RIAT+
(Regional Integrated Assessment Tool)

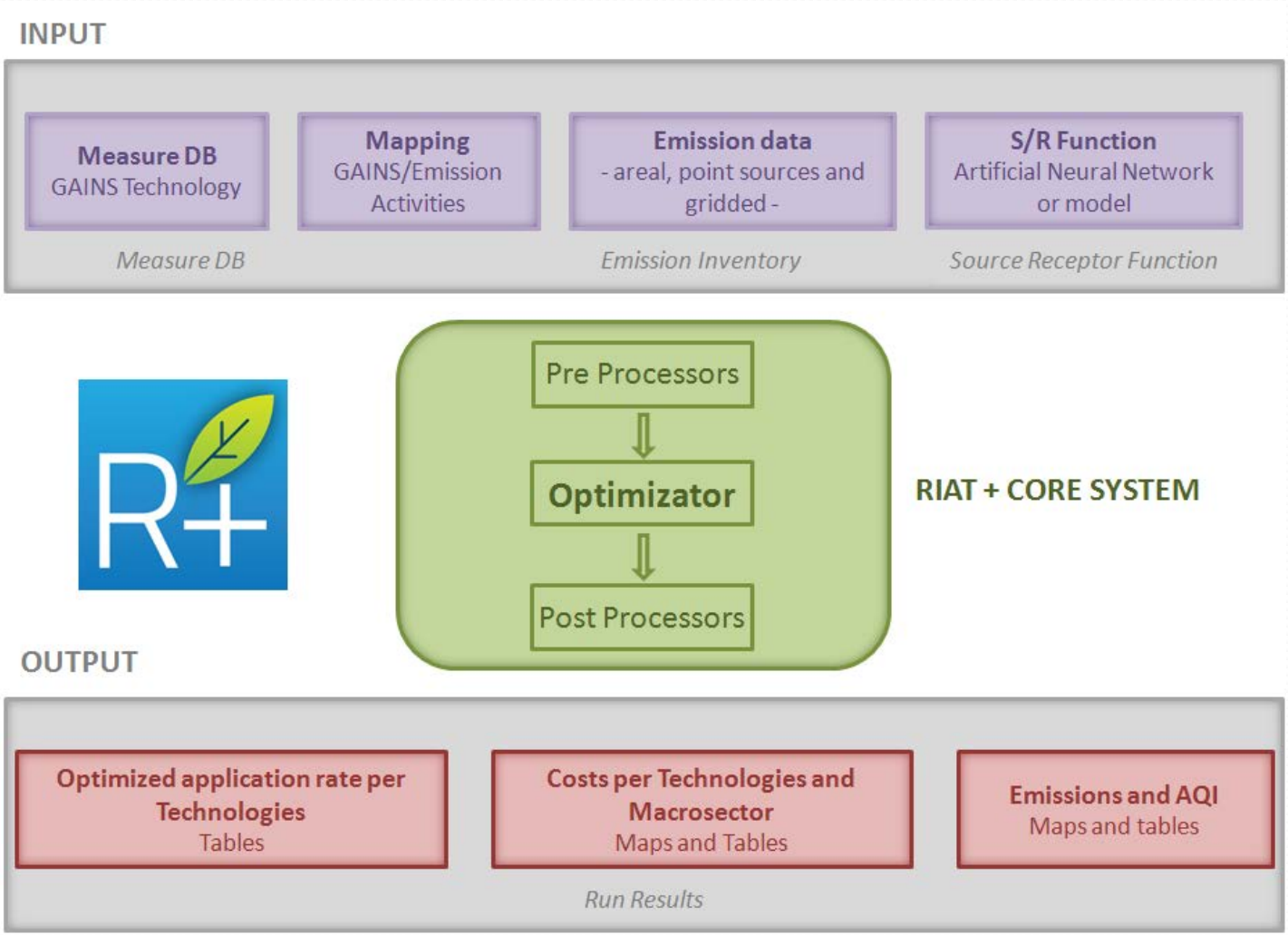
General concepts

G.Maffeis & R.Gianfreda - TerrAria srl
riat@terraria.com
+390287085654
Via Gioia 132 Milano Italy

