



A TIMES model as a means of local network planning

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MAX-PLANCK-GESELLSCHAFT

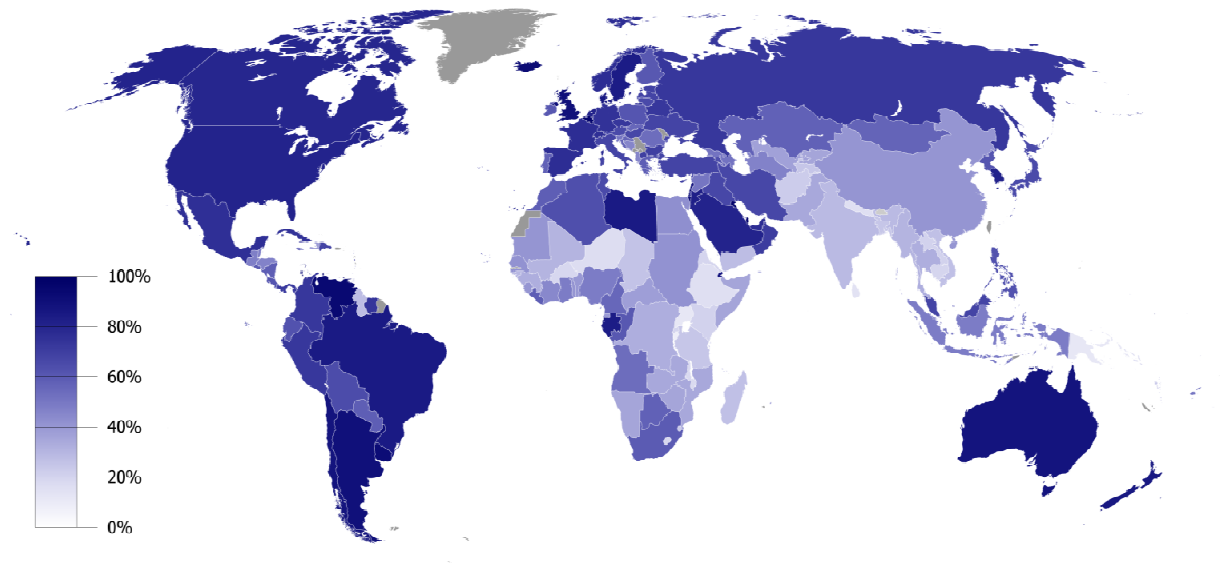
- Max-Planck-Institute for Plasmaphysics (IPP)
 - Development of fusion power plant as a sustainable energy source
 - Investigation of two fusion concepts: Tokamak and Stellerator
 - Energy system scenario studies
 - » Assess and provide technical and economic fusion data
 - » Study the role of fusion in the energy system of the future
 - » Explore conditions under which fusion will be competitive



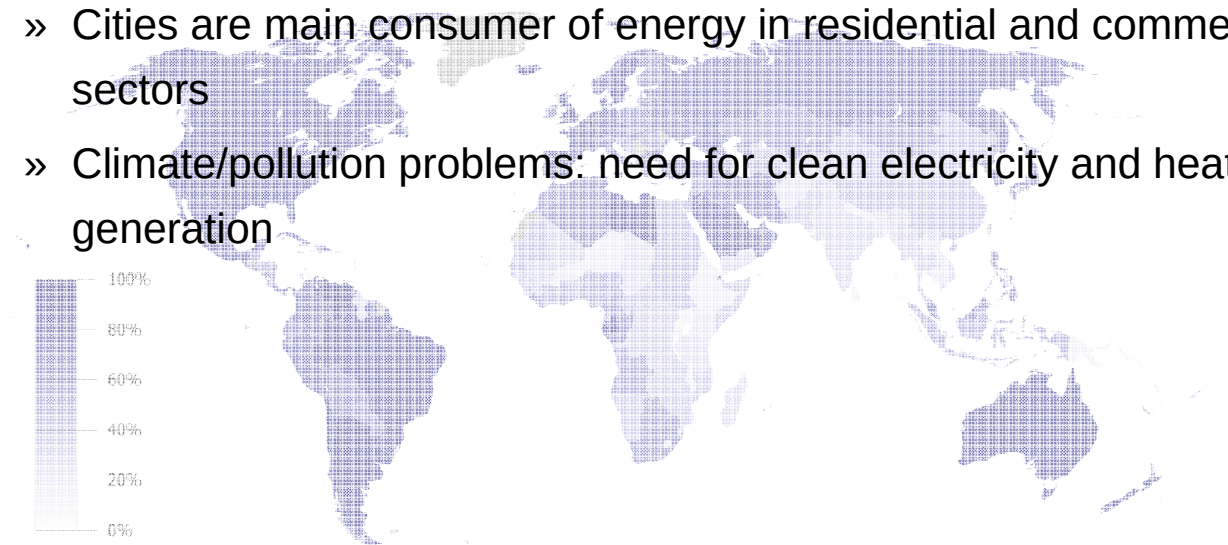
- Local/urban energy system models
 - Small scale
 - » Allocation of system parameters to observables
 - » Identification of defined activities



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 - Ongoing urbanization



- Local/urban energy system models
 - Small scale
 - » Allocation of system parameters to observables
 - » Identification of defined activities
 - Ongoing urbanization
 - » Cities are main consumer of energy in residential and commercial sectors
 - » Climate/pollution problems: need for clean electricity and heat generation



Model of residential, commercial and industrial sectors of urban energy system

- Focus
 - Heat generation, distribution and demand
- Goals
 - Provide basis for decision-making
 - Projection of energy demands and emissions in the medium and long term
 - Assess cost-effectiveness of development projects



Questions asked

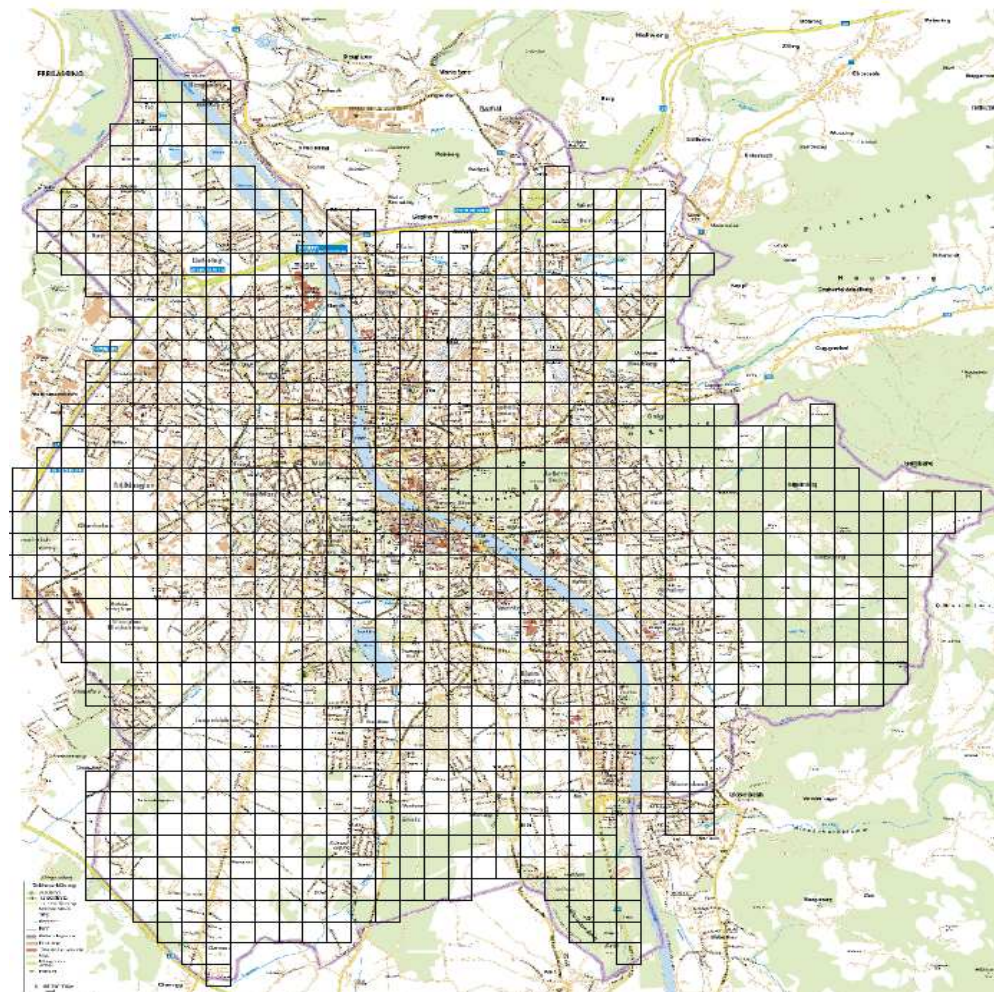
- Heat demand in 10, 20, 30 years?
- Cost effective way to supply this demand?
- Efficiency improvement: Which buildings should be reconstructed and where?
- District heat grid: Extension or removal?
- Costs of grid maintainance?
- Primary energy consumption in 10, 20, 30 years?
- How can CO₂ target be met?
- Local emission pattern?



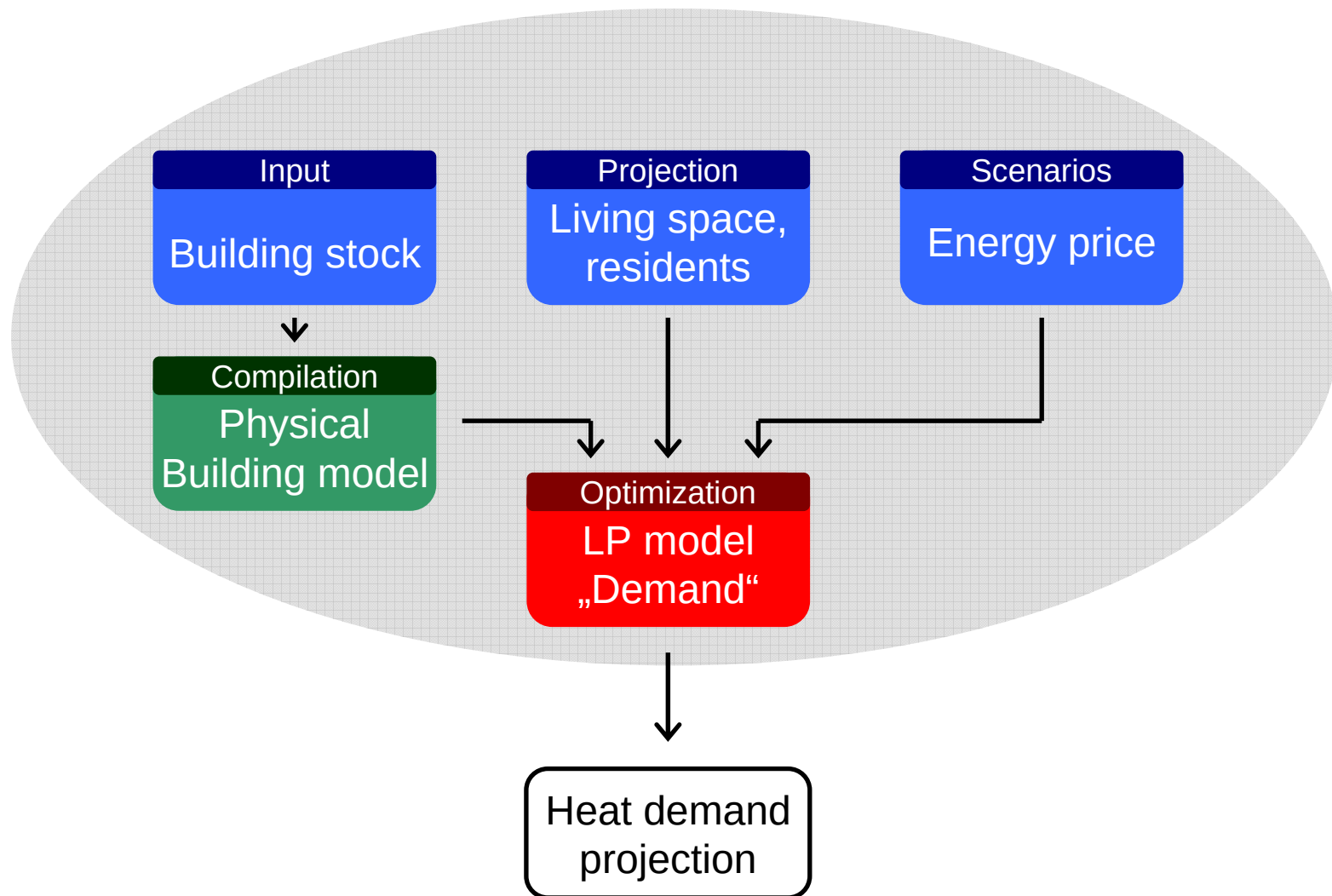
- Use GIS and spatially high resolved data to represent model area
- Construct two energy models representing the
 - Demand side („demand module“)
 - Grid and supply structure („grid module“)
- Couple energy models to
 - Physical model of buildings
 - Technical model of grid components
 - Lifecycle assessment model



