

SHERPA/RIAT+ training course

RIAT+ a Regional Integrated Assessment Tool to evaluate effective air quality measures at regional scale: methodology

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TerrAria srl

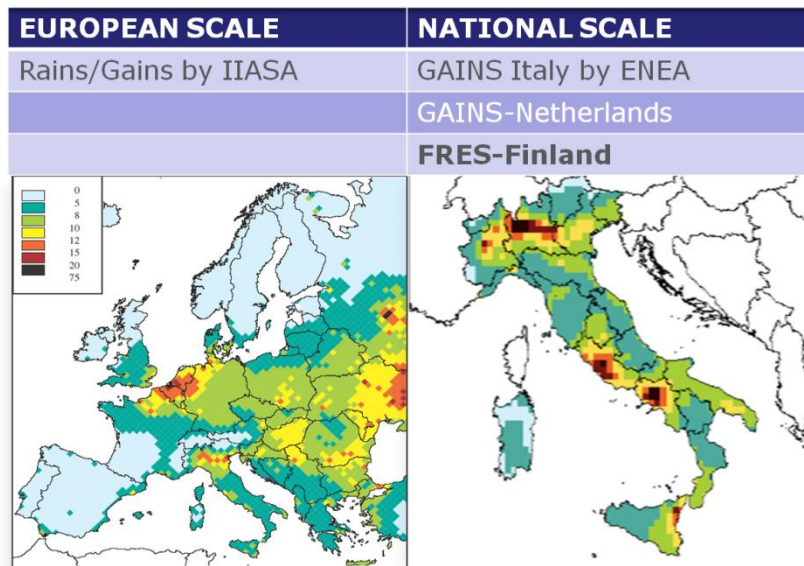
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RIAT+ : the starting point

The definition of a methodology and its implementation in a software tool, RIAT+, to support regional/local authorities in the definition, application and evaluation of air quality plans policies, devoted to the reduction of population exposure to PM10, PM2.5, NO₂ and O₃.



RIAT+ answers to the aim to develop, at regional scale, a tool to plan cost-effective air quality policies harmonized with national and EU actions



RIAT+ : the team



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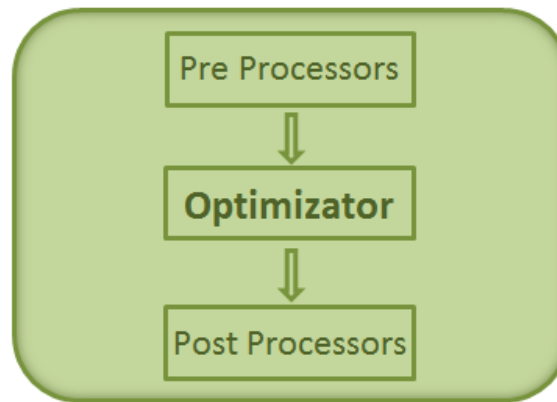
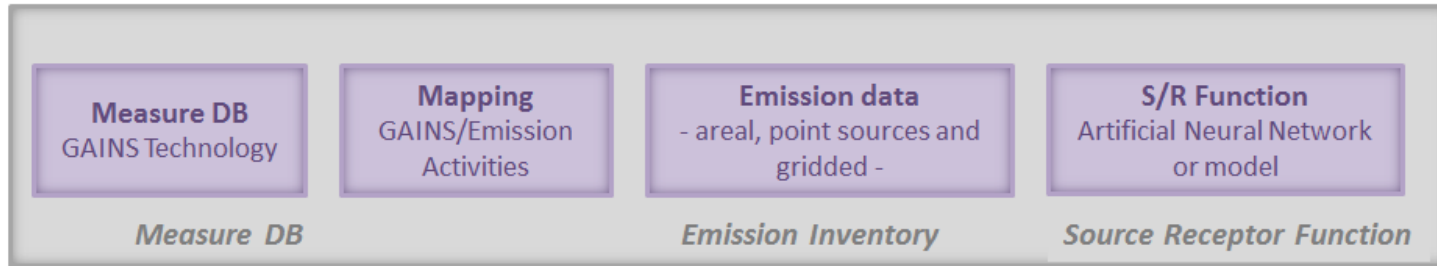


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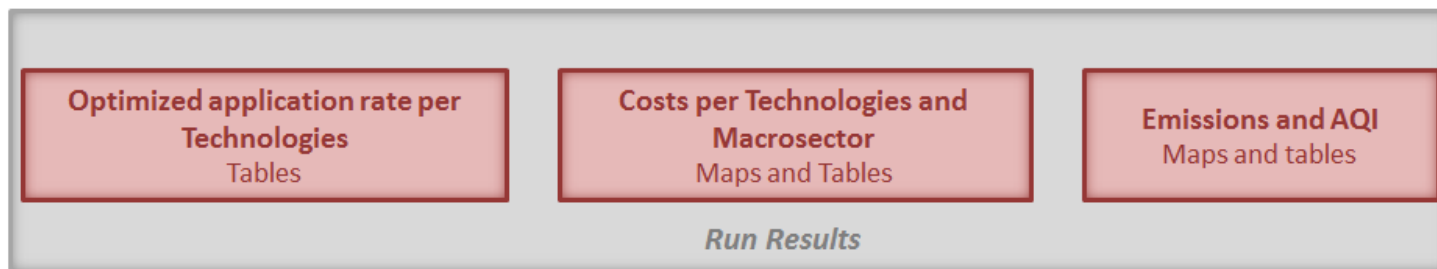
**OPERA: Operational Procedure for
Emission Reduction Assessment**