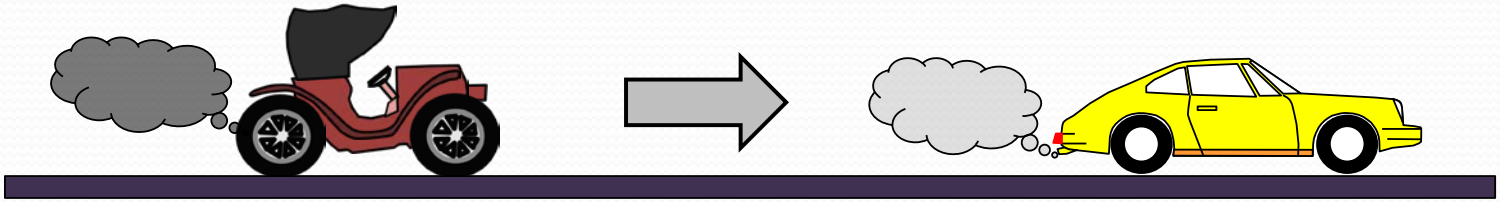
Summary

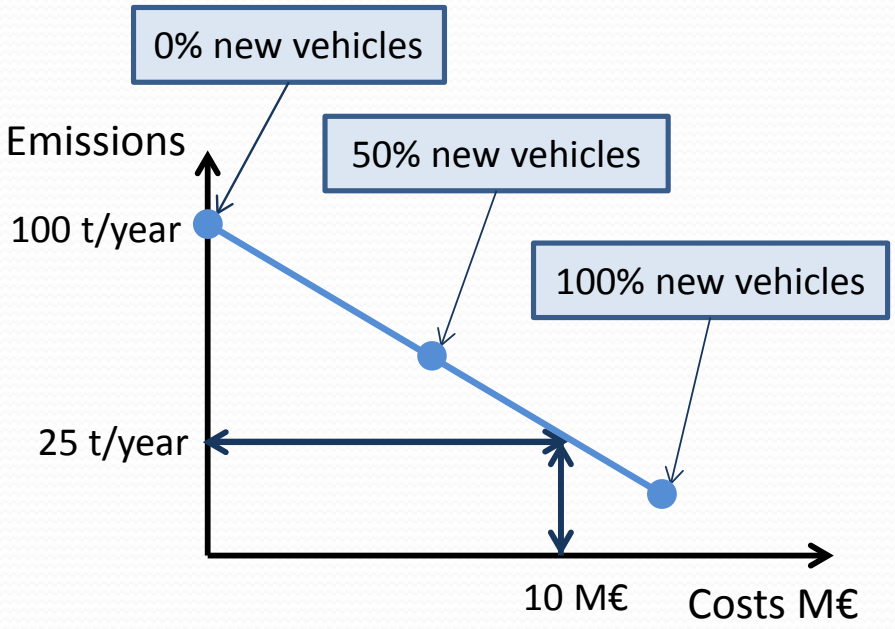
- RIAT+ general scheme
- RIAT+ for dummies
- RIAT+ formulation
- RIAT+ procedures

RIAT+ Scheme


INPUT
Measure DB
GAINS Technology
Mapping
GAINS/Emission Activities
Emission data
- areal, point sources and gridded -
S/R Function
Artificial Neural Network or model
Measure DB
Emission Inventory
Source Receptor Function
Pre Processors
Optimizator
Post Processors
RIAT + CORE SYSTEM
OUTPUT
Optimized application rate per Technologies
Tables
Costs per Technologies and Macrosector
Maps and Tables
Emissions and AQI
Maps and tables
Run Results

CORE1: emissions & technologies





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

Cost *[M€/year]*

$$C_{s,t} = \alpha_t . c_t . A_s$$

Application rate *of the new technology* t

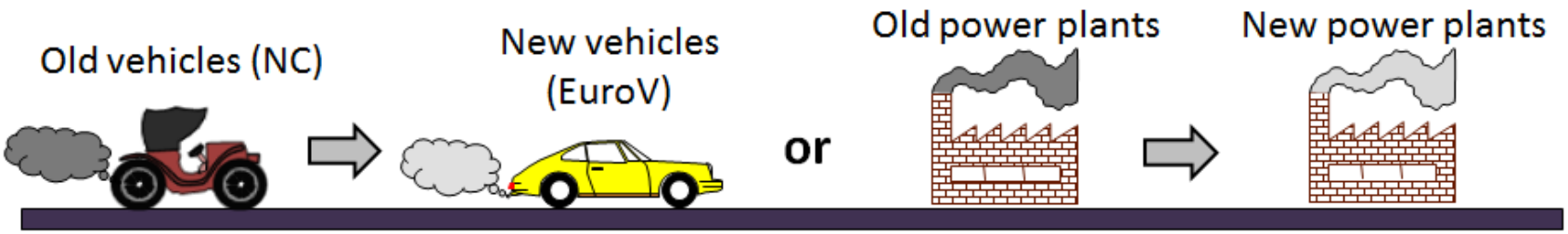
$$E_{p,s,t} = \alpha_t . e_{p,t} . A_s + (1 - \alpha_t) e_{p,0} . A_s$$

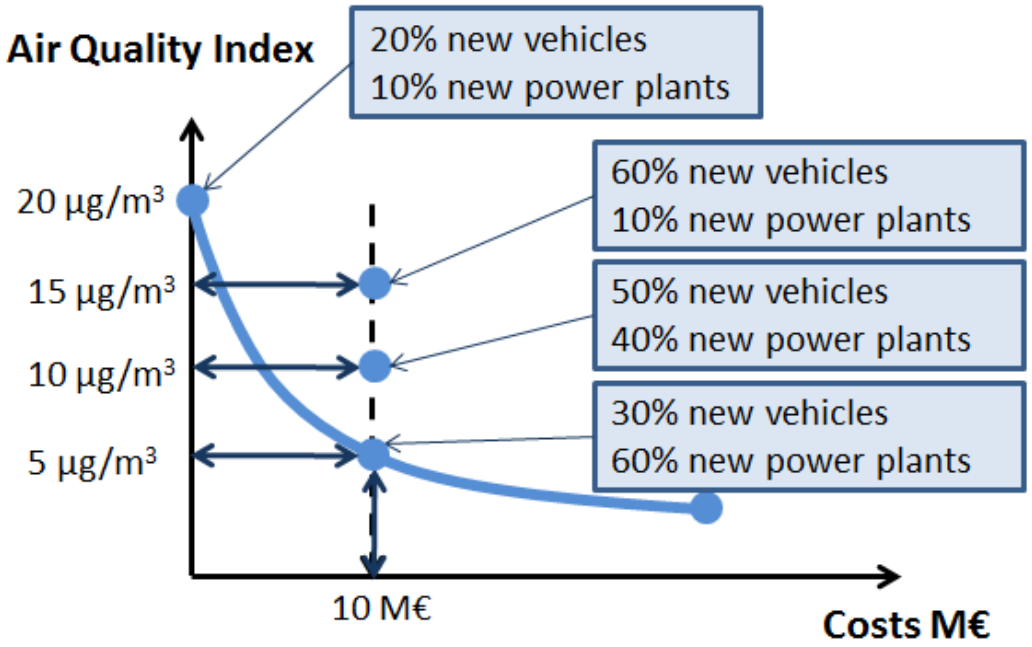
Emission *[ktonnes/year]*

Emissions factor of the new technology

Emission factor of the old technology

CORE2: technologies & concentration





Optimization: find the set of Application Rates which minimize the Air Quality Index for a given cost.