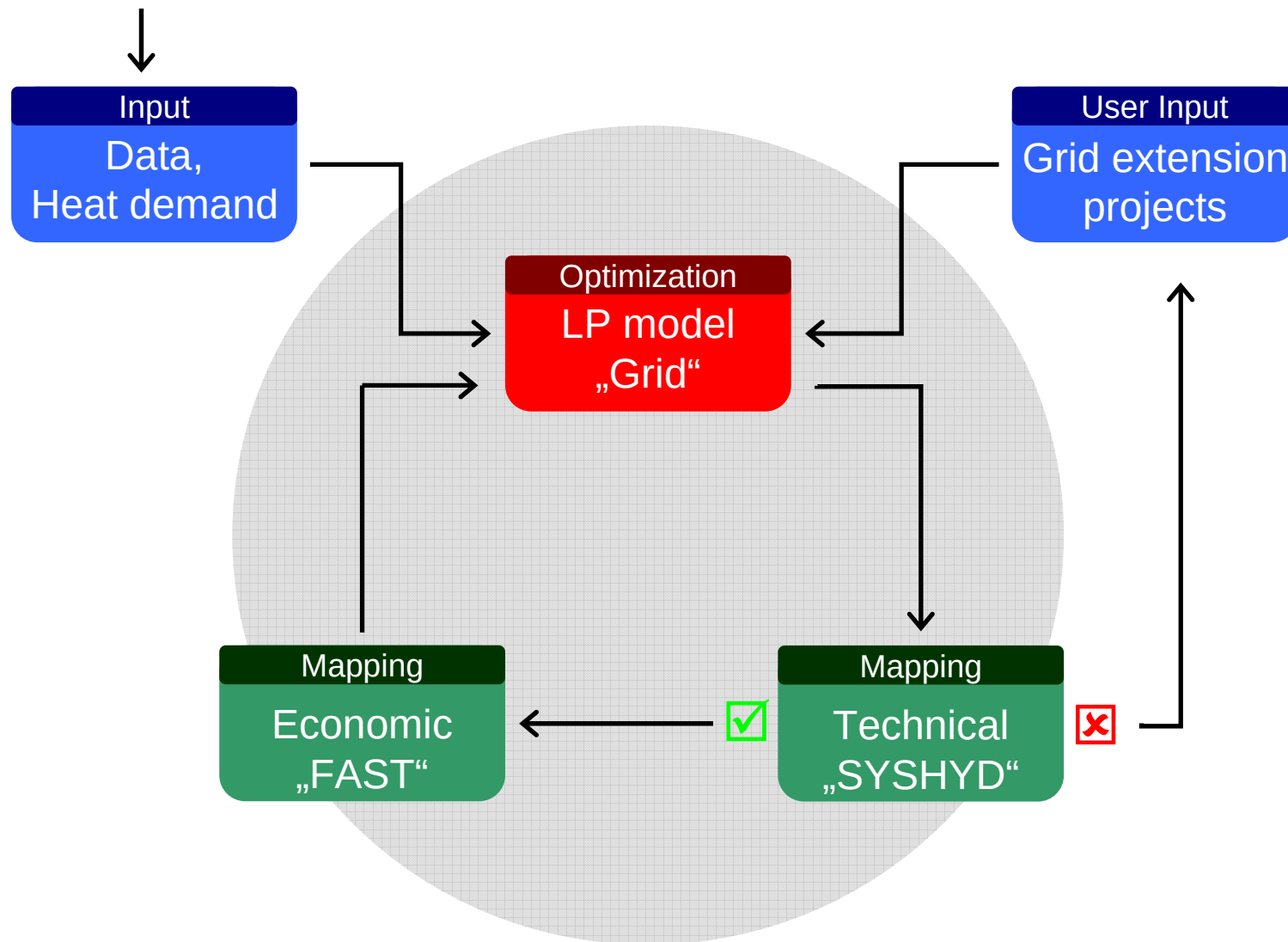
Model area



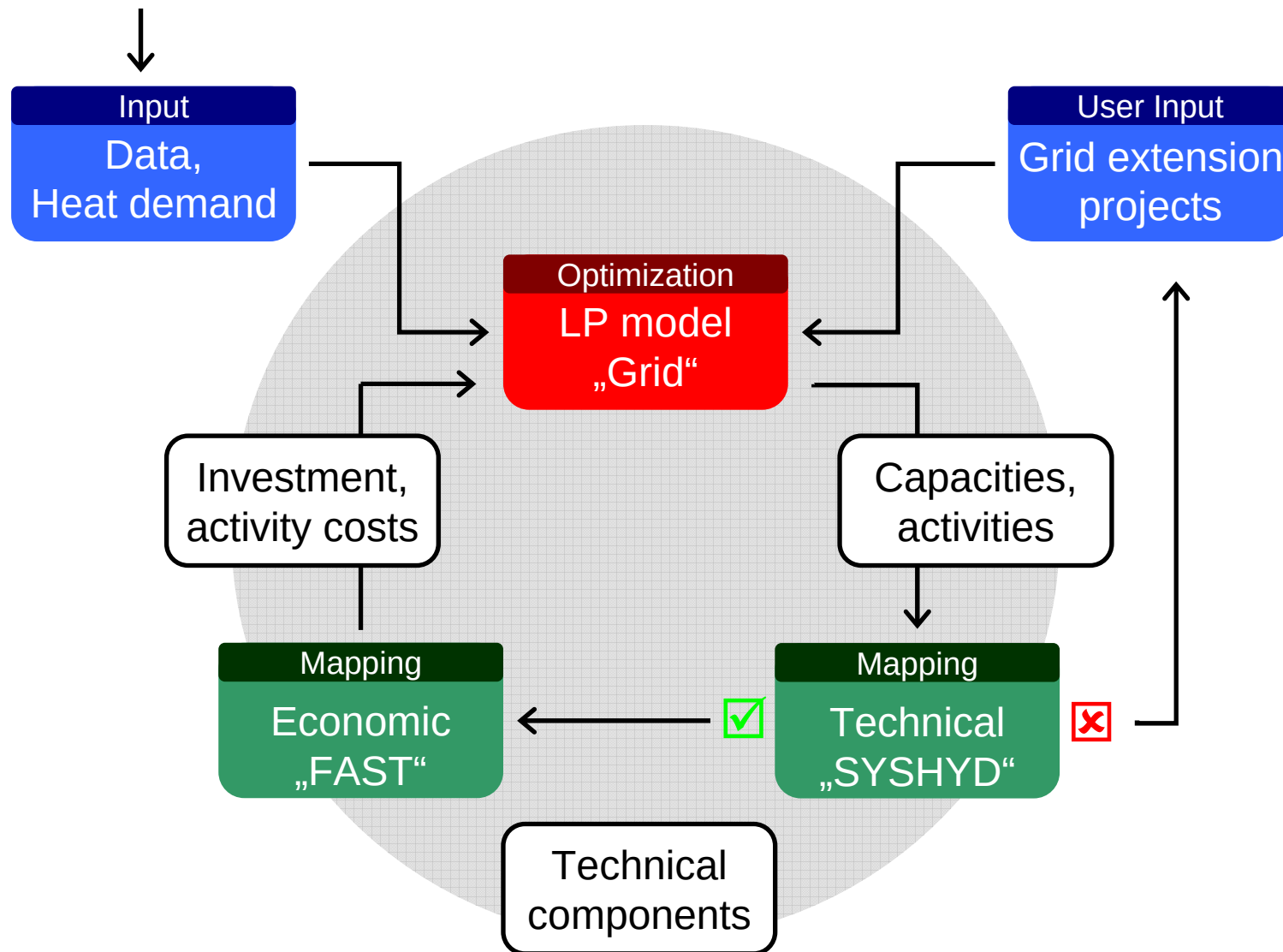
Model structure: Demand module



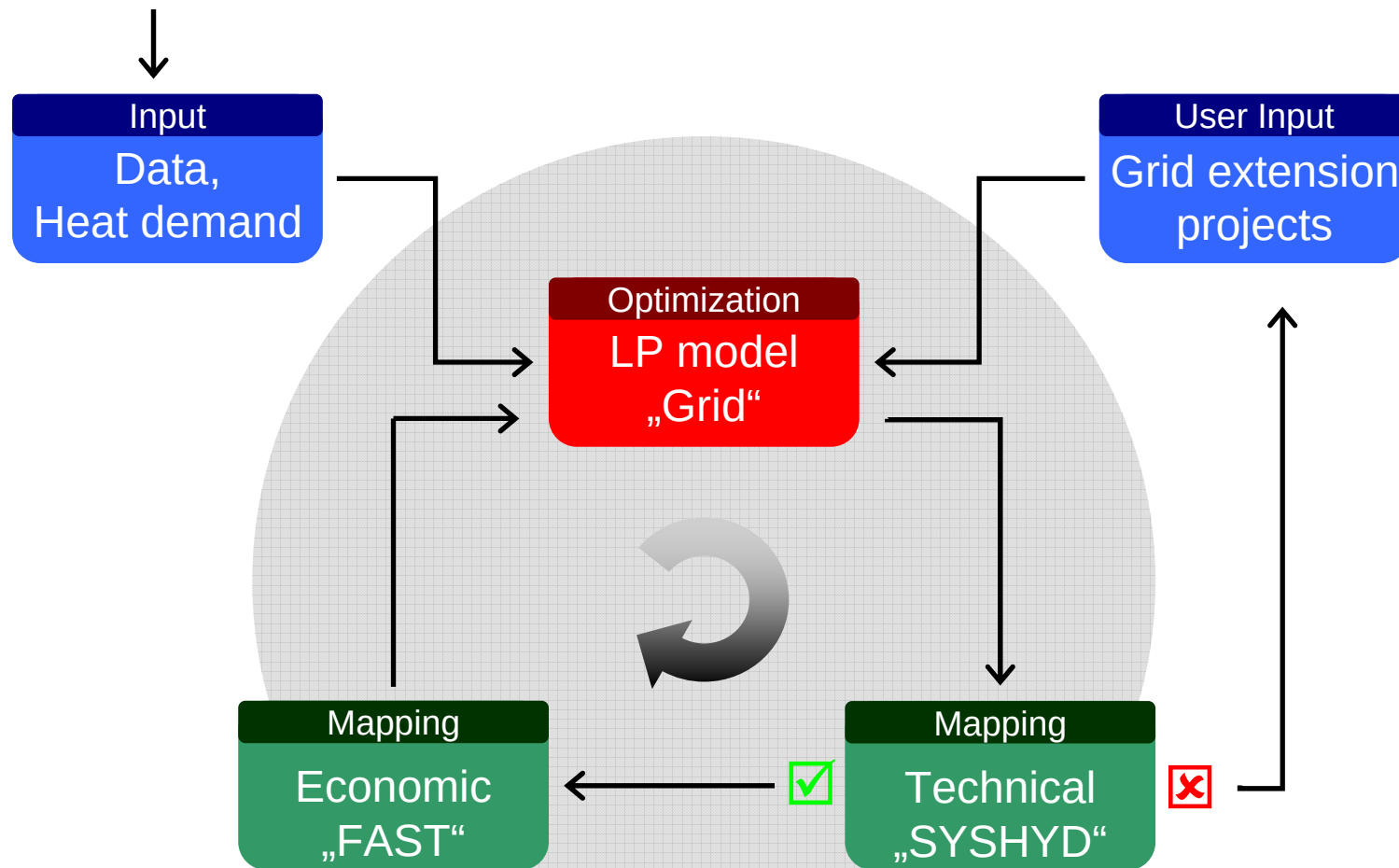
Model structure: Grid module



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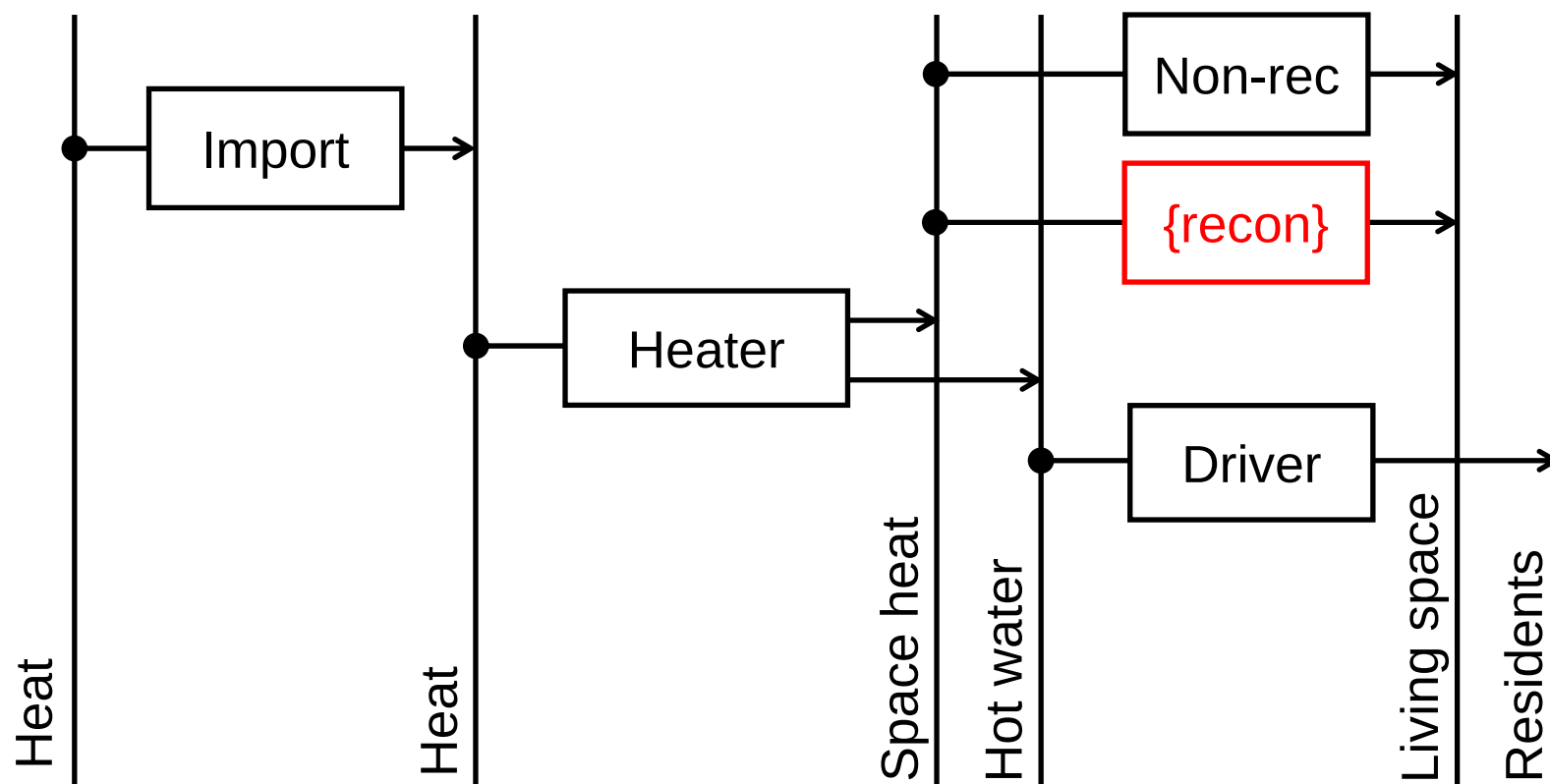
Model structure: Grid module



Self-consistency problem!



RES – Demand module



- Base year data:
 - Building stock
 - » Living space
 - » Specific energy need: **Physical building model**
- Projection
 - Living space and Population
 - Heat price: **Scenarios**
- Technical data
 - Possibilities of reconstruction