Core: the sistem

INPUT



OUTPUT



Core: the decision support



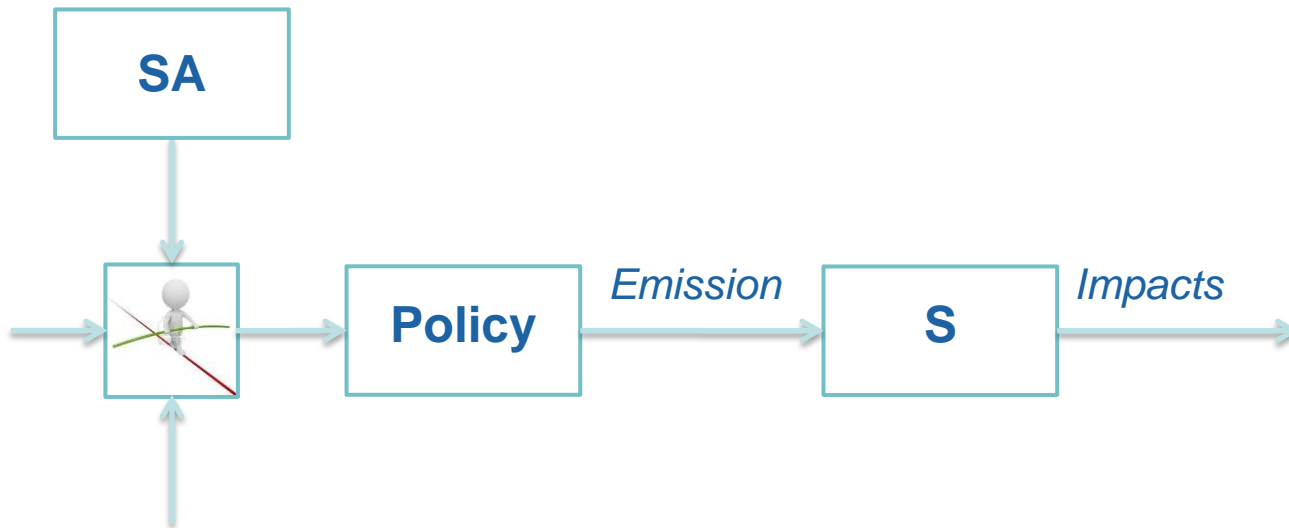
Scenario analysis:
assesses the impacts of
proposed actions

**Optimization
approach:**
identifies emission
reduction measures
maximizing the
environmental benefits
and minimizing costs

Scenario analysis

In RIAT+ scenario analysis is possible in two ways:

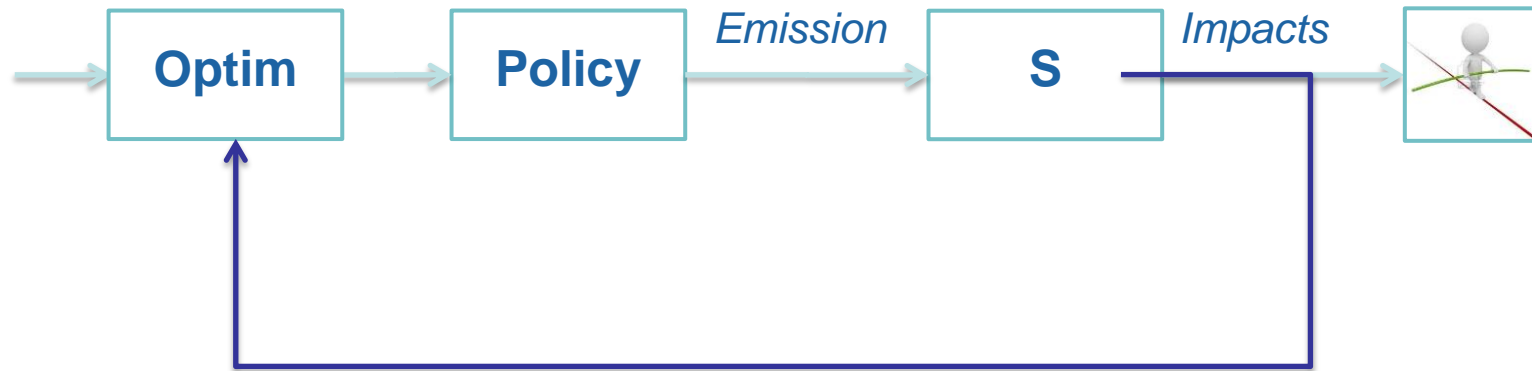
1. Emission (macrosector) level – *aggregated approach*
2. Technology level – *detailed approach*



Optimization analysis

In RIAT+ optimization analysis is possible in two ways:

1. Cost-effectiveness – *best technologies at a fixed cost*
2. Multi-objective – *best technologies at varying costs*



Virtual emission

Virtual emissions are the starting point to compute reduced emissions. They are necessary to correctly bring back the regional emission inventory to a "virtual" state in which no technologies are applied (all technologies ARs set to zero), this guarantees that applying the CLE ARs we obtain exactly the regional emission inventory data.