Total Cost [M€]

$$C = \alpha_1 . c_1 . A_1 + \alpha_2 . c_2 . A_2 + \ldots$$

***Application rates** for the different technologies*

$$\min\left[AQI(\alpha_1, \alpha_2, \ldots \alpha_t)\right]$$

AQI for a pollutant q

CORE3: a Plan

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€]

General formulation: ingredients

- **Emissions inventory** at a reference YEAR (SNAP3 level & fuels in CORINAR, sectors & fuels in NFR …)
- **Technologies and their application rate** in CLE scenario of that YEAR (derived from GAINS)

Linked to an emission ACTIVITY&FUEL, characterized by EFFICIENCY (EFF % per pollutant) to reduce emission, a COST to reduce emission (Meuro/ActivityLevel), a APPLICATION RATE (AR % per year) i.e. a level of application, a POTENTIAL (maximum application), CLE/MFR (application per year)

RIAT+ conserves as a starting point these two levels: REGIONAL (emissions) and EUROPEAN (technologies)

Emission: general formulation

Emissions [in tons/year] scenario with a set of technologies referred to a specific year, to the pollutant *p*, to the macrosector, sector, activity <*i,j,k*> triple

Application of the set of technologies using their diffusion and their RE

Term to take into account the **emission not reduced due to the NOC** technologies

"**virtual emission**" emissions [in tons/year] referring to the year of the emission inventory, without any application of technologies

$$E_{SCEN\_YEAR\ i,j,k,p} = E_{V\_REF\_YEAR\ i,j,k,p} * \left[\sum_{t=1}^{T_{i,j,k}} \left[\left(1 - eff_{i,j,k,t,p}\right) * AR_{SCEN\_YEAR\ i,j,k,t} \right] + \left(1 - \sum_{t=1}^{T_{i,j,k}} AR_{SCEN\_YEAR\ i,j,k,t} \right) \right] * \frac{AL_{SCEN\_YEAR\ j,j,k}}{AL_{REF\_YEAR\ j,j,k}}$$

the ratio between the $AL_{SCEN\_YEAR\ i,j,k}$ and the $AL_{REF\_YEAR\ i,j,k}$ represents **the evolution of the emission activity** in the two years considered (in terms of increase or decrease).

$T_{i,j,k}$ the technologies (**TM**) that can be applied in the macrosector, sector, activity <*i,j,k*> triple

$eff_{i,j,k,t,p}$: **removal efficiency** (between 0 and 1) of a particular **technology *t*** (in the macrosector, sector, activity <*i,j,k*> triple), for a selected **pollutant *p***;

$AR_{SCEN\_YEAR\ i,j,k,t}$ **application rate** of a **particular year** (between 0 meaning no technology use, 1 full application);

$AL_{SCEN\_YEAR\ i,j,k}$ **activity levels** of a **particular year** -SCEN_YEAR-;

$AL_{REF\_YEAR\ i,j,k}$ activity levels of a particular year -REF_YEAR- of a macrosector, sector, activity <*i,j,k*> triple;

Virtual Emission

- Virtual emissions are the starting point for the projection of emissions and for the optimization process.
- As suggested by the name, virtual emission are not real, but needed to correctly apply the technologies method
- So it is mandatory to 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 to the reference year we obtain exactly the regional emission inventory data

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

Emission projection

From all the equations shown, the final formulation of the emission for specific scenario in a particular year is computed on the base of the emission inventory at a reference year is:

Parts of the reference emission inventory due to virtual emission formulation

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

CLE and MFR Emission Projection

CLE and MFR emissions results after the application of CLE and MFR's ARs for a specific year based on emission inventory at a reference year:

$$E\_CLE_{SCEN\ YEAR\ i,j,k,p} = E_{REF\_YEAR\ j,jk,p} * \frac{\left[\sum_{t=1}^{T_{i,j,k}}\left[\left(1-eff_{i,j,k,t,p}\right) * AR\_CLE_{SCEN\_YEAR\ i,j,k,t}\right] + \left(1-\sum_{t=1}^{T_{i,j,k}} AR\_CLE_{SCEN\_YEAR\ i,j,k,t}\right)\right]}{\sum_{t=1}^{T_{i,j,k}}\left[\left(1-eff_{i,j,k,t,p}\right) * AR\_CLE_{REF\_YEAR\ i,j,k,t}\right] + \left(1-\sum_{t=1}^{T_{i,j,k}} AR\_CLE_{REF\_YEAR\ i,j,k,t}\right)} * \frac{AL_{SCEN\_YEAR\ j,j,k}}{AL_{REF\_YEAR\ j,j,k}}$$

$$E\_MFR_{SCEN\ YEAR\ i,j,k,p} = E_{REF\_YEAR\ j,jk,p} * \frac{\left[\sum_{t=1}^{T_{i,j,k}}\left[\left(1-eff_{i,j,k,t,p}\right) * AR\_MFR_{SCEN\_YEAR\ i,j,k,t}\right] + \left(1-\sum_{t=1}^{T_{i,j,k}} AR\_MFR_{SCEN\_YEAR\ i,j,k,t}\right)\right]}{\sum_{t=1}^{T_{i,j,k}}\left[\left(1-eff_{i,j,k,t,p}\right) * AR\_CLE_{REF\_YEAR\ i,j,k,t}\right] + \left(1-\sum_{t=1}^{T_{i,j,k}} AR\_CLE_{REF\_YEAR\ i,j,k,t}\right)} * \frac{AL_{SCEN\_YEAR\ j,j,k}}{AL_{REF\_YEAR\ j,j,k}}$$