 - » Specific energy need
 - » Investment costs

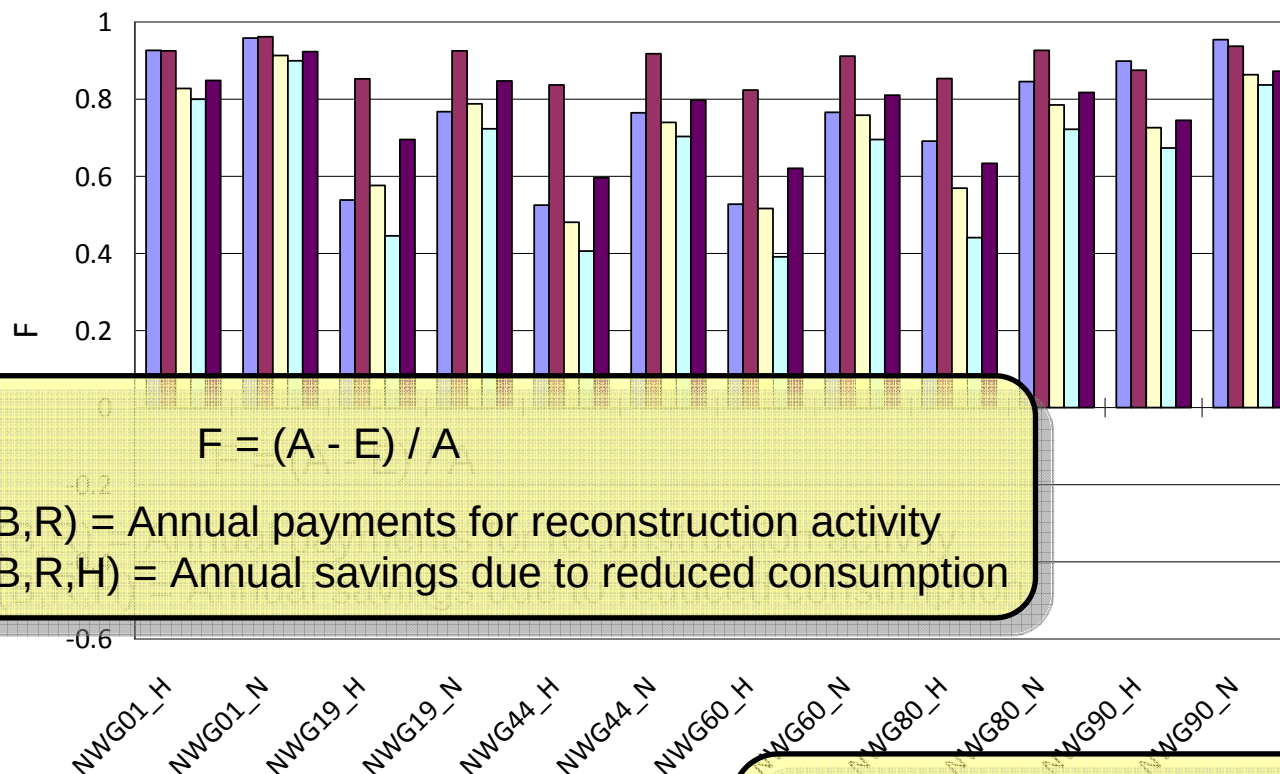


Demand module

Optimization: Investment $\leftrightarrow$ consumption

Heat price (H)

50 €/MWh



$$F = (A - E) / A$$

$A = A(B, R)$ = Annual payments for reconstruction activity

$E = E(B, R, H)$ = Annual savings due to reduced consumption

Reconstruction

roof

window

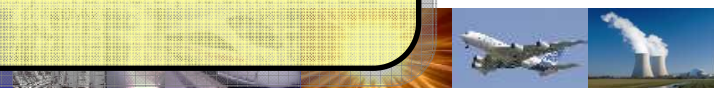
full

wall & roof

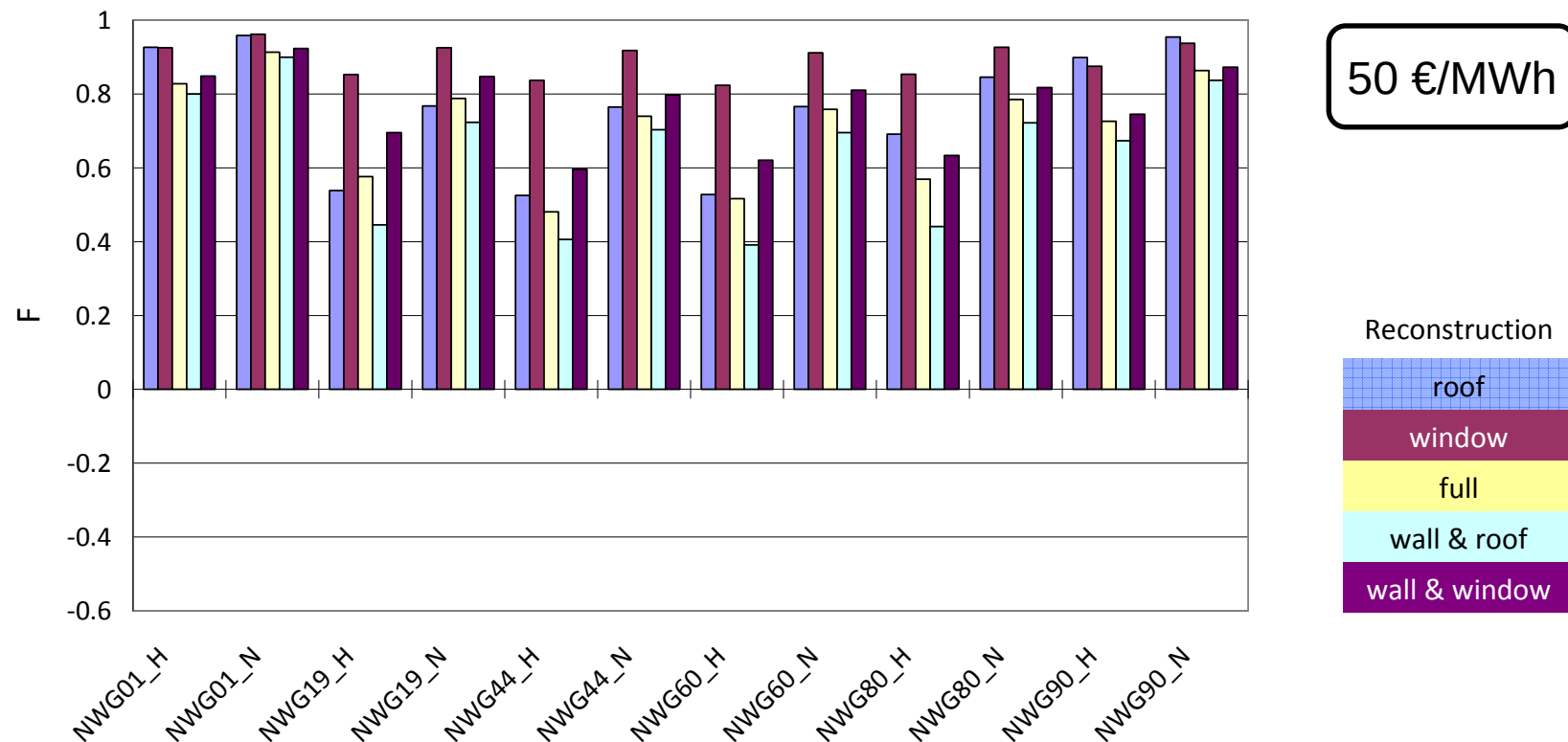
wall & window

Building types (B):

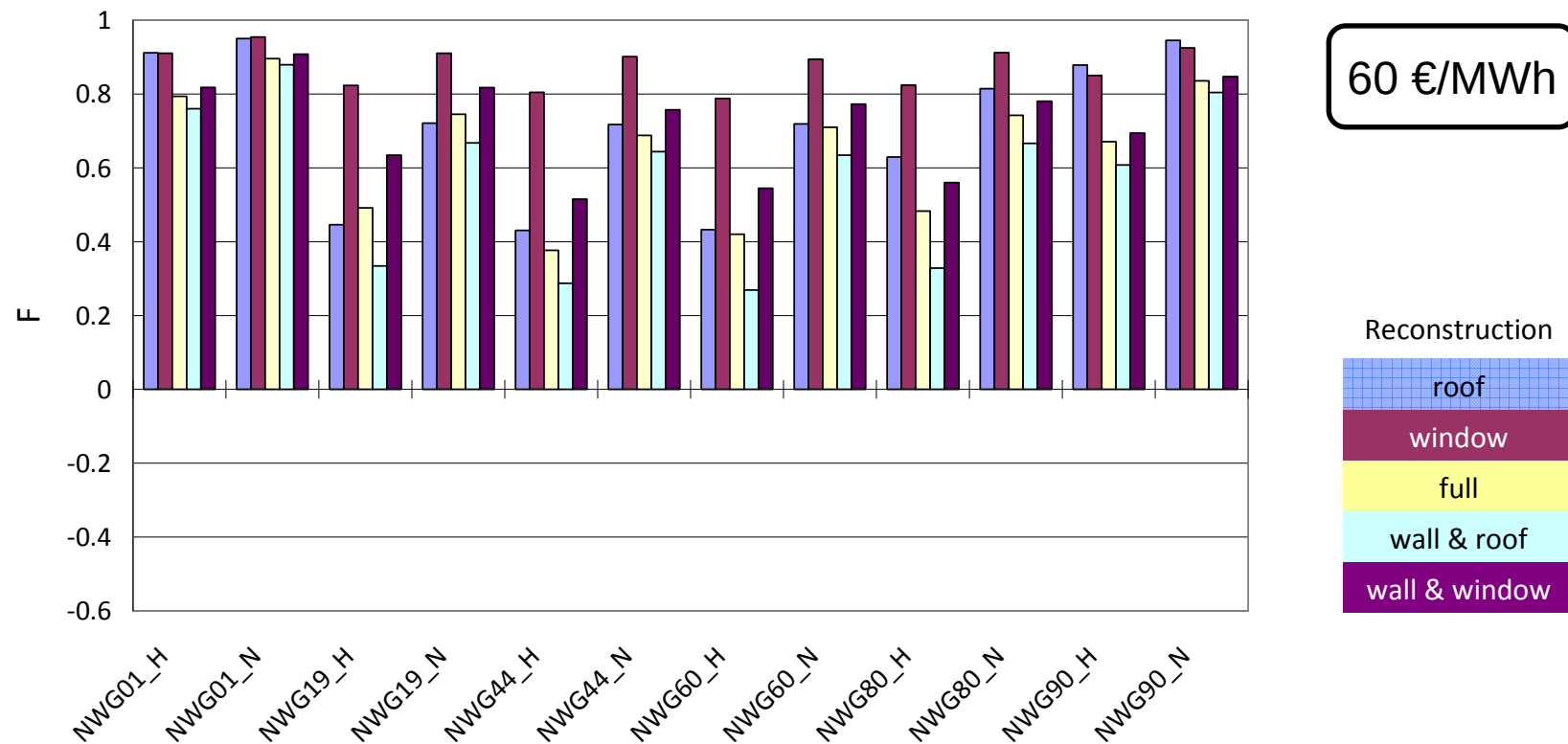
- Single family house, built 1960
- Multi family house, built 2001
- etc...