$$E_{REF_YEAR\ i,j,k,p} = E_{V_REF_YEAR\ i,j,k,p} * \left[\sum_{t=1}^{T_{i,j,k}} [(1 - eff_{i,j,k,t,p}) * AR_{REF_YEAR\ i,j,k,t}] + \left(1 - \sum_{t=1}^{T_{i,j,k}} AR_{REF_YEAR\ i,j,k,t} \right) \right]$$

$$* \frac{AL_{REF_YEAR\ j,j,k}}{AL_{REF_YEAR\ j,j,k}}$$

CONSTRAINT: $\Sigma(AR)$ for each pollutant (some technologies are multi-pollutant) must be ≤ 1 ; the remaining part (AR to 1) is defined NOC (\rightarrow part of emissions not reduced)

$$E_{V_REF_YEAR\ i,j,k,p} = \frac{E_{REF_YEAR\ j,jk,p}}{\sum_{t=1}^{T_{i,j,k}} [(1 - eff_{i,j,k,t,p}) * AR_{REF_YEAR\ i,j,k,t}] + \left(1 - \sum_{t=1}^{T_{i,j,k}} AR_{REF_YEAR\ i,j,k,t} \right)}$$

Emissions projection

Emission scenarios or projections are the application of a specific rate of AR for the involved technologies to the virtual emissions

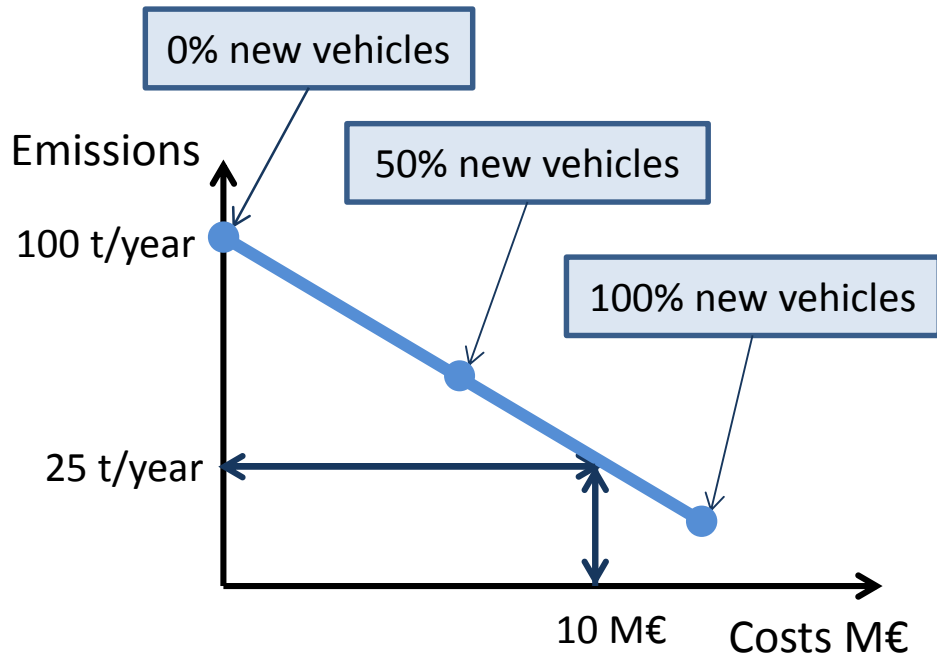
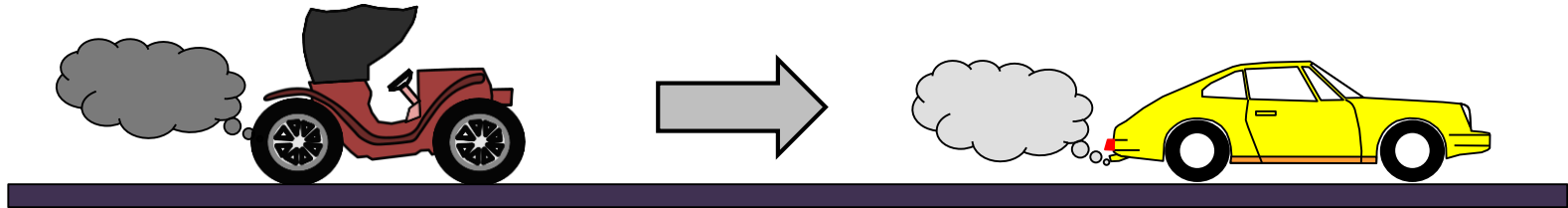
$$\begin{aligned} E_{SCEN_YEAR\ i,j,k,p} &= E_{REF_YEAR\ i,j,k,p} \\ & * \frac{\sum_{t=1}^{T_{i,j,k}} [(1 - eff_{i,j,k,t,p}) * AR_{SCEN_YEAR\ i,j,k,t}] + \left(1 - \sum_{t=1}^{T_{i,j,k}} AR_{SCEN_YEAR\ i,j,k,t}\right)}{\sum_{t=1}^{T_{i,j,k}} [(1 - eff_{i,j,k,t,p}) * AR_{REF_YEAR\ i,j,k,t}] + \left(1 - \sum_{t=1}^{T_{i,j,k}} AR_{REF_YEAR\ i,j,k,t}\right)} \\ & * \frac{AL_{SCEN_YEAR\ j,j,k}}{AL_{REF_YEAR\ j,j,k}} \end{aligned}$$