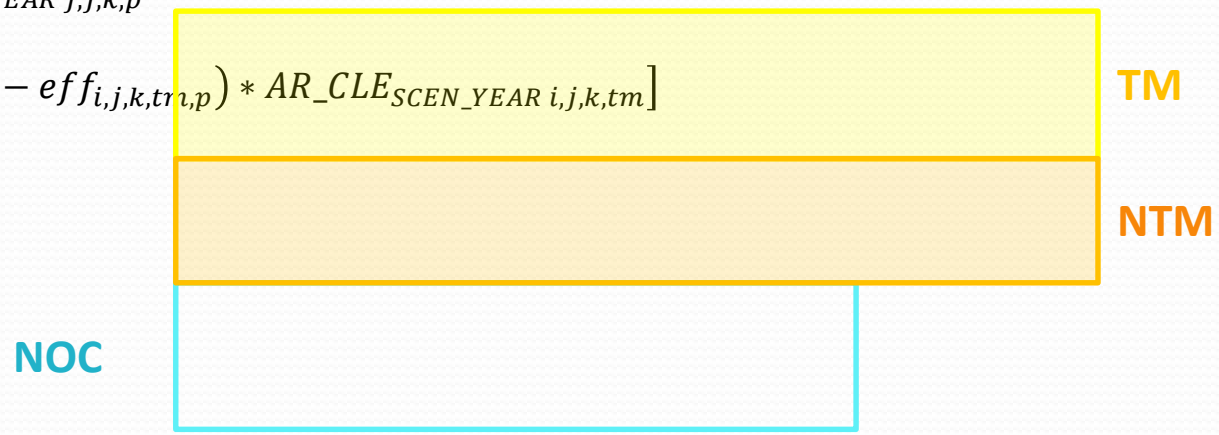
MFR computation

- RIAT+ measure database contains the CLE and Potential (maximum applicable) application rates
- MFR (Maximum Feasible Reduction) scenario is defined as the upper reduction limit for emissions in RIAT+ used to train ANNs
- To estimate MFR application rates for each activity, the first step is the *sorting of the removal efficiency* of the technologies, for each pollutant
- Then the technology with the highest RE is applied until reaching the potential level of application of the technology itself. The same procedure is applied to all the technologies until the saturation (the sum of the technologies application rates reaches the value of 100%)
- Through this procedure the maximum reduction of emissions is guaranteed for each activity and pollutant.

TM & NTM general formulation

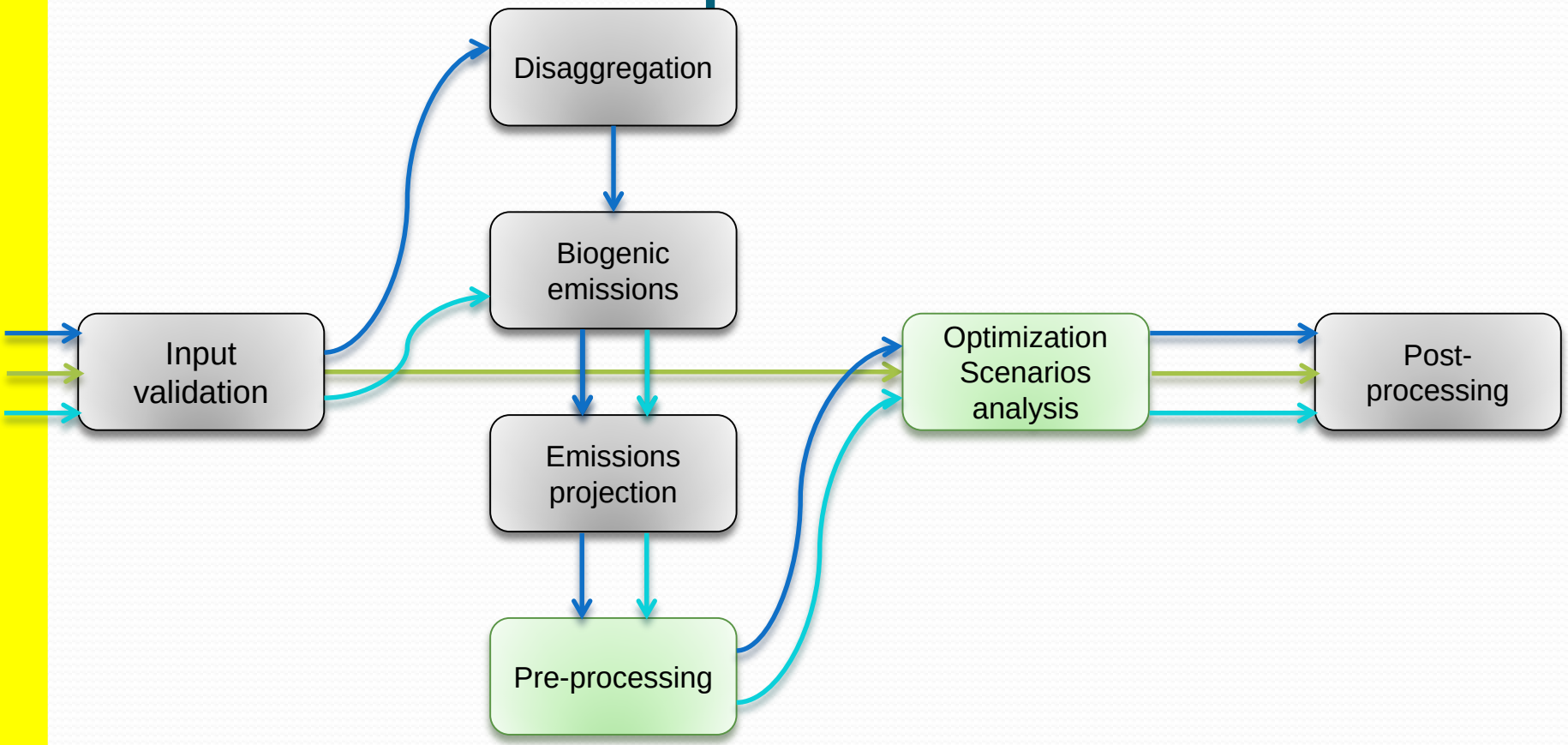
The remaining emissions after the application of CLE of the scenario year (when the emission inventory refers to the reference year) reducing bt T are:

$$E\_CLE_{SCEN\ YEAR\ i,j,k,p} = E_{BC\_REF\_YEAR\ j,j,k,p} * \left[\sum_{tm=1}^{TM_{i,j,k}} \left[\left(1 - eff_{i,j,k,tm,p}\right) * AR\_CLE_{SCEN\_YEAR\ i,j,k,tm}\right]\right]$$



CONSTRAINT: conservation of mass constraints (total removal efficiency of TM & NTM <= 1) is explicitly stated (for each activity and each primary pollutant)

RIAT+ procedures

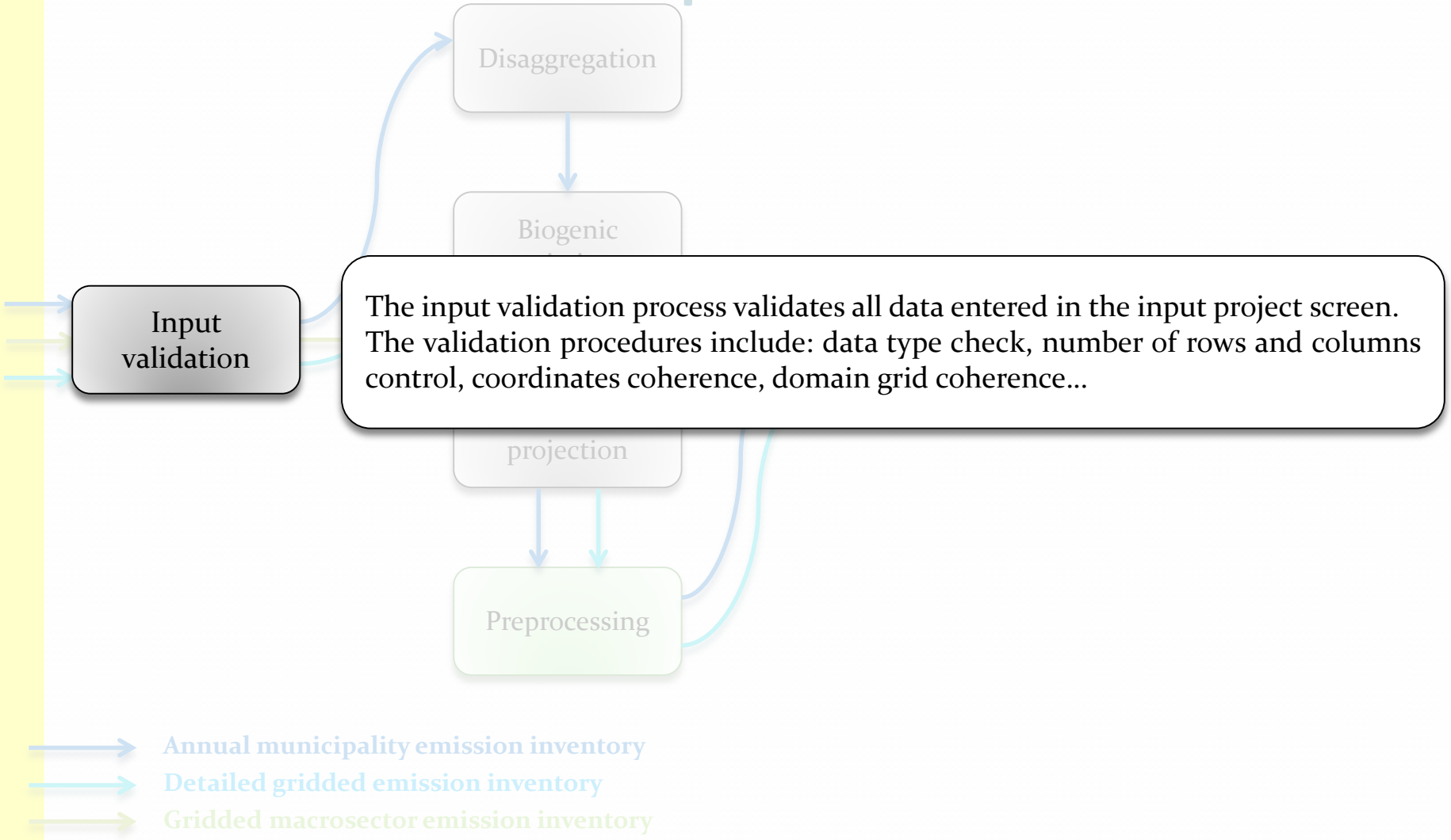


Annual municipality emission inventory

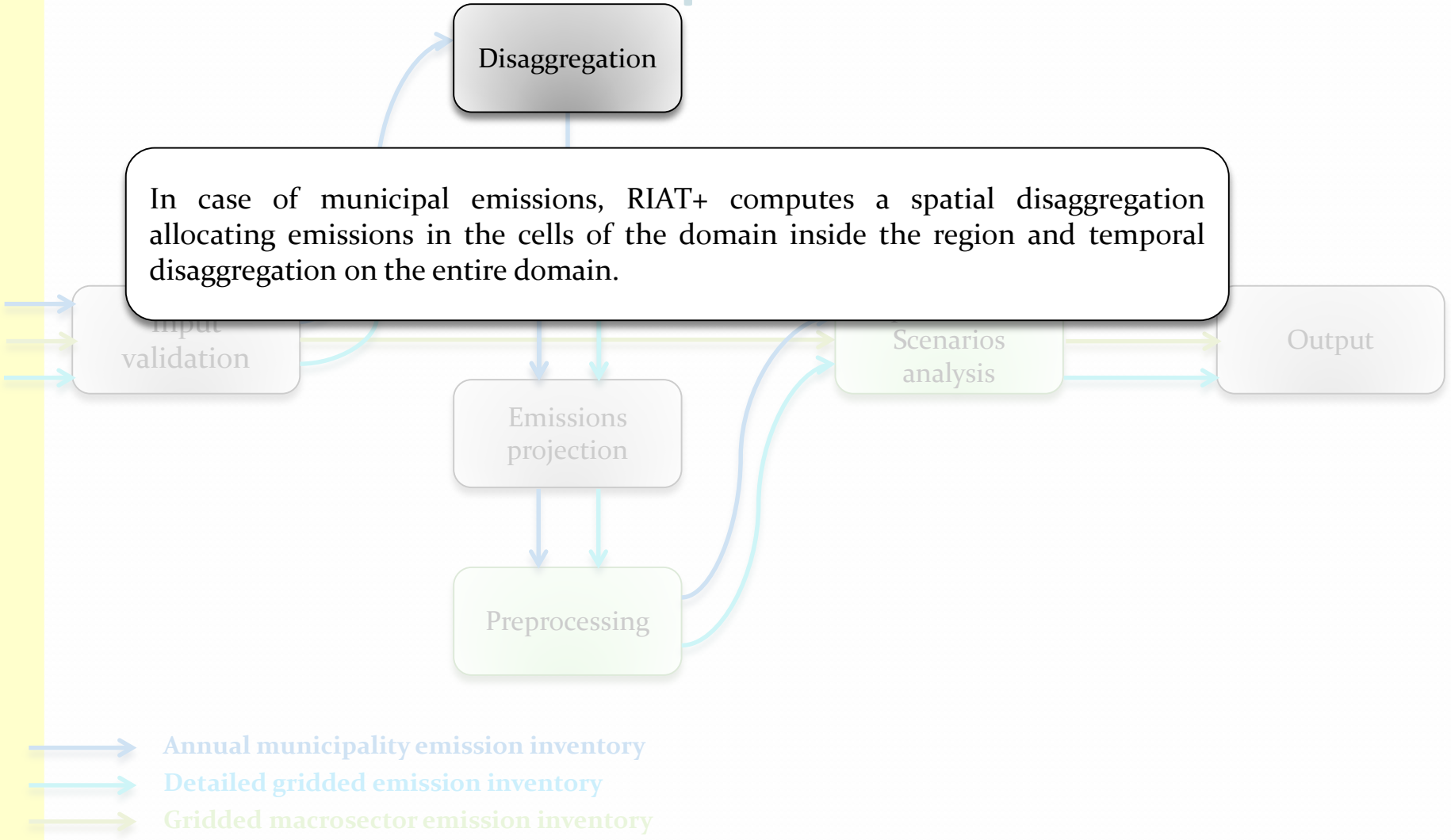
Detailed gridded emission inventory

Gridded macrosector emission inventory

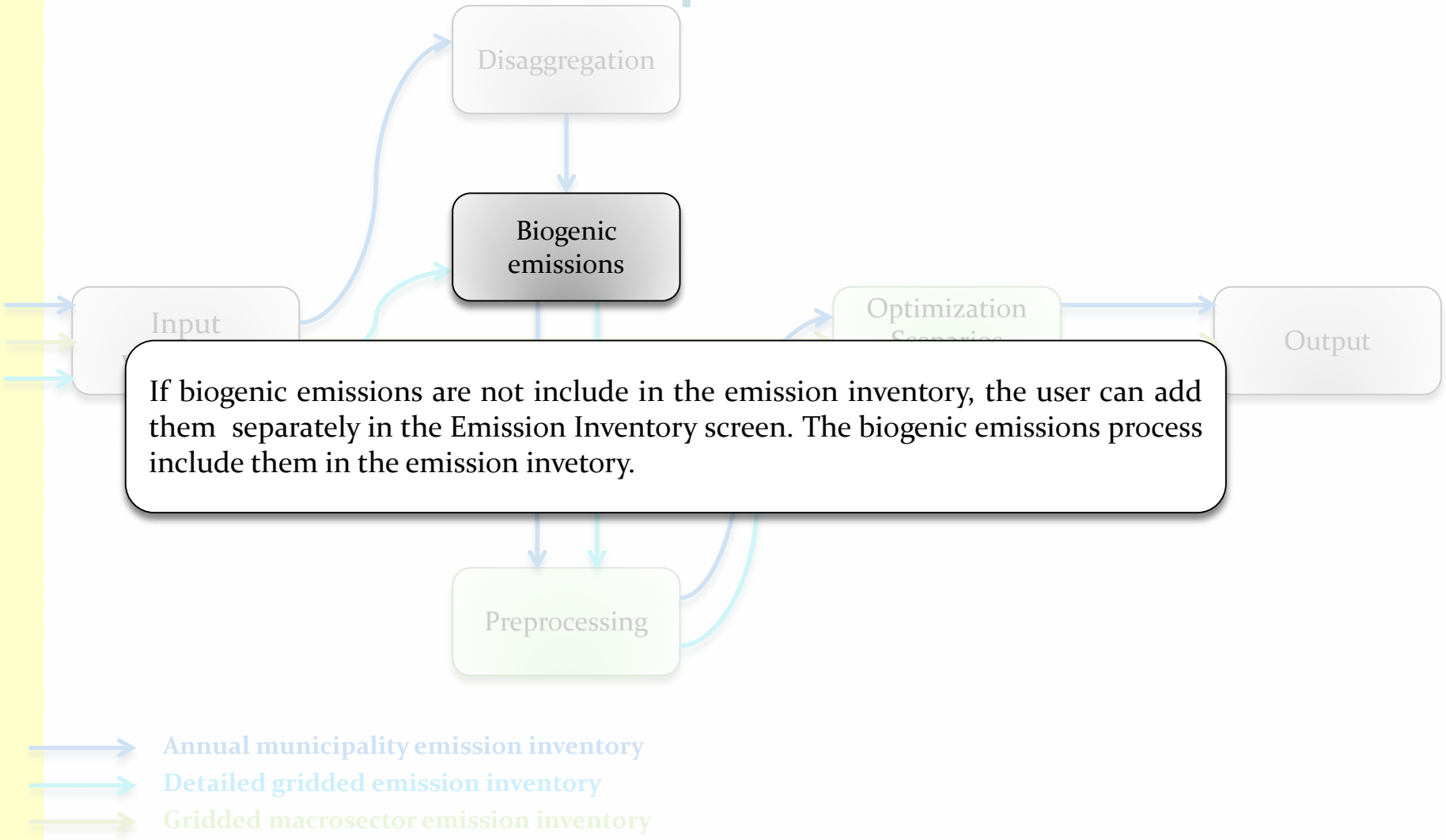