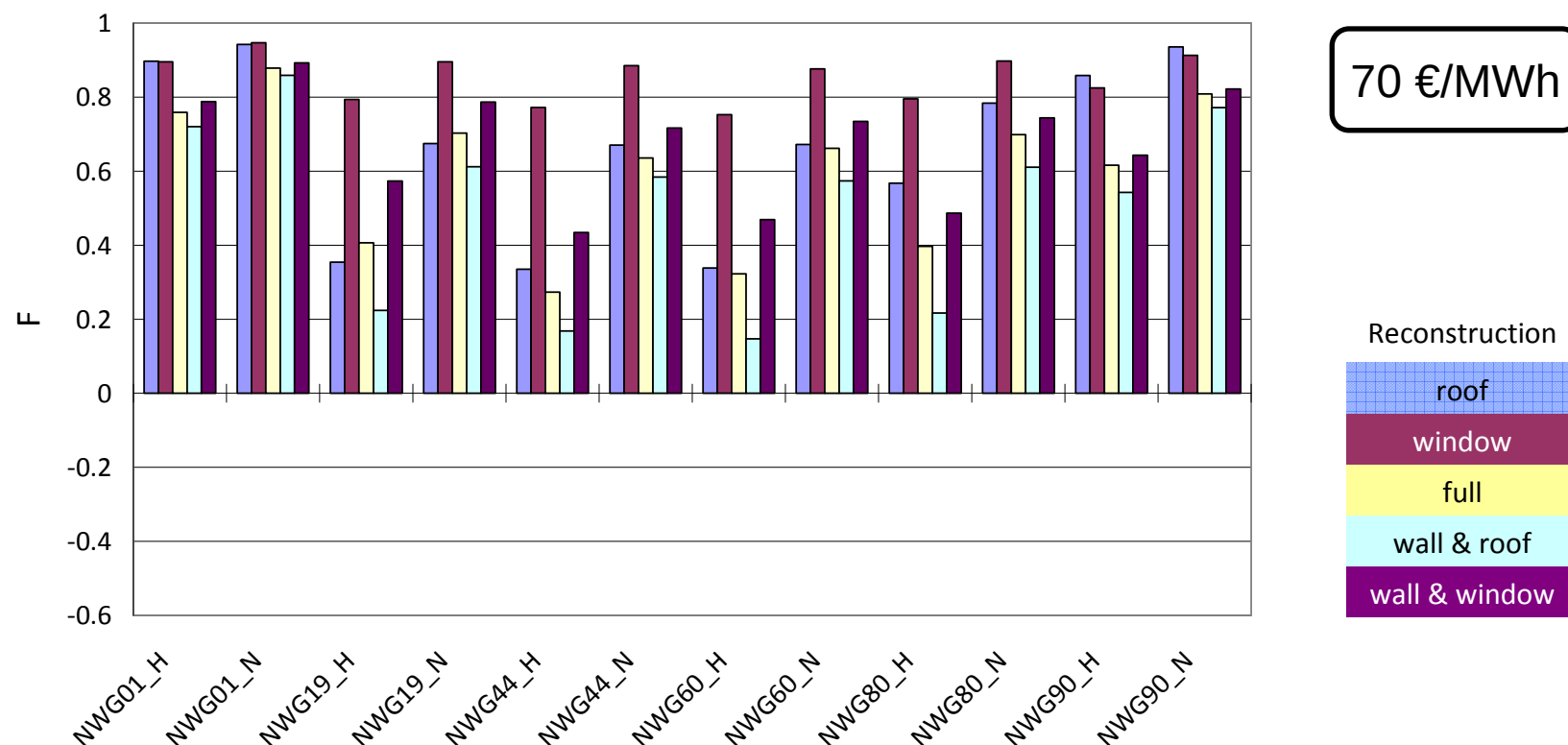
Optimization: Investment $\leftrightarrow$ consumption



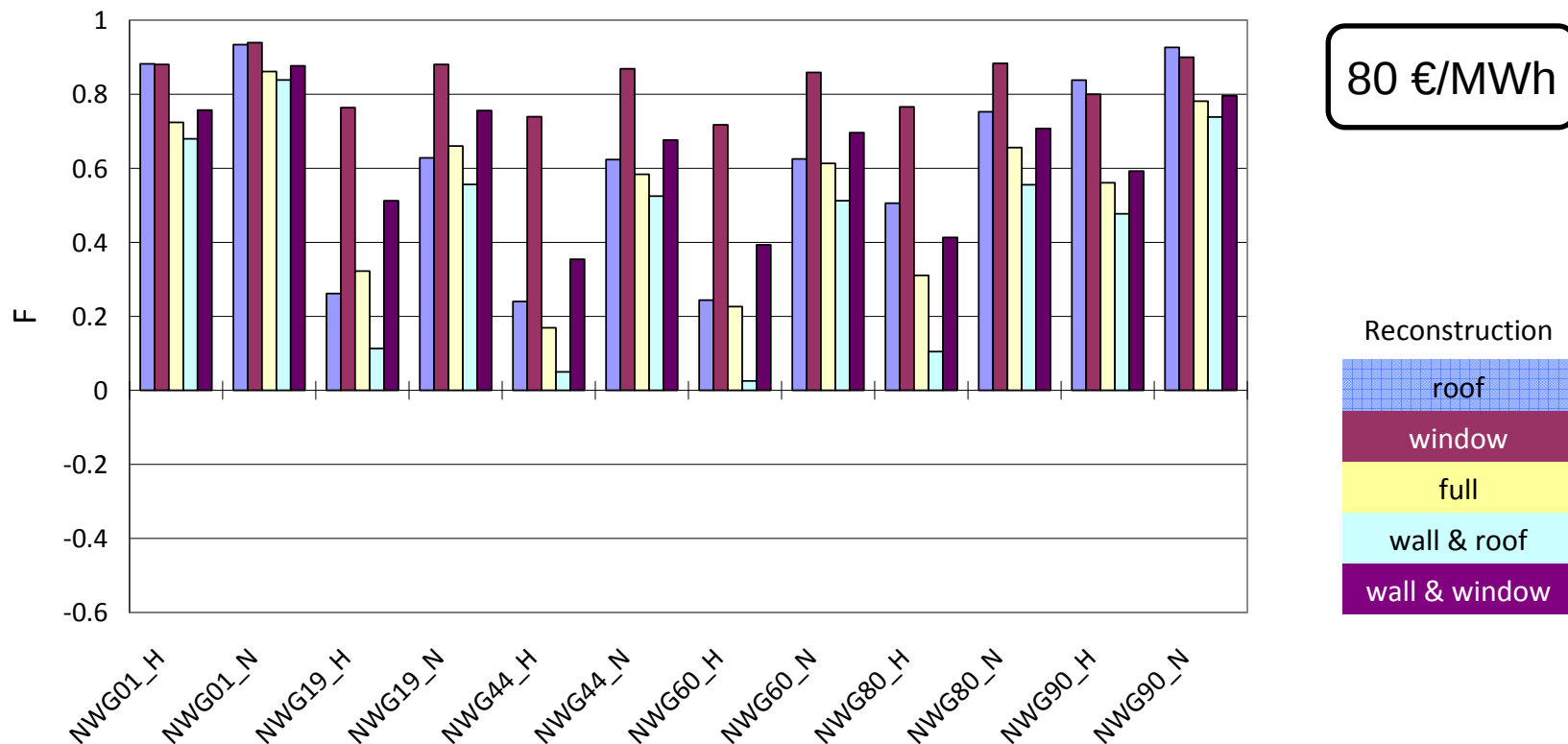
Optimization: Investment $\leftrightarrow$ consumption



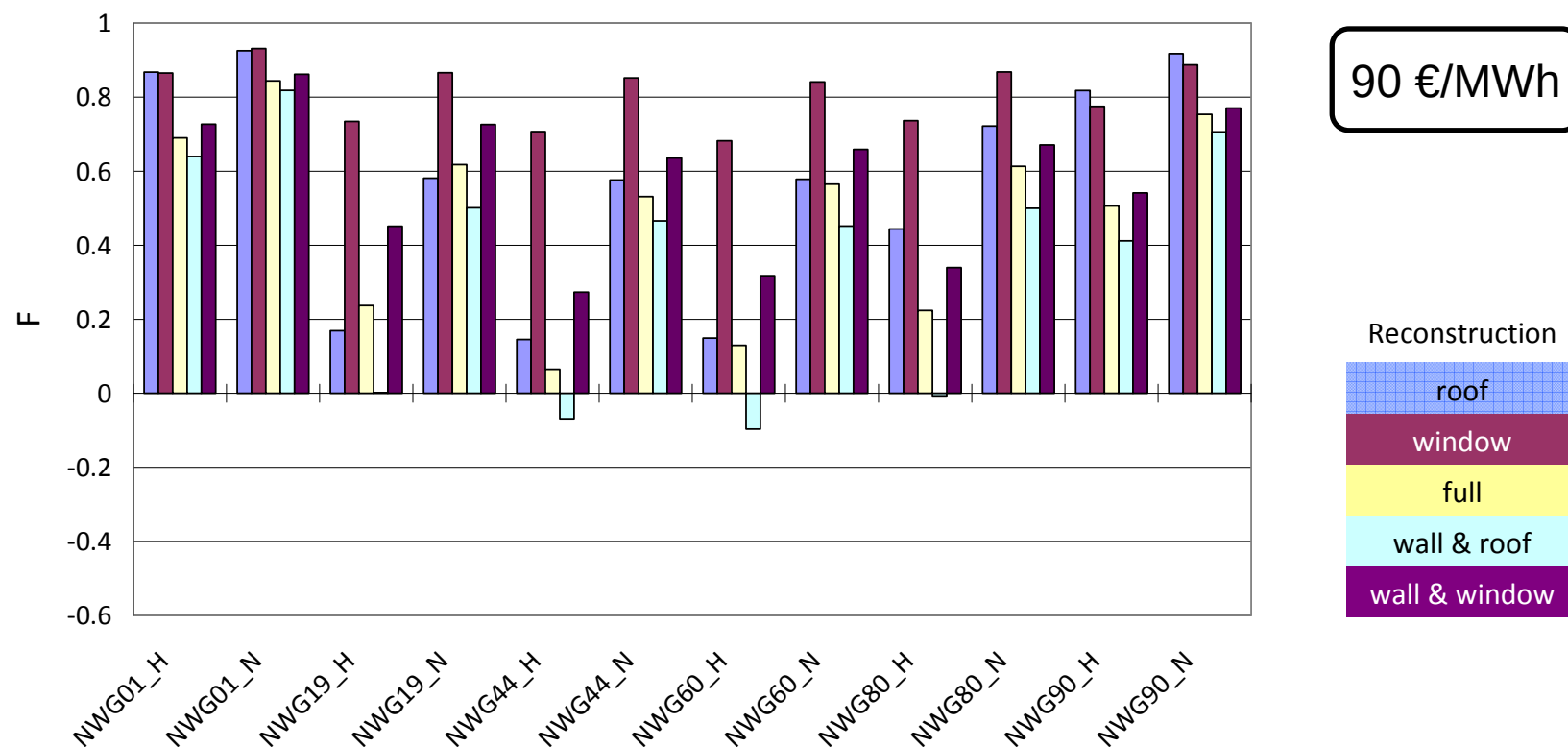
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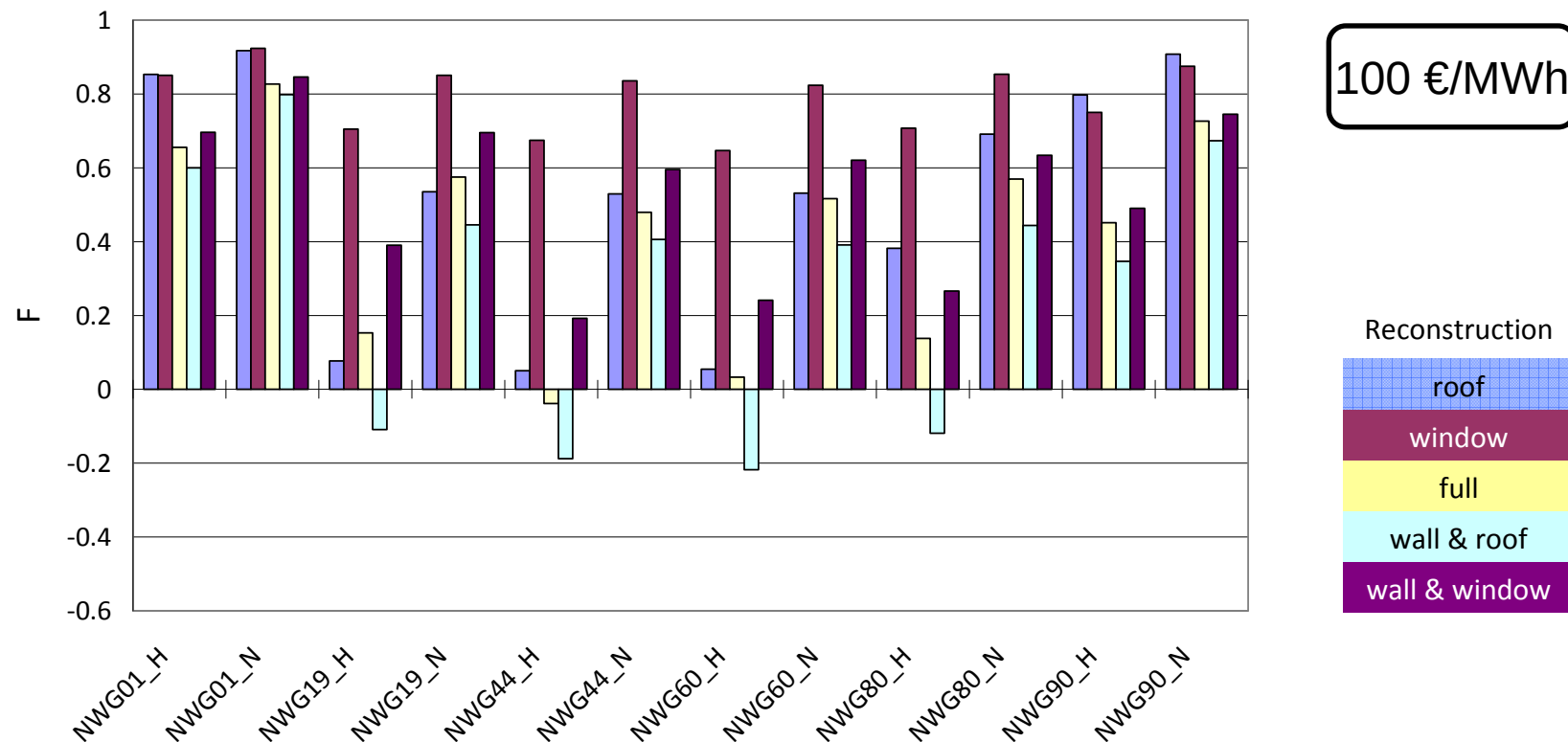
Optimization: Investment $\leftrightarrow$ consumption



