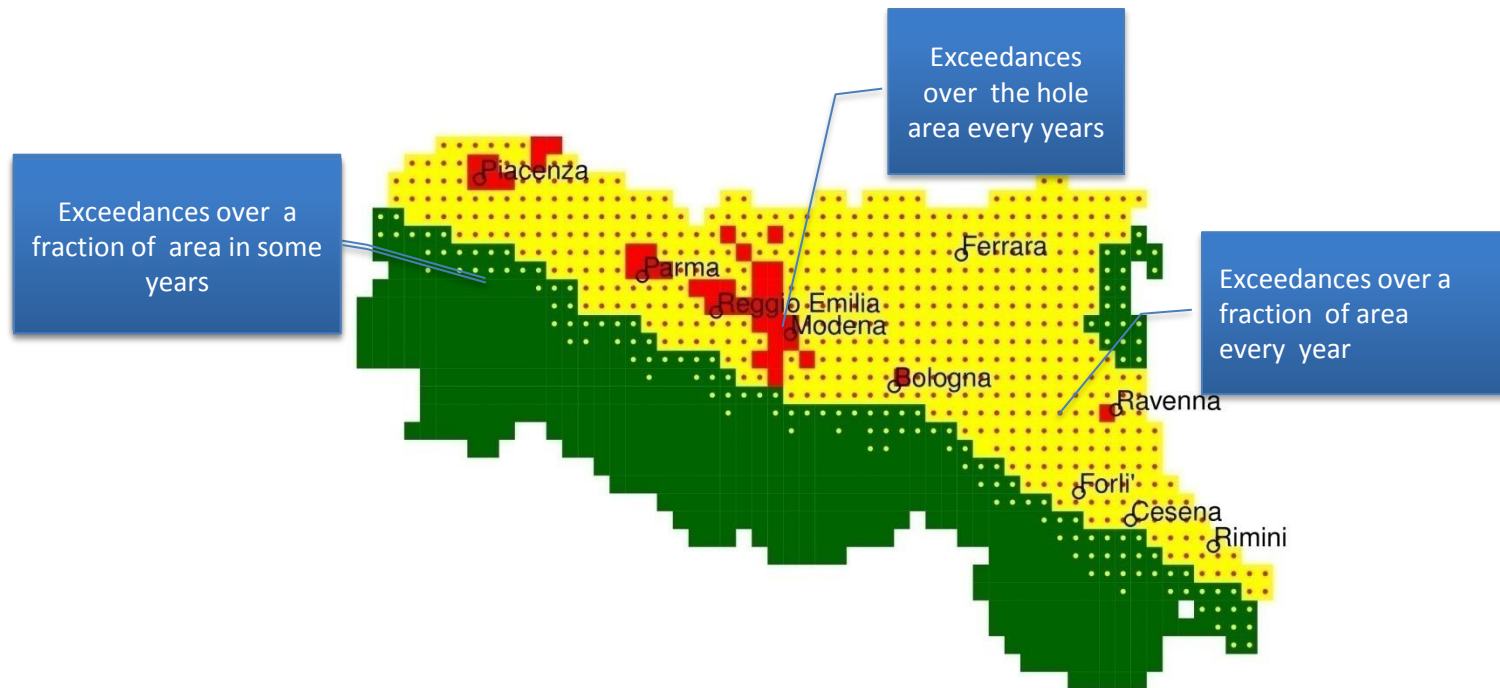
- Meteorology variability has been estimated from multiannual model simulation
- Sub grid variability has been estimated comparing the model basecase output with higher resolution interpolation of observed data performed with kriging algorithm



The equivalent limit value (ELV) for PM10

- The annual ELV is set to 28 (instead of 40) microg/m³.
- we suppose that the respect of the ELV for PM10 will guarantee the respect of the annual LV for PM2.5 and NO₂ (except for hot spots)