NON Technical measures

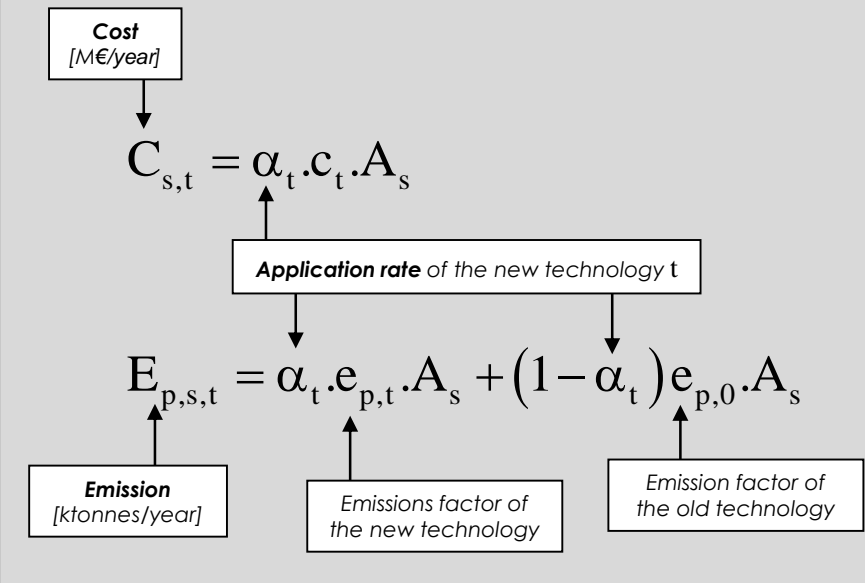
NTM are treated as TM with a CONSTRAINT: emission mass conservation (total removal efficiency of TM & NTM ≤ 1) is explicitly stated (for each activity and each primary pollutant)

$$\begin{aligned}
 & E_{CLE_{SCEN_YEAR}}_{i,j,k,p} \\
 &= E_{BC_REF_YEAR}_{j,j,k,p} \\
 & * \left[\sum_{tm=1}^{TM_{i,j,k}} [(1 - eff_{i,j,k,tm,p}) * AR_{CLE_{SCEN_YEAR}}_{i,j,k,tm}] \right. \\
 & + \sum_{ntm=1}^{NTM_{i,j,k}} [(1 - eff_{i,j,k,ntm,p}) * AR_{CLE_{SCEN_YEAR}}_{i,j,k,ntm}] + \left. \left(1 - \sum_{t=1}^{TM_{i,j,k}} AR_{CLE_{SCEN_YEAR}}_{i,j,k,t} \right) \right] \\
 & * \frac{AL_{SCEN_YEAR}_{j,j,k}}{AL_{REF_YEAR}_{j,j,k}}
 \end{aligned}$$

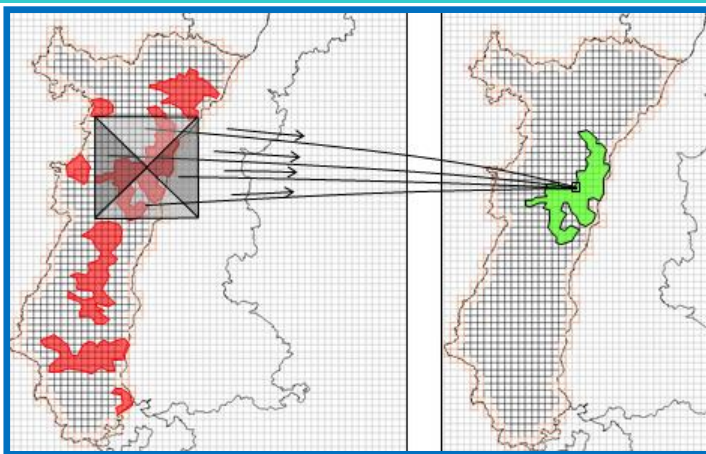
Input: emission & techno



When a new technology (t) replace an old technology (0) in a sector of activity (s):



Input: S/R function (ANNs)



$AQI(x,y) = F_{S/R}$ (quadrant Emissions)
 4 quadrants emissions (point/areal) for
 6 precursors

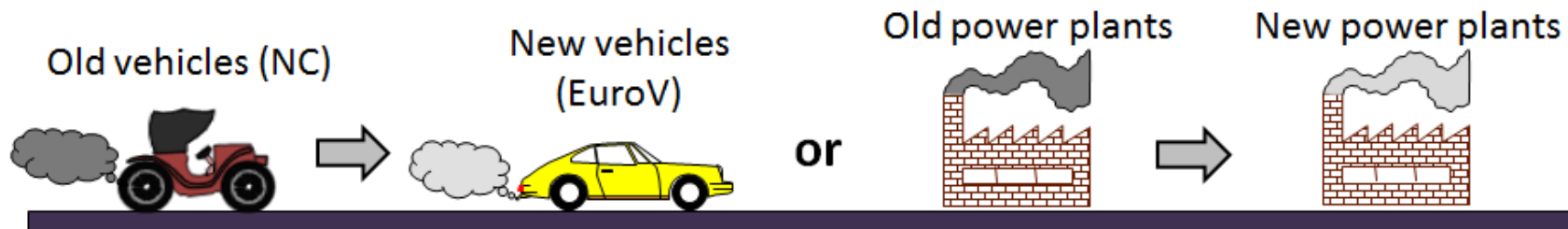
CTM training
 scenarios:

B = CLE + 15%

H = MFR - 15%

SCENARIOS	AREAL EMISSIONS					POINTEMISSIONS				
	NOX	VOC	NH ₃	PM	SO ₂	NOX	VOC	NH ₃	PM	SO ₂
0	B	B	B	B	B	B	B	B	B	B
1	L	L	L	L	L	B	B	B	B	B
2	H	H	H	H	H	B	B	B	B	B
3	H	L	L	L	L	B	B	B	B	B
4	L	H	L	L	L	B	B	B	B	B
5	L	L	H	L	L	B	B	B	B	B
6	L	L	L	H	L	B	B	B	B	B
7	L	L	L	L	H	B	B	B	B	B
8	H	H	L	L	L	B	B	B	B	B
9	H	L	H	H	H	B	B	B	B	B
10	H	L	H	L	L	B	B	B	B	B
11	H	L	H	L	H	B	B	B	B	B
12	B	B	B	B	B	L	L	L	L	L
13	B	B	B	B	B	H	H	H	H	H
14	B	B	B	B	B	H	L	L	H	H
15	B	B	B	B	B	L	L	L	L	H
16	B	B	B	B	B	H	L	L	L	H
17	H	H	H	H	H	H	H	H	H	H
18	H	L	H	H	H	H	L	L	H	H
19	L	L	L	L	H	L	L	L	L	H
20	H	L	H	L	H	H	L	L	L	H
21	H	H	L	L	L	H	H	L	L	L

Core: optimization



Multi-objective approach

$$\min_x J(x) = \min_x \left[AQI(x) \quad C(x) \right]$$

$$x \in X$$

Cost-effective approach

$$\min_x AQI(x)$$

$$C(x) \leq L$$

Control variables

(application rates):

- Technical measures
- Non technical measures

AQP: the most effective measures



Optimization: Find the best application rates of 3000 different technologies.



legislation

Air Quality Index

CLE: Current Legislation

Global technical measures

Global + Local technical measures

All measures

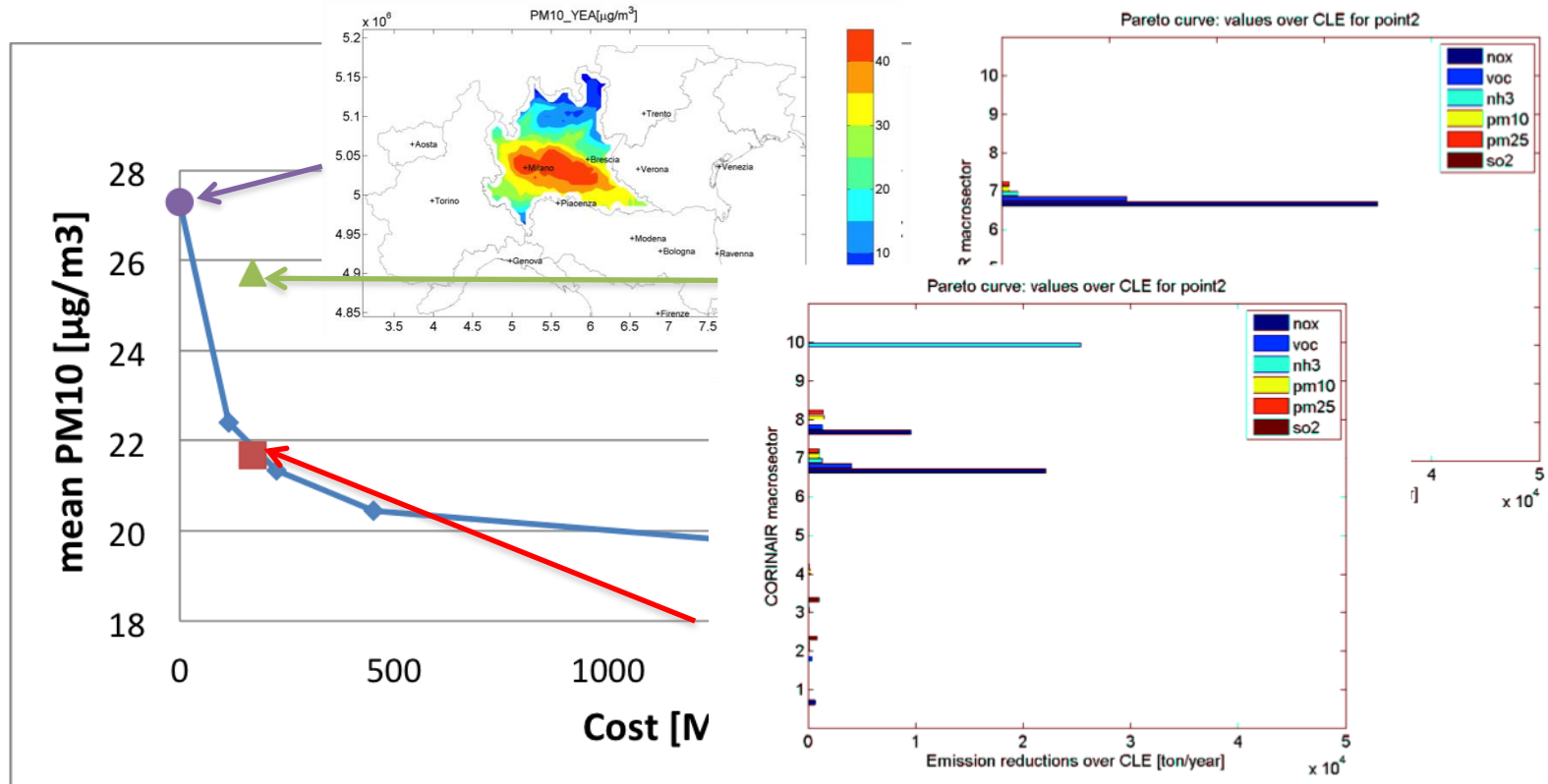
Cost over CLE [M€]