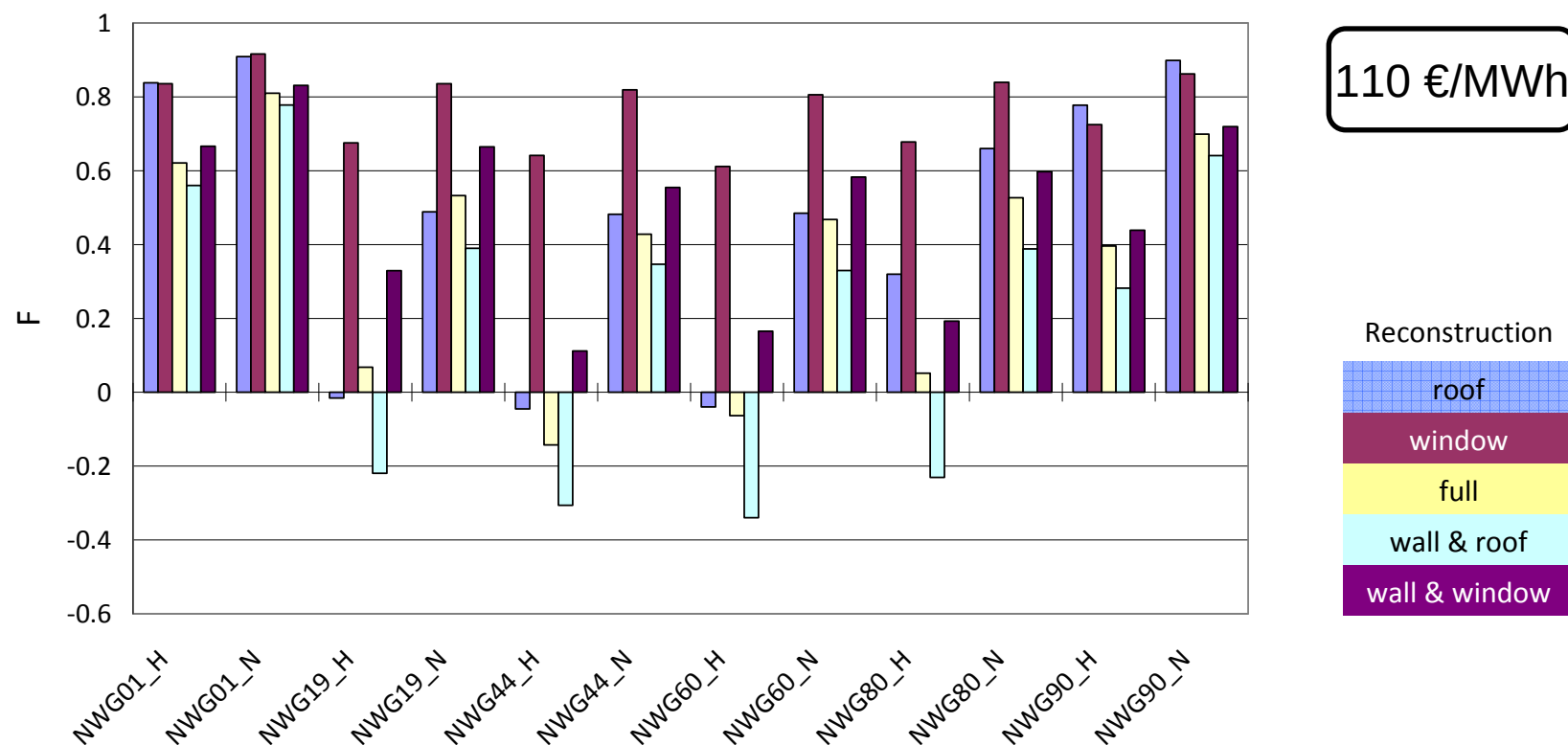
Optimization: Investment $\leftrightarrow$ consumption



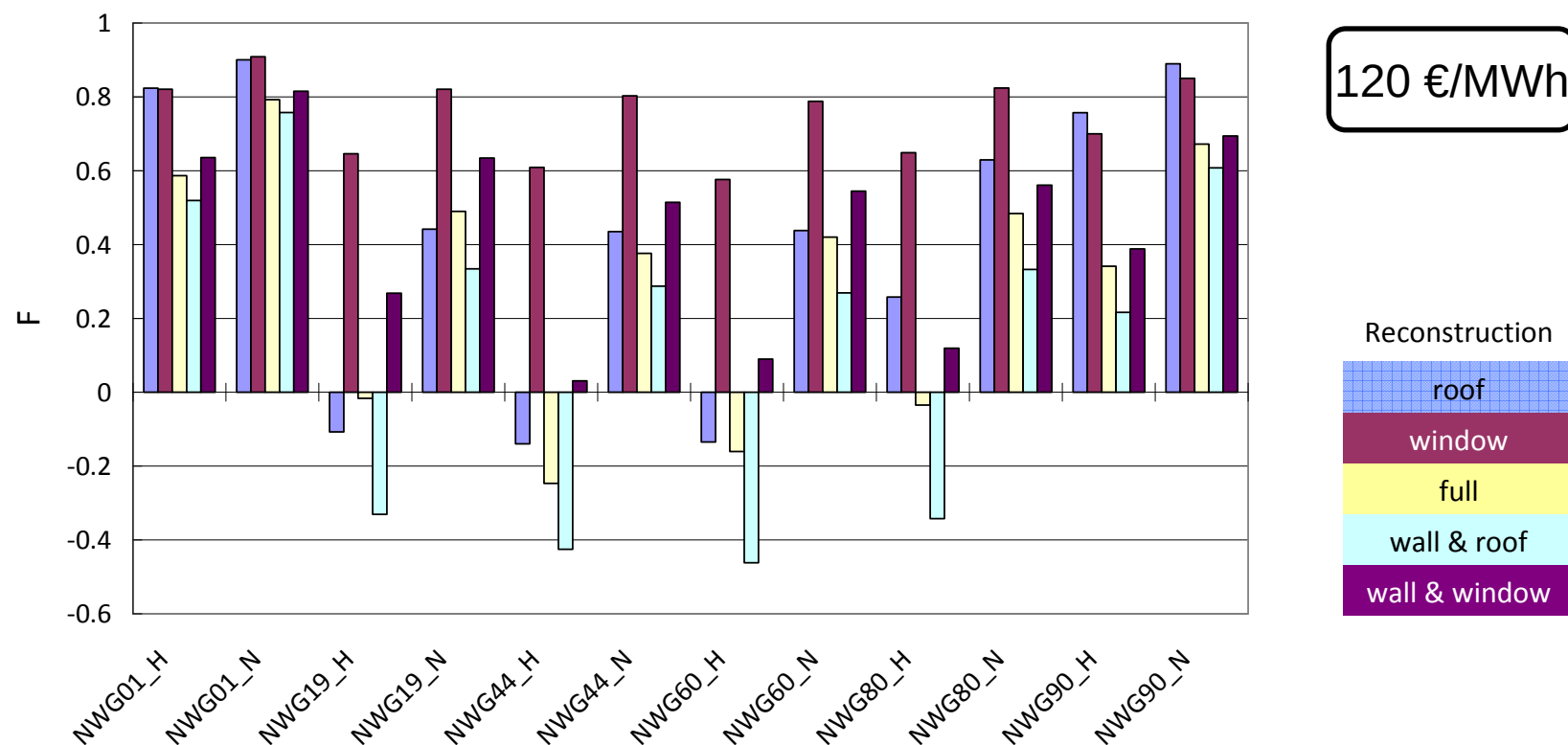
Optimization: Investment $\leftrightarrow$ consumption



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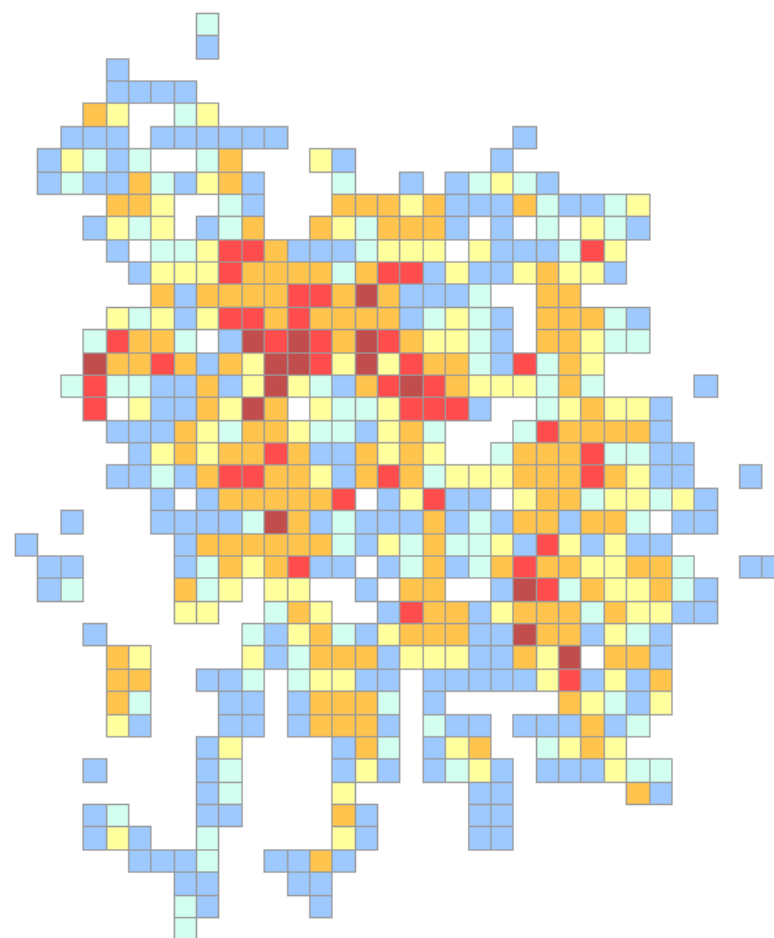