RIAT+ processes



RIAT+ processes

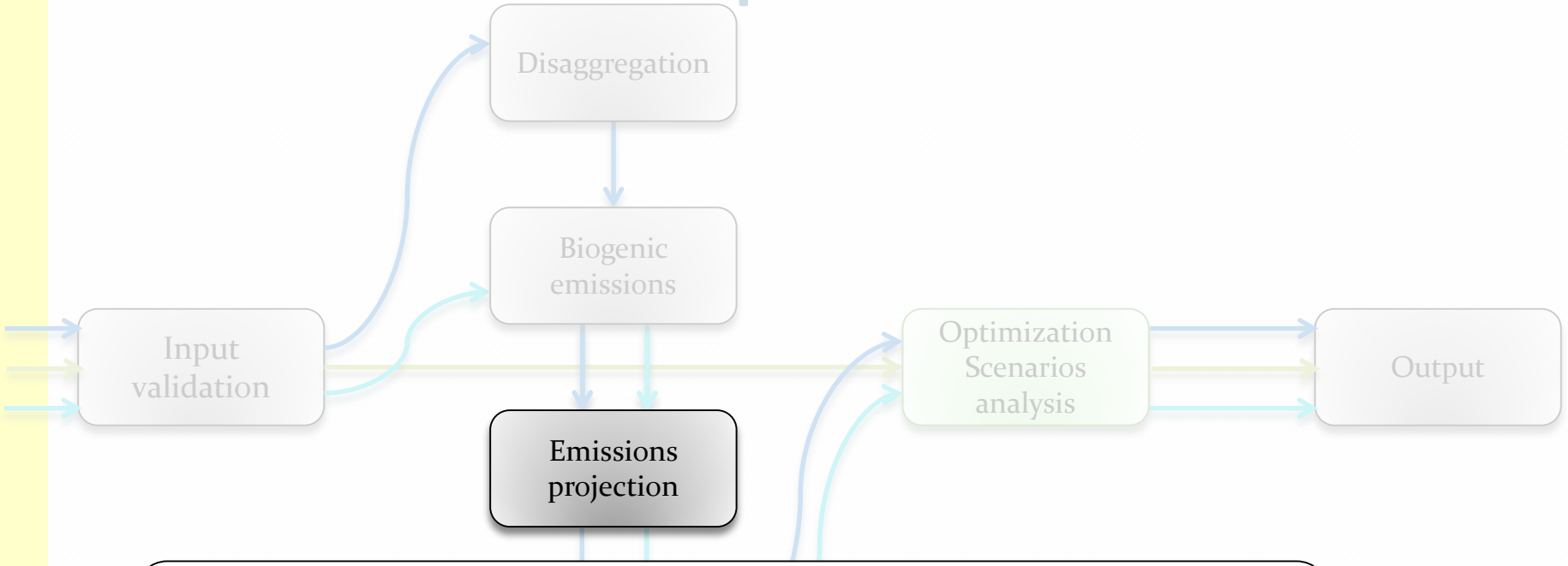


RIAT+ processes



If biogenic emissions are not include in the emission inventory, the user can add them separately in the Emission Inventory screen. The biogenic emissions process include them in the emission invetory.