20

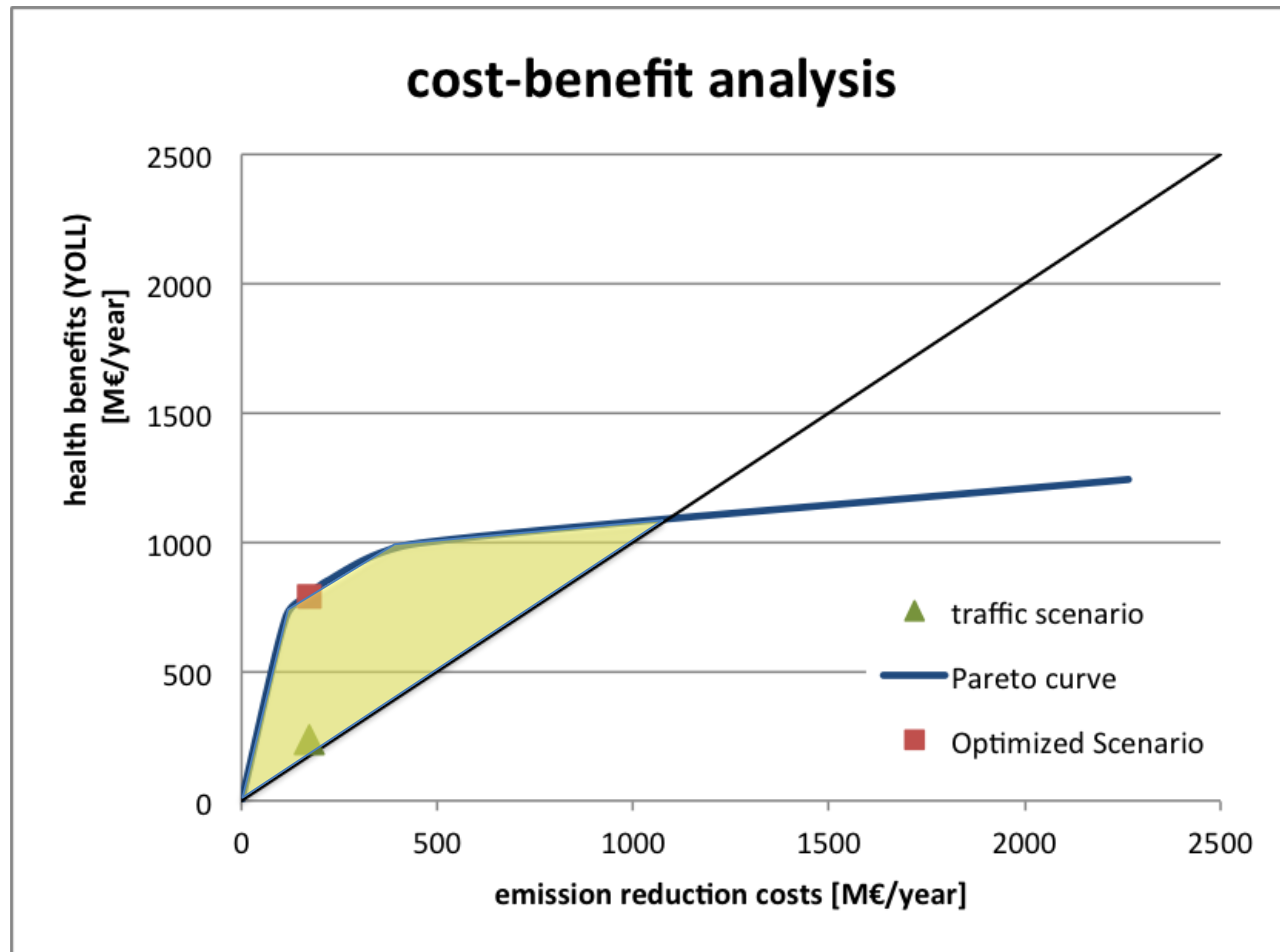


Scenario & optimization - Lombardy

Impacts	CLE	Traffic scenario	Optimized scenario
Emission reduction costs	0 €	170 M€	170 M€
PM10 [$\mu\text{g}/\text{m}^3$]	27,3	- 6%	- 21%
Health costs (PM10)		- 6%	- 19%