Optimization: Investment $\leftrightarrow$ consumption



Results: Heat demand

2005



MWh/a

0 - 375

375 - 625

625 - 1000

1000 - 2000

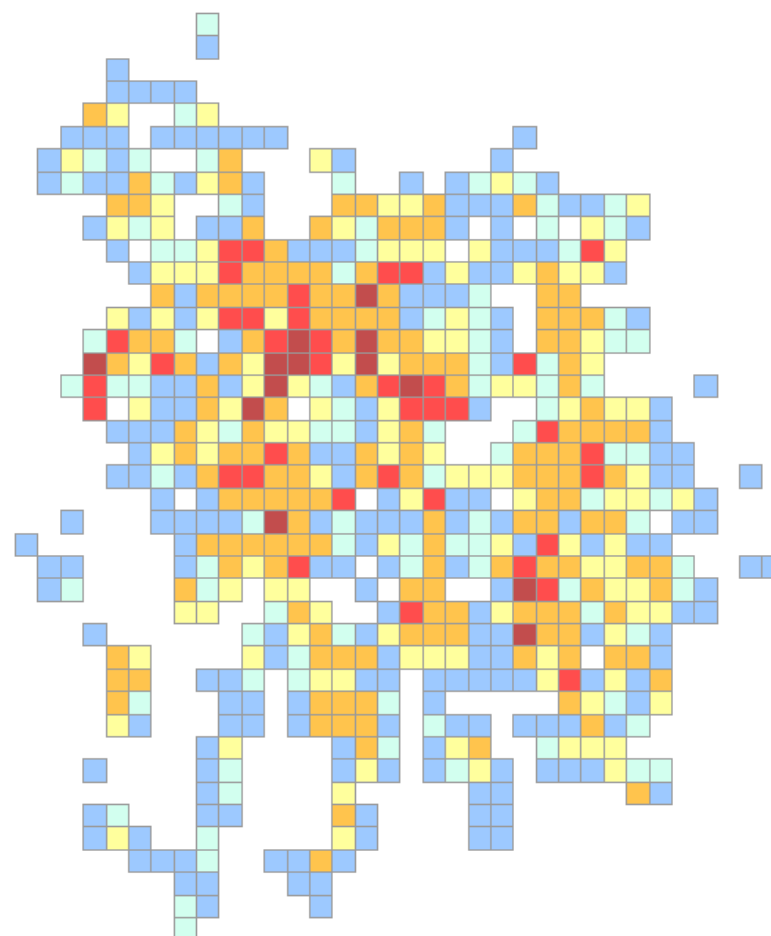
2000 - 3000

3000 - 5000



Results: Heat demand

2010



MWh/a

0 - 375

375 - 625

625 - 1000

1000 - 2000

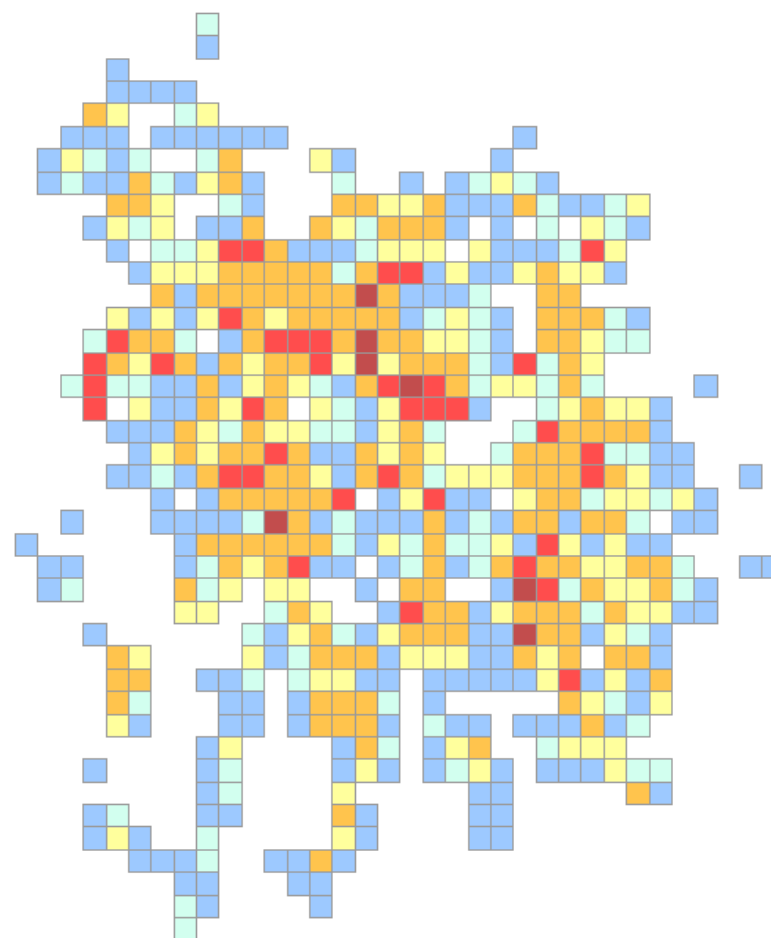
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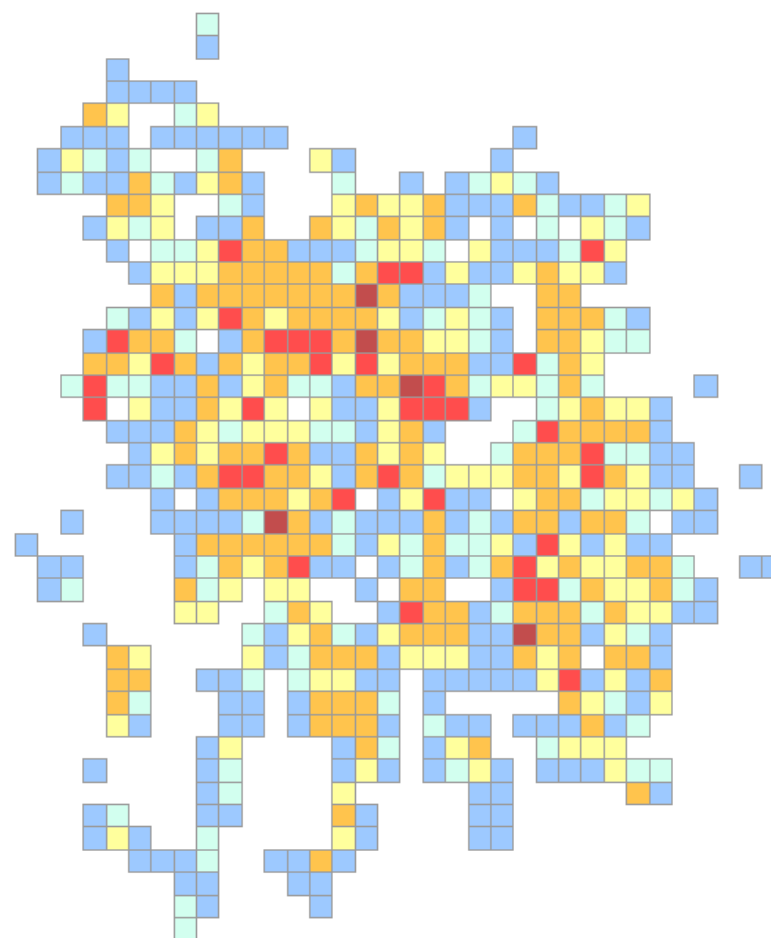
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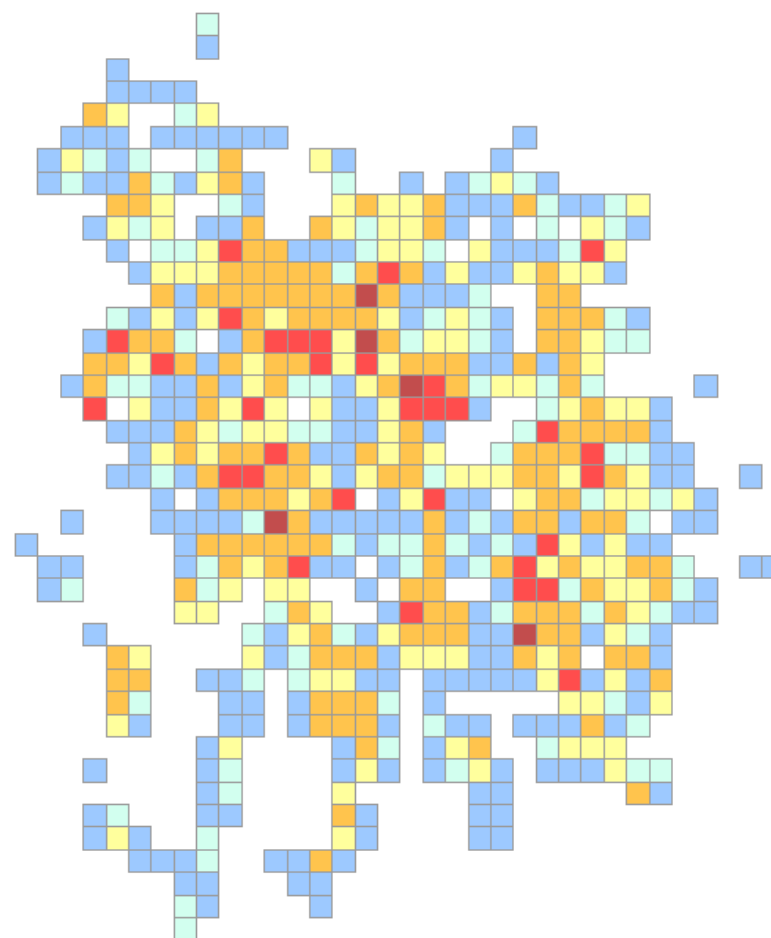
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Results: Heat demand

2025



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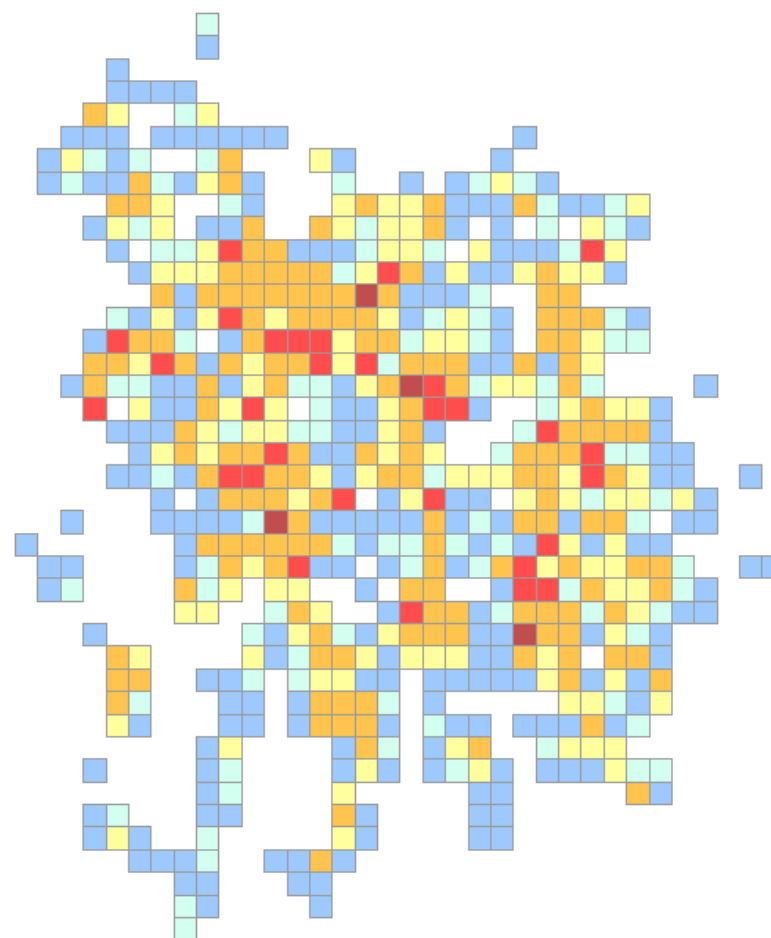
2000 - 3000