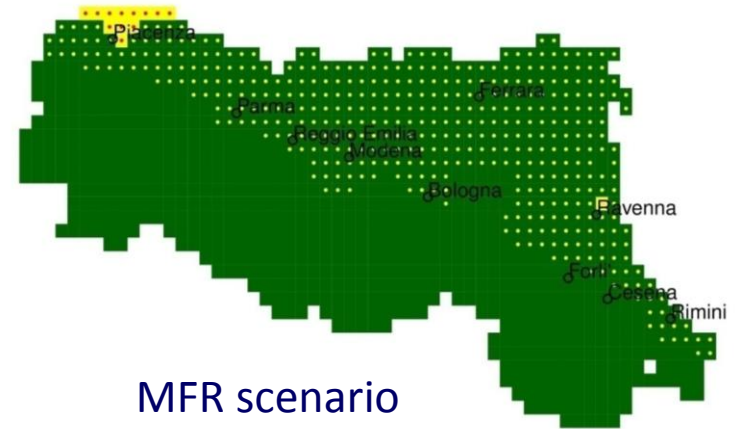
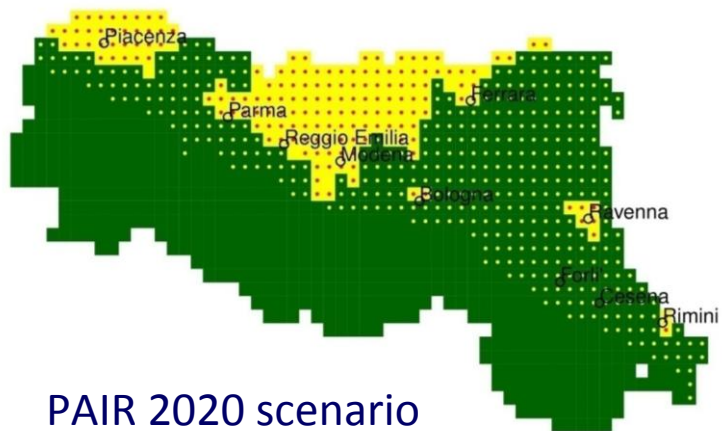
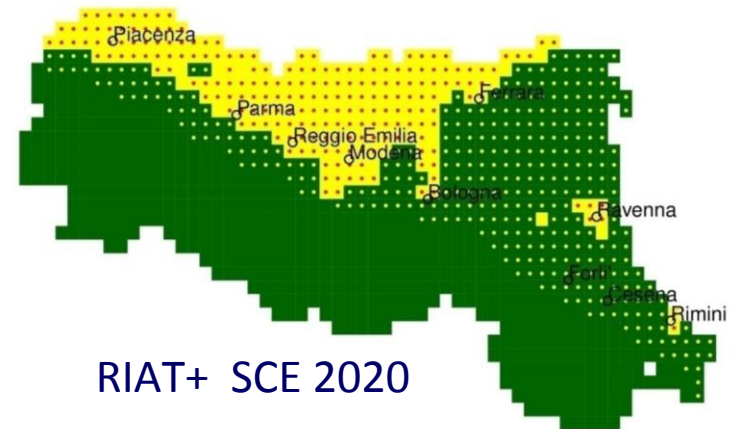