RIAT+ processes



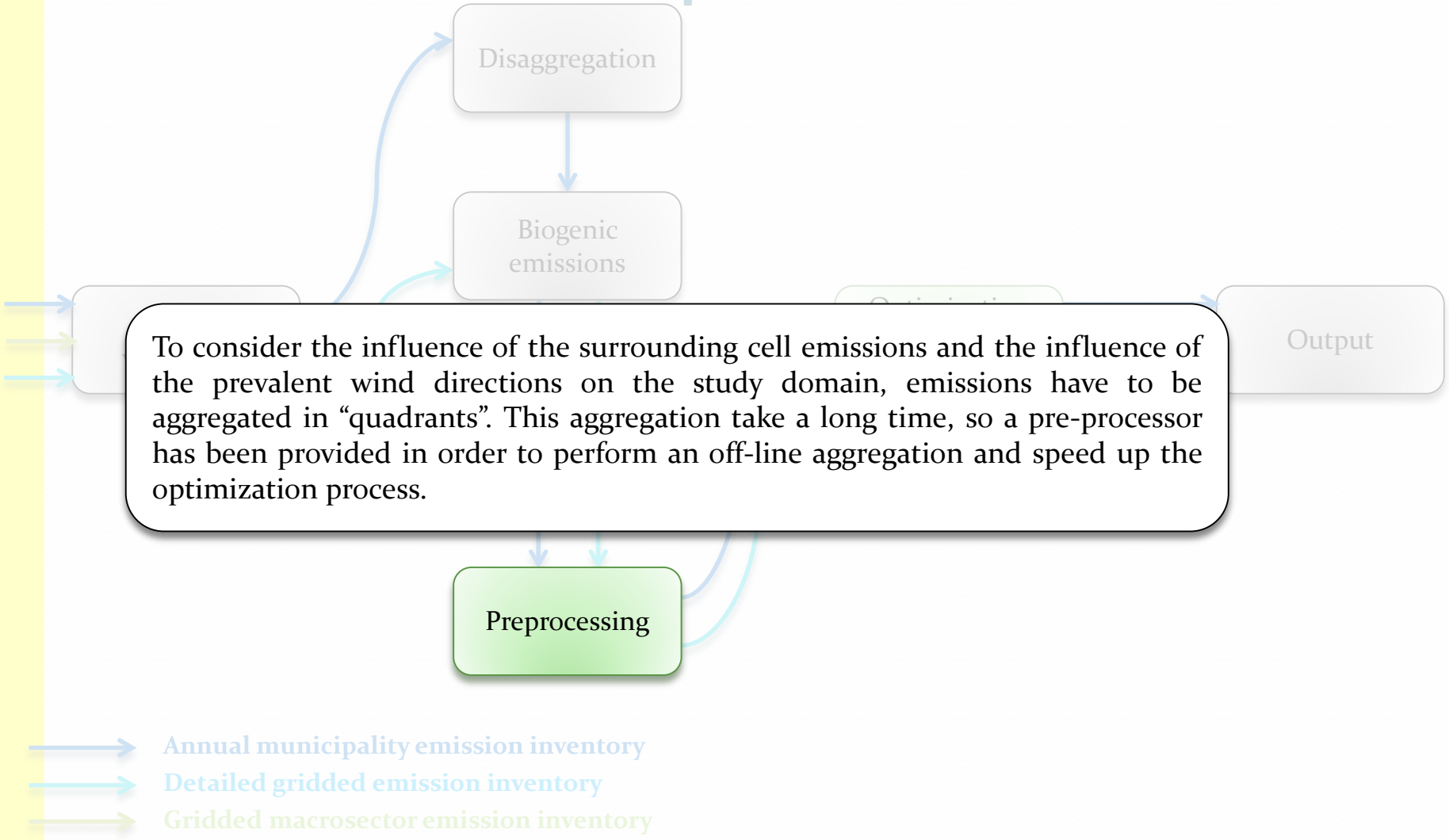
The emissions projection process computes virtual emissions and virtual activity level, representing the starting point for optimization; also cle and mfr projections are computed.

Annual municipality emission inventory

Detailed gridded emission inventory

Gridded macrosector emission inventory

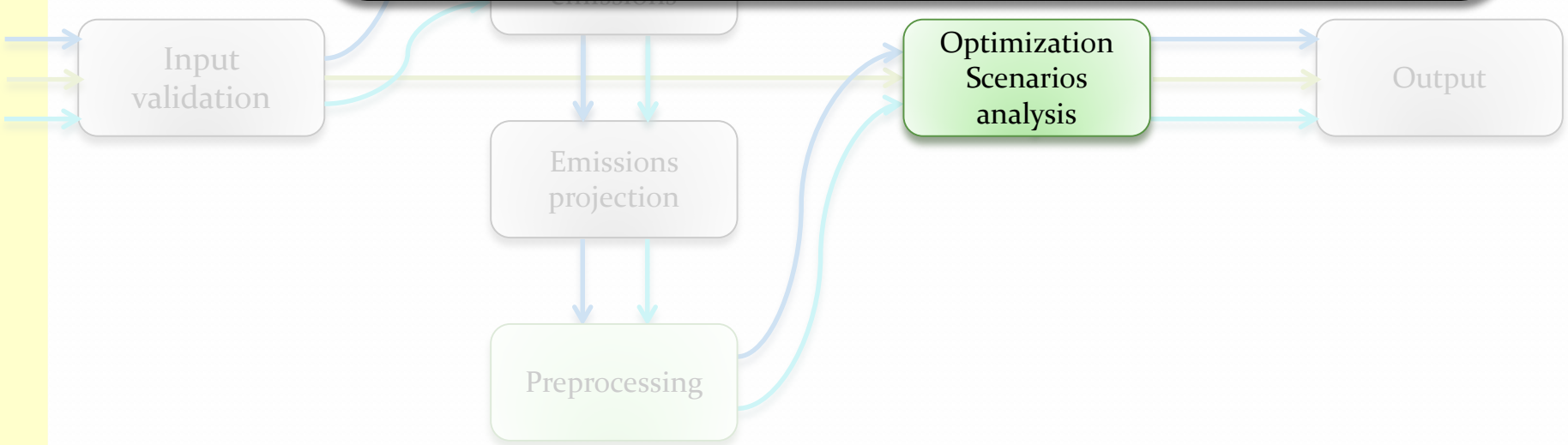
RIAT+ processes



RIAT+ processes

It is the core of RIAT+. This process allows four different types of analysis:
- Multi Objective optimization
- Cost Effectiveness optimization
- Detailed scenario analysis
- Aggregated scenario analysis

Air quality indexes, Emission reduction costs, external costs and Greenhouse gases are computed.



RIAT+ processes