3000 - 5000



Results: Heat demand

2030



MWh/a

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375 - 625

625 - 1000

1000 - 2000

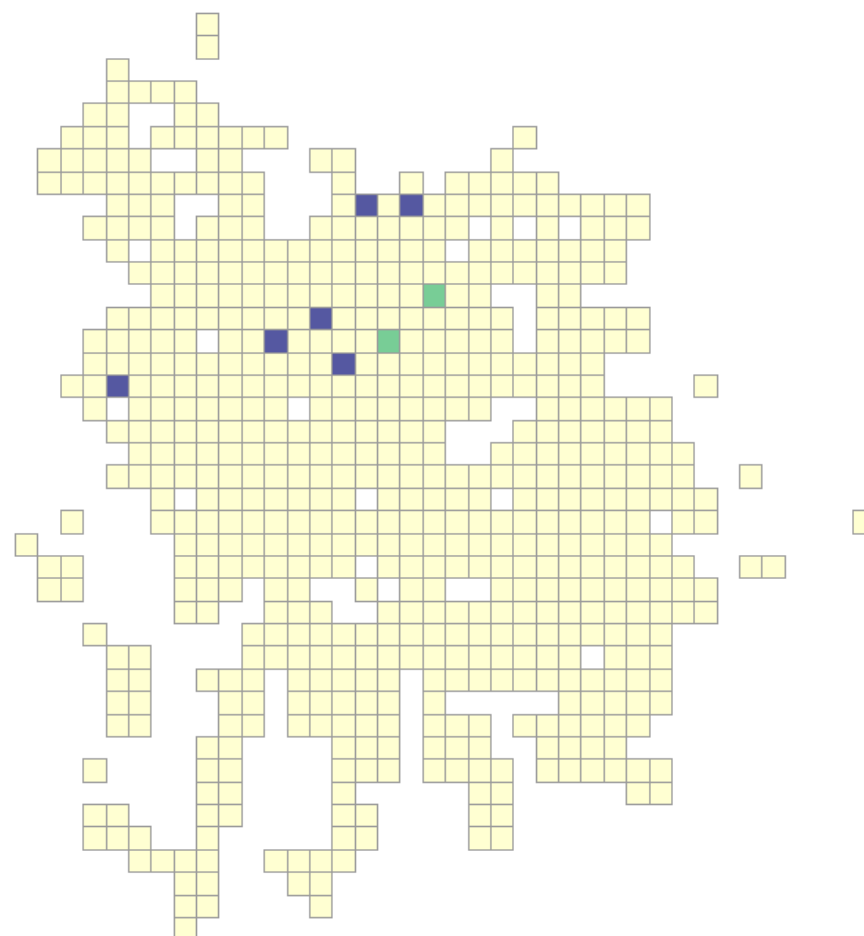
2000 - 3000

3000 - 5000



Results: Reconstruction state

2005



%

0 – 30

30 – 50

50 – 80

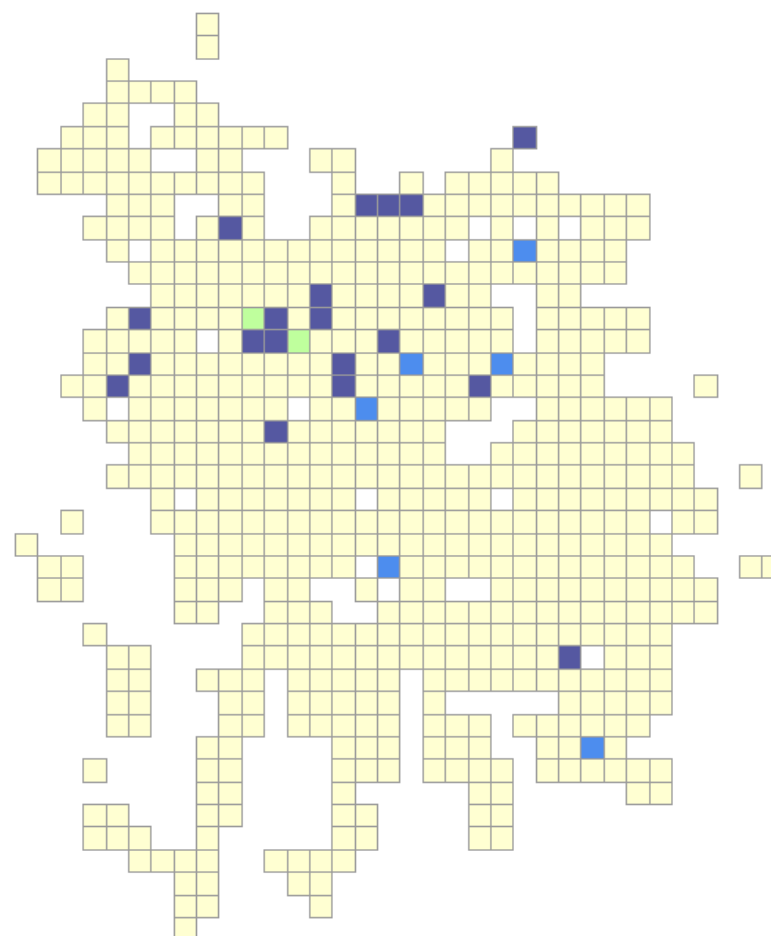
80 – 90

90 – 100



Results: Reconstruction state

2010



%

0 – 30

30 – 50

50 – 80

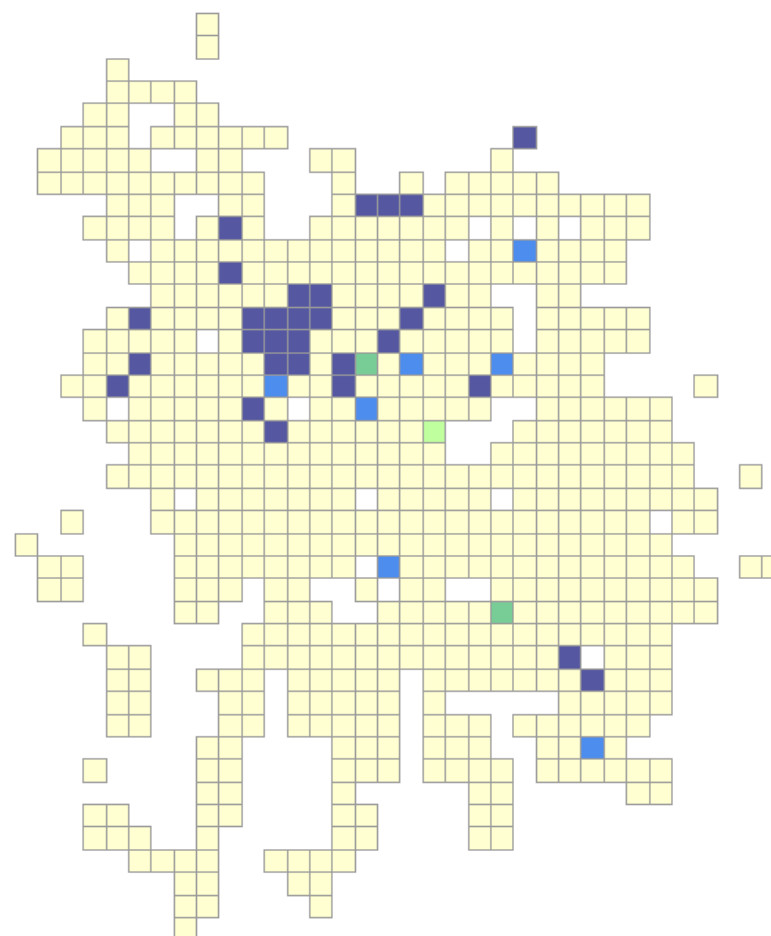
80 – 90

90 – 100



Results: Reconstruction state

2015



%

0 – 30

30 – 50

50 – 80

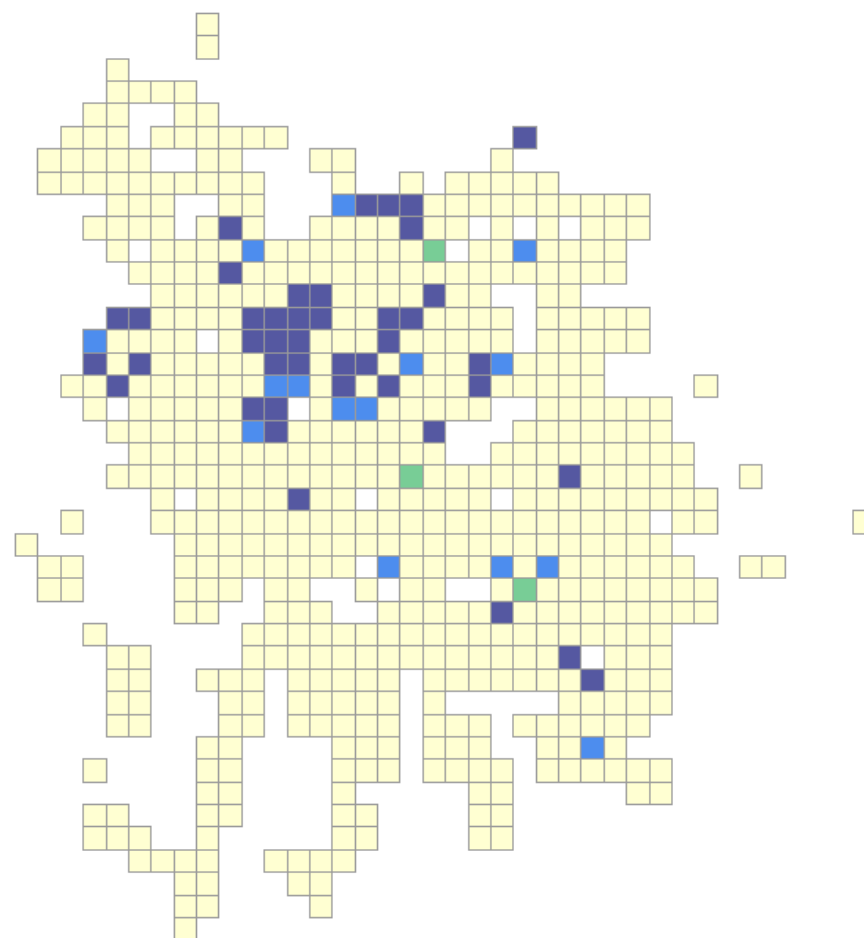
80 – 90

90 – 100