Cost effectiveness - Lombardy



RIAT+



RIAT+ is an IAM sw focused at regional scale with a **user friendly** interface. RIAT+ main features are:

- manage **different input** (e.g. gridded or polygonal, annual or seasonal, SNAP detailed or aggregated emissions);
- **various policies** could be evaluated with RIAT+: emission abatement, energy efficiency and NTM
- multi objective and cost effectiveness (**optimization**), detailed and aggregated (**scenarios analysis**)

www.riatplus.eu

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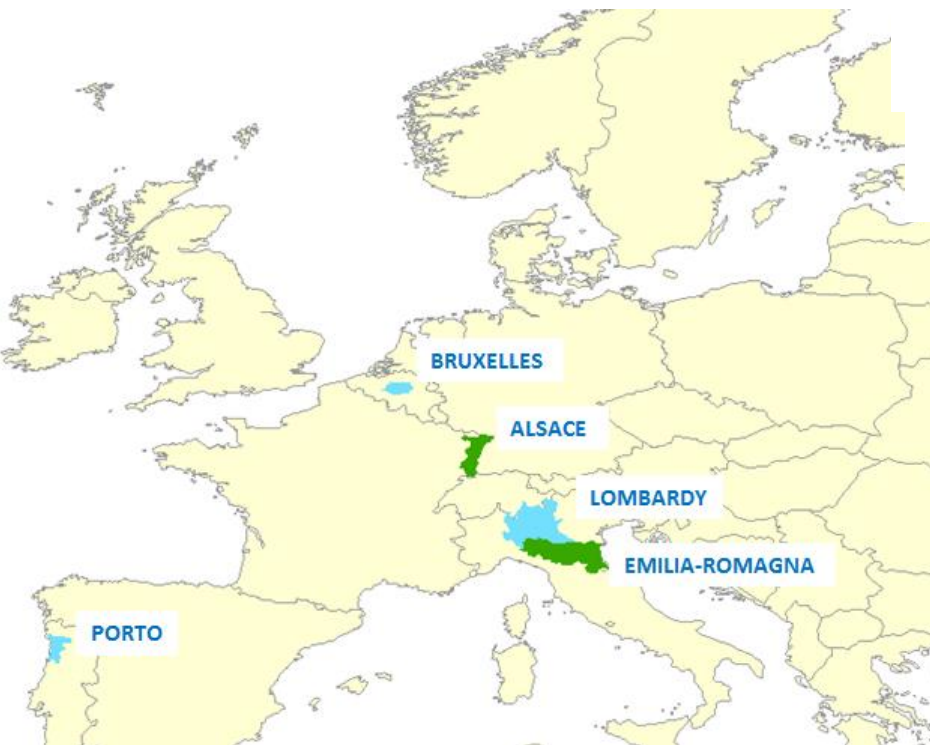
Join **LINKEDIN**
group **RIAT+**
Community

Due to these features now RIAT+ is a **concrete instrument** to support AQ planning, as its significant applications shows. Moreover, next slides will illustrate how each EU Region can apply RIAT+.

RIAT+ APPLICATIONS

RIAT+ was applied in EU Regions with different aims.

- In **Lombardy Region** – scenario way, to support the ex-post evaluation of the AQ Plan.