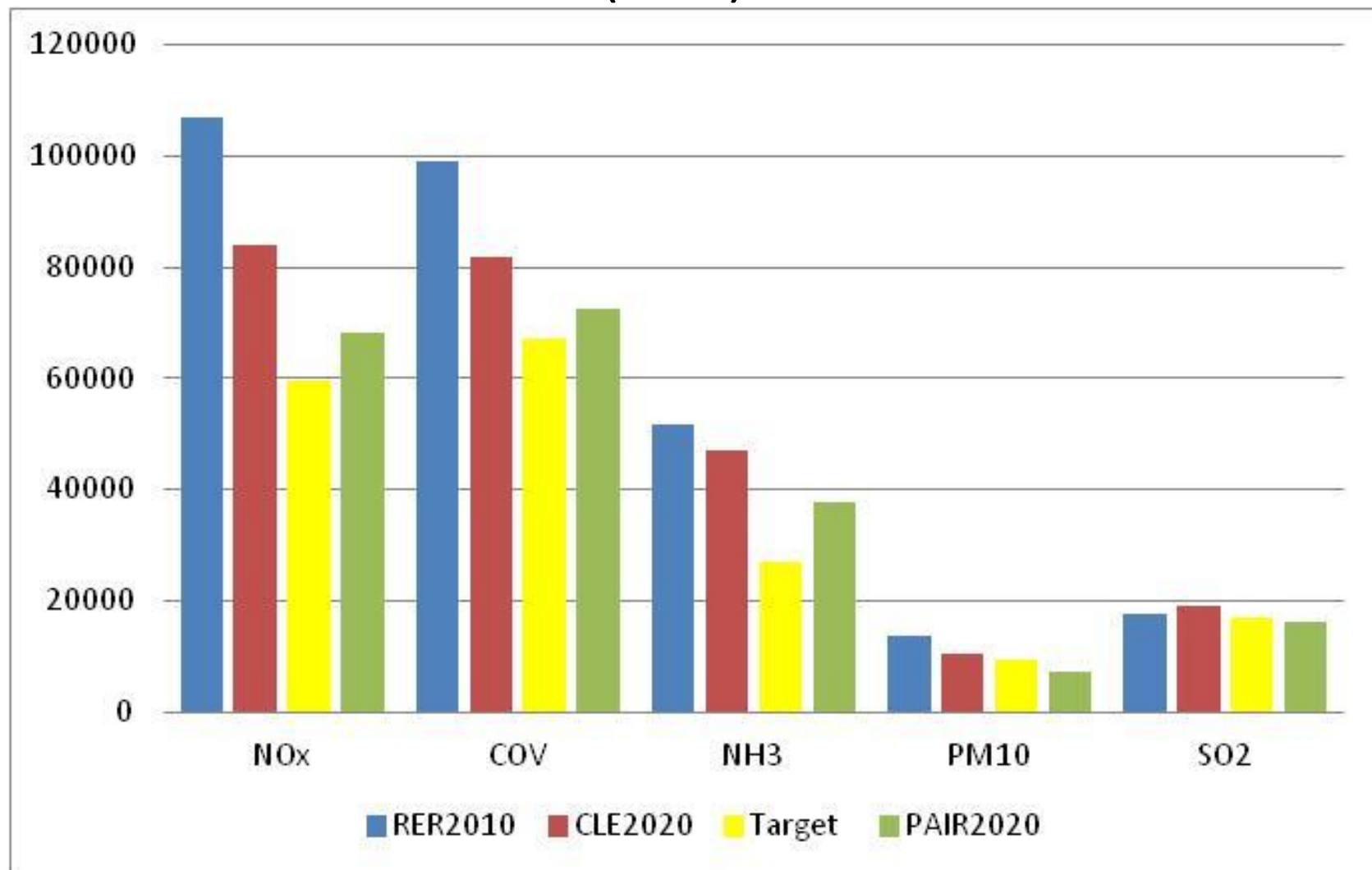
Base case scenario (2010)