Activity details

Measures List

SNAP	Sector	Activity	Technology	LowHigh	Application Ra.	CLE AR	OPTAR	POTAR	EmiRed...	EmiRedV.	EmiRedN...	EmiRedP.	EmiRedP.	E
7	Heavy dut.	Medium d.	EURO VI...	1	56.8	67.0	100.0	7023.0	421.3	-0.8	405.0	326.7	0	0
8	Other tran.	Medium d.	Stage 3A...	1	13.0	31.0	100.0	1584.0	209.0	0.0	264.7	245.8	0	0
7	Light duty ...	Medium d.	EURO 6 o...	1	28.3	43.4	100.0	939.2	99.0	-0.8	204.7	165.1	0	0
3	Industry ...	Natural g...	Combust...	1	80.0	98.9	100.0	713.5	0.0	0.0	0.0	0.0	0	0
7	Light duty ...	Medium d.	EURO 6 o...	1	55.9	65.9	100.0	863.0	29.0	-1.0	190.1	153.4	0	0
7	Light duty ...	Gasoline ...	EURO 5 o...	1	27.7	33.8	100.0	623.1	233.4	-5.0	0.9	0.7	0	0
7	Light duty ...	Gasoline ...	EURO 5 o...	1	27.7	33.8	100.0	263.1	281.4	-1.1	0.2	0.2	0	0
1	Power he...	Biomass f...	Combust...	2	46.5	78.3	100.0	191.4	0.0	0.0	0.0	0.0	0	0
7	Light duty ...	Medium d.	EURO 6 o...	1	55.9	65.9	100.0	170.2	5.5	-0.3	50.9	41.1	0	0
7	Light duty ...	Gasoline ...	EURO 5 o...	1	27.7	33.8	100.0	166.8	45.4	-1.6	0.2	0.2	0	0
7	Light duty ...	Gasoline ...	EURO 5 o...	1	29.3	36.7	100.0	113.3	90.9	-0.3	0.3	0.2	0	0
7	Light duty ...	Gasoline ...	EURO 5 o...	1	52.9	54.0	100.0	110.6	40.1	-0.9	0.2	0.1	0	0
7	Light duty ...	Gasoline ...	EURO 5 o...	1	42.1	48.3	100.0	94.6	76.7	-0.3	0.3	0.2	0	0
3	Industry ...	Heavy fuel	Combust...	1	80.0	98.5	100.0	77.1	0.0	0.0	0.0	0.0	0	0
1	Power he...	Natural g...	Energy pr...	1	0.0	2.8	2.8	75.1	1.9	0.0	0.2	0.1	0	0
3	Industry ...	Natural g...	Combust...	1	0.0	1.1	100.0	67.1	0.0	0.0	0.0	0.0	0	0
7	Light duty ...	Medium d.	EURO 6 o...	1	55.9	65.9	100.0	55.5	14.9	0.0	70.5	56.9	0	0
7	Light duty ...	Liquefied...	EURO 5 o...	1	52.9	55.3	100.0	50.6	10.6	0.0	0.0	0.0	0	0
7	Light duty ...	Liquefied...	EURO 5 o...	1	27.7	30.0	100.0	48.7	10.2	0.0	0.0	0.0	0	0
7	Light duty ...	Gasoline ...	EURO 5 o...	1	52.9	54.0	100.0	46.8	50.6	-0.2	0.0	0.0	0	0
7	Light duty ...	Natural g...	EURO 5 o...	1	27.7	30.1	100.0	39.6	10.2	0.0	0.0	0.0	0	0
7	Light duty ...	Natural g...	EURO 6 o...	1	52.9	55.1	100.0	35.7	9.2	0.0	0.0	0.0	0	0
2	Residenti...	Firewood	Thermost...	1	0.0	57.5	57.5	33.9	1033.8	0.0	173.2	162.5	4	0
2	Residenti...	Medium d.	Thermost...	1	0.0	57.5	57.5	31.2	1.5	0.0	3.5	3.3	0	0
7	Light duty ...	Gasoline ...	EURO 6 o...	1	52.9	54.0	100.0	29.7	8.2	-0.3	0.0	0.0	0	0

Optimized Measures

- Optimized AR over CLE
- Optimized AR below CLE

Application Rate

- Optimized
- Over CLE
- CLE
- Potential

EmiRed = Emi Reduced (respect CLE)

Export Excel

APPLYING RIAT+

To apply RIAT+ in your Region at first you need to **download** RIAT+ installation kit (the software, the user guide, and two regional test cases) from its website.

RIAT+ is **free** of charge: only an end user license agreement (**EULA**) should be signed online.

The screenshot shows the RIAT+ website interface. At the top, there are logos for "Regional Integrated" and "Regional Integrated Assessment Tool PLUS". A navigation menu includes "Home", "Applications", "Download tool", "Future Developments", "Training", "References", "Dissemination", and "NEWS". The main content area displays "Download" and "Welcome" with a login field for "Username: gianfreda" and a "Logout" button. The "END USER LICENCE AGREEMENT RIAT+ 1.0" section contains the following text:

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The European Union together with:

- Agenzia Prevenzione Ambiente Emilia-Romagna
- Universitv of Brescia Dipartimento di Ineeegneria Meccanica e

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At the bottom, there are logos for the European Union, arpa (agenzia regionale prevenzione e ambiente dell'emiliaromagna), TerrAria s.r.l., cnrs, and UNIVERSITÉ DE STRASBOURG.

RIAT+ : FIRST GUESS by SHERPA

Very soon it will be ready the NEW RIAT+ version linked to SHERPA, so it will be possible to apply RIAT+ in your region in a very **simple way**.

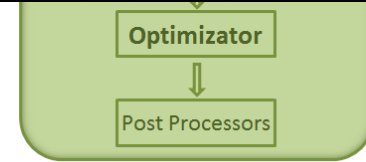
SHERPA will provide all RIAT+ input :

- First: select the domain
- 7x7 km emissions
- S/R function – linear regression relations
- GAINS measure database

SHERPA first guess input are:

- Maybe less detailed
- But easier & quicker

The screenshot shows the RIAT+ software interface. On the left is a list of countries with checkboxes: AUSTRIA, BELGIUM, BULGARIA, SWITZERLAND, CYPRUS, CZECH REPUBLIC, GERMANY, DENMARK, ESTONIA, GREECE, SPAIN, FINLAND, FRANCE, CROATIA, HUNGARY, IRELAND, ICELAND, ITALY, LIECHTENSTEIN, LITHUANIA, LUXEMBOURG, LATVIA, REPUBLIC OF MONTENEGRO, REPUBLIC OF MACEDONIA, MALTA, NETHERLANDS. The main area shows a map of Europe with a red arrow pointing to a location in the Balkans. Below the map is a 'Reduction table' with columns for ALL, MS1, MS2, MS3, MS4, MS5, MS6, MS7, MS8, MS9, MS10 and rows for ALL, NOx, NMVOC, NH3, PM25, SOx. The table contains numerical values, mostly zeros. To the right of the table are controls for 'Air quality index' (set to PM25) and 'Seasonality' (set to Annual). Buttons for 'Load config', 'Save config', and 'Map' are also visible.



RIAT + CORE SYSTEM

OUTPUT