→ PM10 exceedances of the daily mean

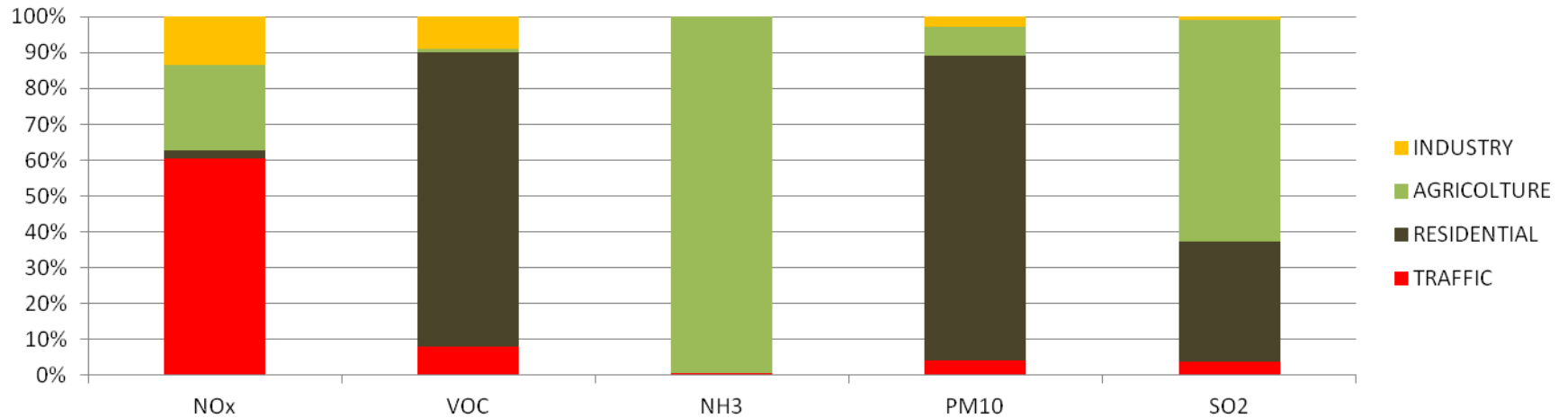
PM10 exceedances of the daily mean



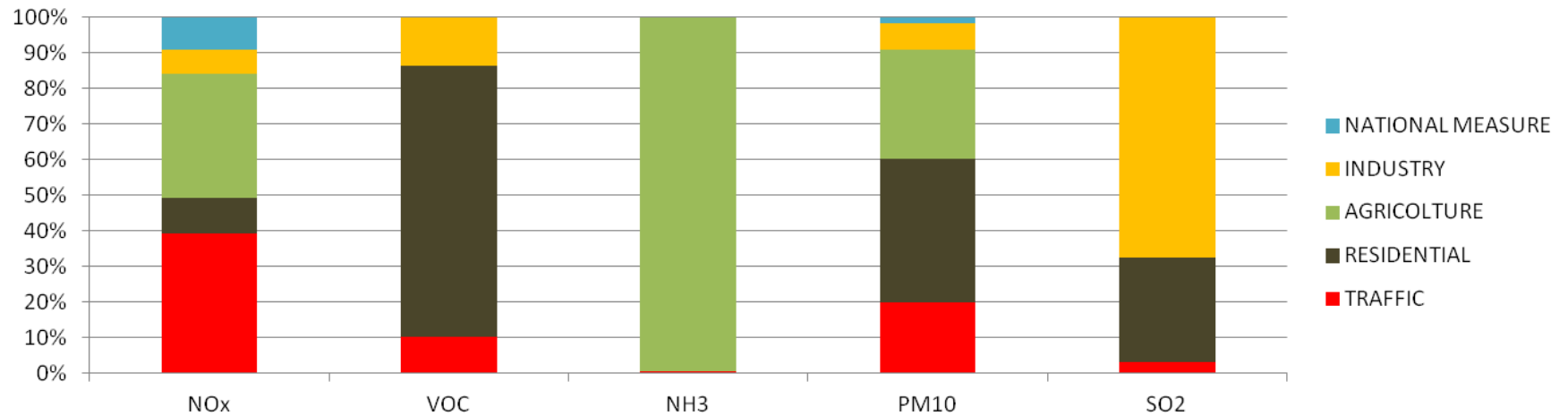
Total emissions for each scenario over Emilia-Romagna (tons)



RIAT+ Emission Reduction



PAIR 2020 Emission Reduction



PAIR2020 Measure

	EMISSION REDUCTION RESPECT TO CLE (ton/year)				
TRAFFIC	NOx	COV	NH3	PM10	SO2
City traffic limitation	571	117	3	48	5
Urban Pedestrian zone, low emission zones, bicycle path	1942	395	7	149	23
Vehicle fleet	272	24		1	1
Public transport	172	43		26	
Trasporti: riduzione flussi autoveicoli su strade extraurbane e piccole aree urbane	1310	342	37	275	35
Truck	1497	39	2	93	18
Ecodriving	495	18	2	16	3
RESIDENTIAL					
Efficiency Building	958	1812		338	135
Fireplace	52	4546		701	
Use of natural gas	121	-11		26	546
Temperature reduction , information population, etc..	454	821	12	162	90
AGRICULTURE					
Livestock			4699		
Fertilizer			4657		
Off road	5526			934	
INDUSTRY					
Efficiency Building	334	58		25	285
BAT	601	1227		58	
Fuel substitution (heavy fuel oil with medium oil)	130	6		146	1490
NATIONAL MEASURE					
Motorway	1457	10		50	
(Emission reduction respect to CLE2020)	15891	9448	9418	3047	2631

Conclusion and remarks

- The RIAT+ tool implemented on Emilia-Romagna provide a wide set of information and data that support the analysis of the pollution factors responsible for the exceedance and of the possible measures for the improvement of air quality:
 - costs – effectiveness analysis is used to set the emission reduction target for the AQ plan;
 - the technical and not technical (energy) measure has been prepared for Emilia Romagna helps to define and evaluate the most effective actions;
 - the source-receptor model is used for a fast screening of the effects on air quality of the selected set of actions and the results confirm that the neural network system ensures very high capability to simulate the non linear source-receptor relationship between AQIs and the emission of their precursors.
 - the emissions output help to prepare the input data for the detailed evaluation of the selected scenario by the CTM (NINFA)
- RIAT+ has been apply to define the regional action plan and can be usefull to estimate the effectiveness of measure contained in the plan.