Results: Reconstruction state

2020



%

0 – 30

30 – 50

50 – 80

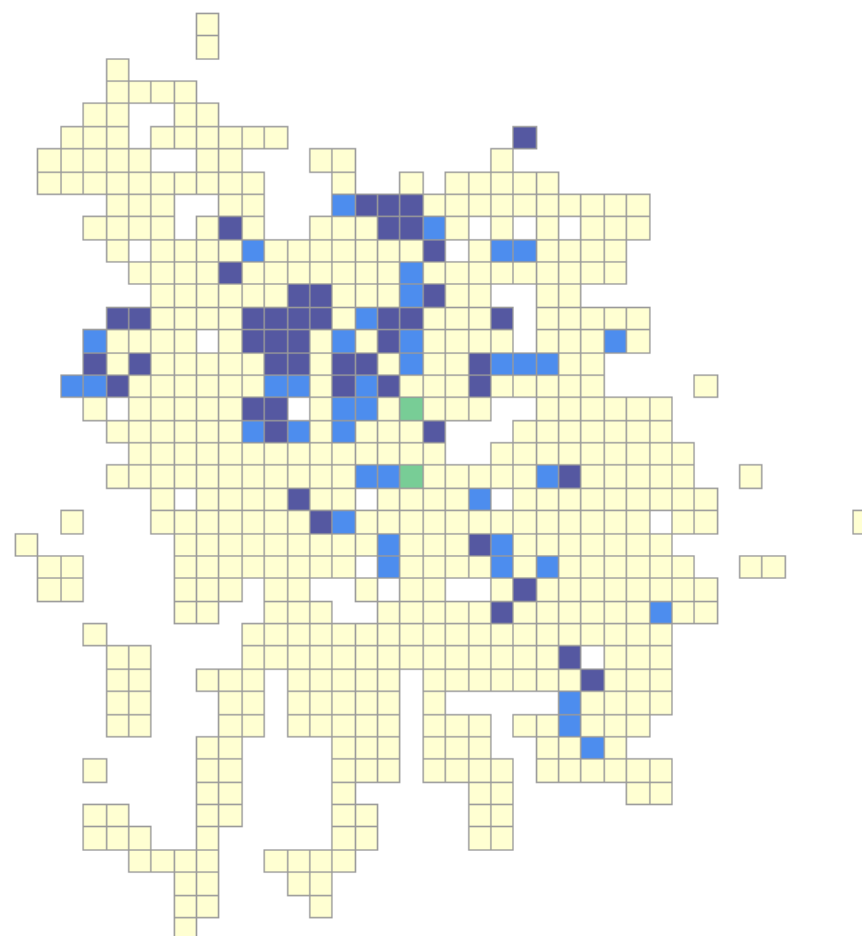
80 – 90

90 – 100



Results: Reconstruction state

2025



%

0 – 30

30 – 50

50 – 80

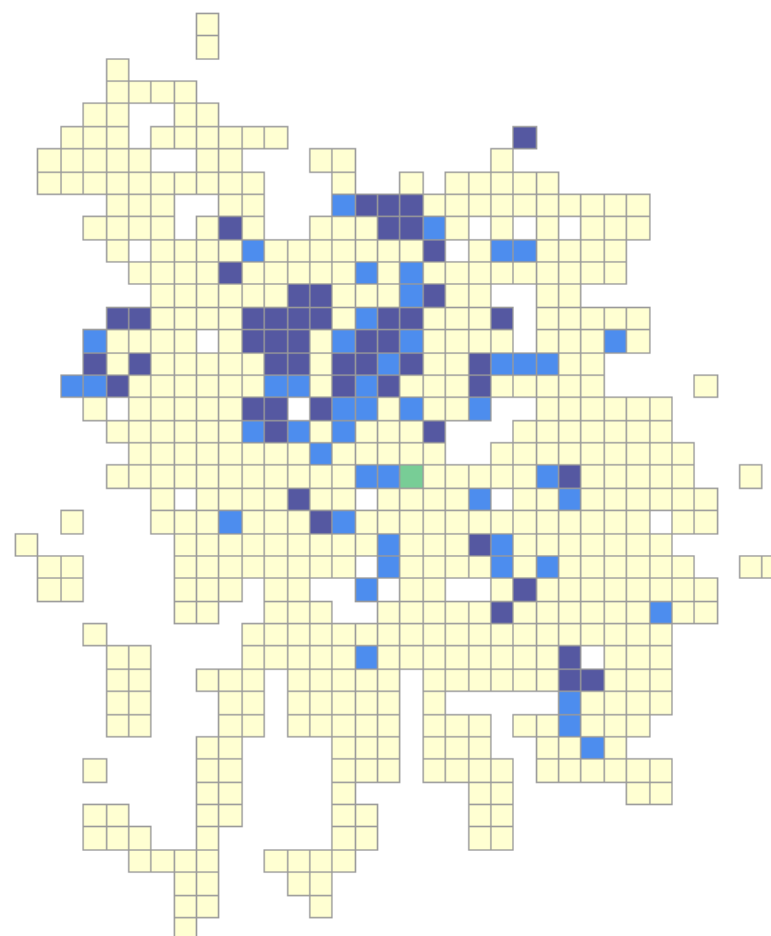
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90 – 100



Results: Reconstruction state

2030



%

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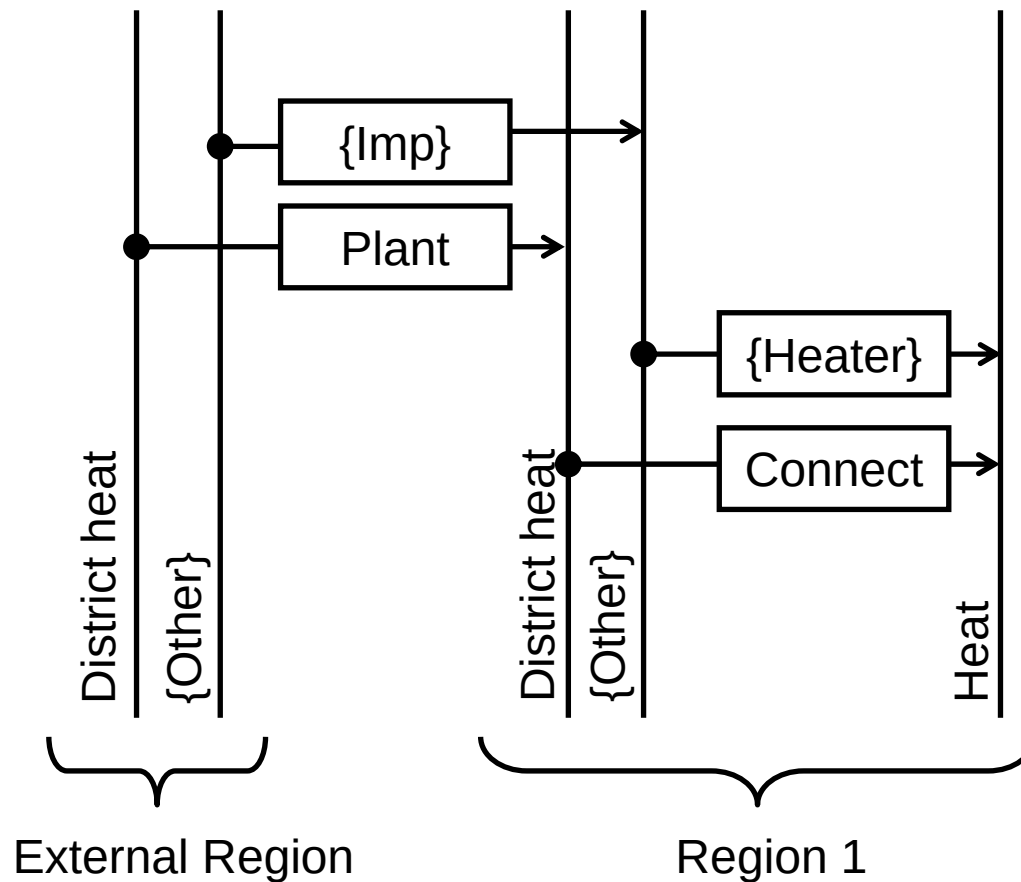
50 – 80

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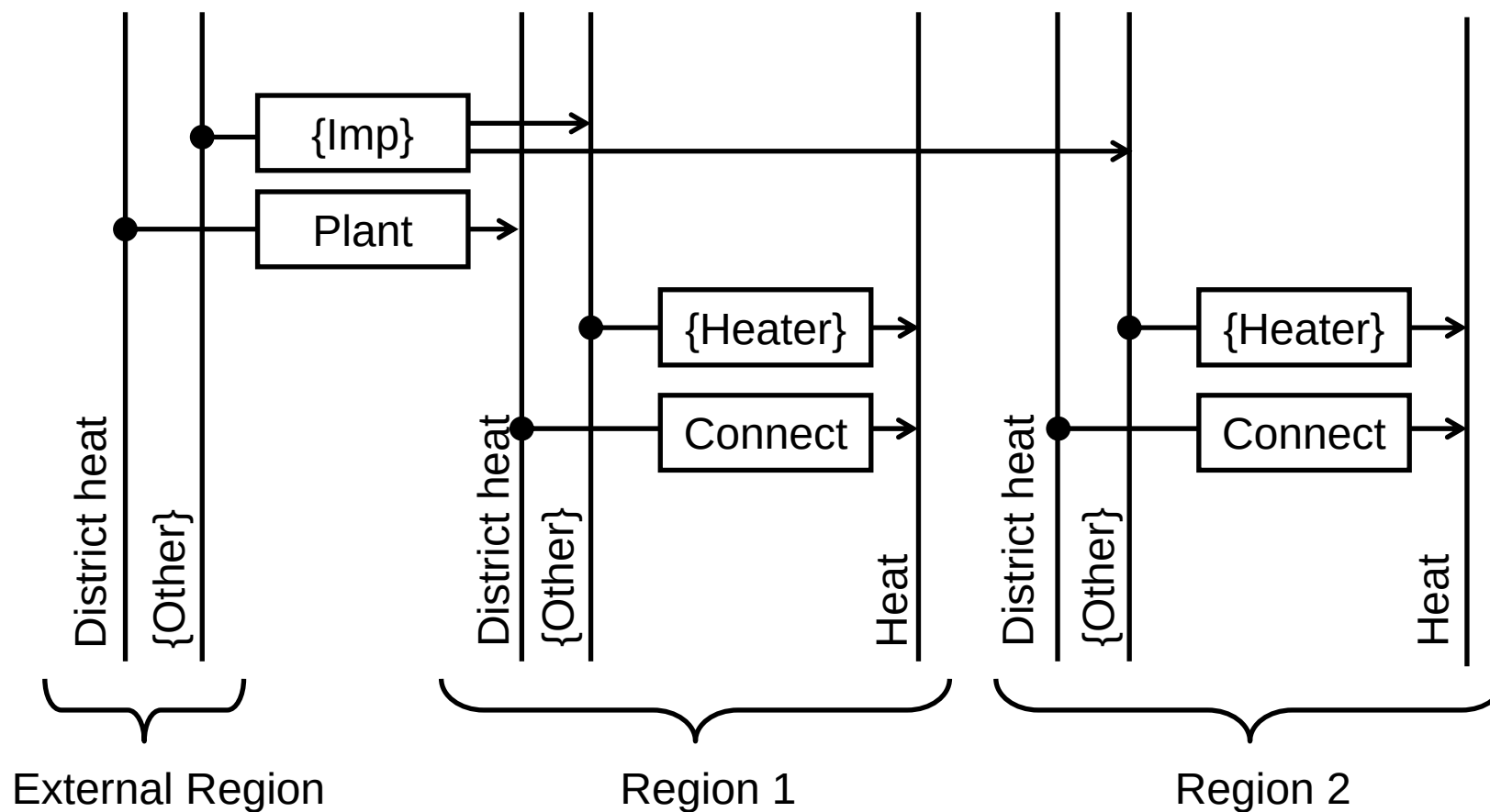
90 – 100



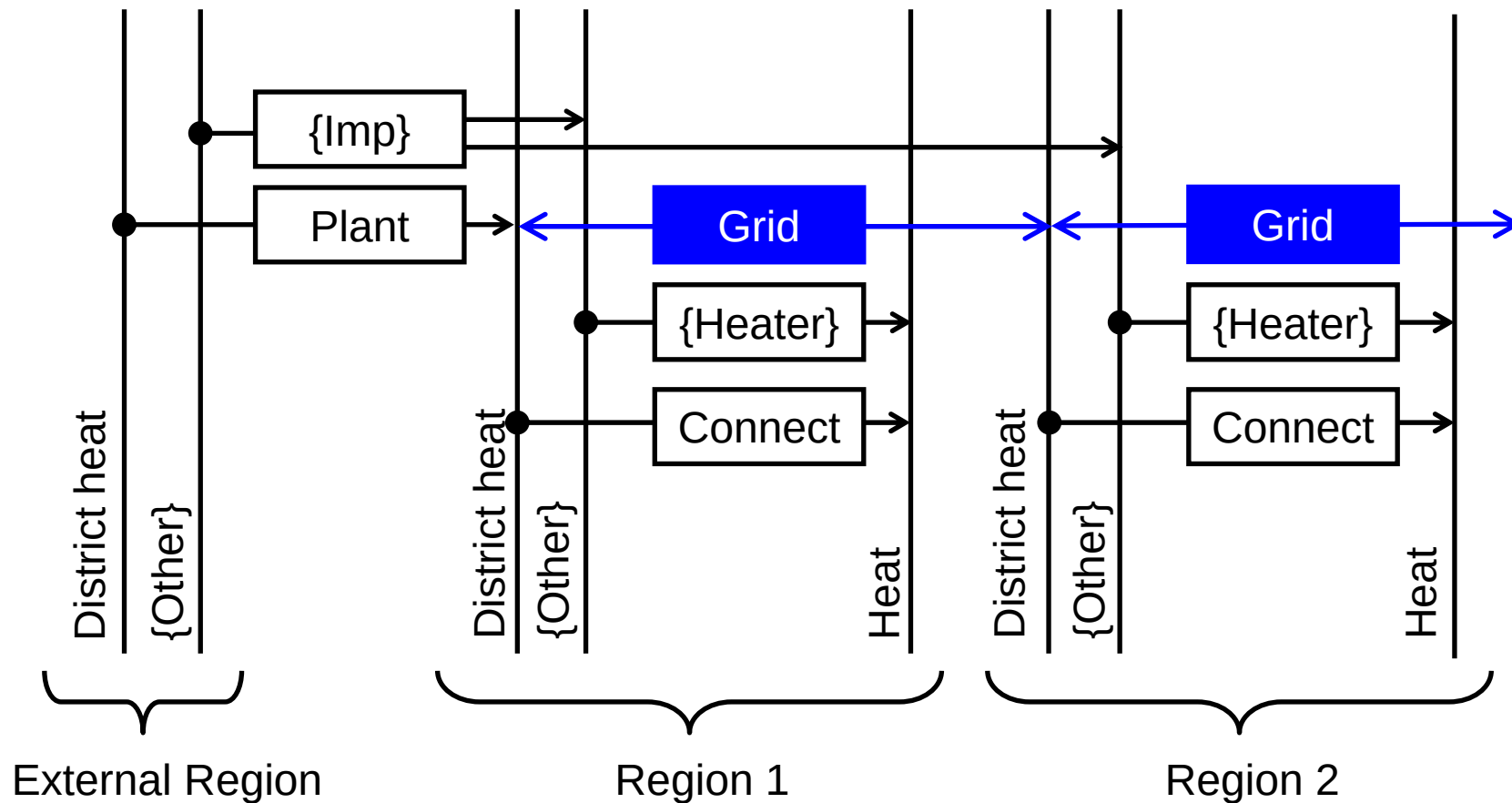
RES – Grid module



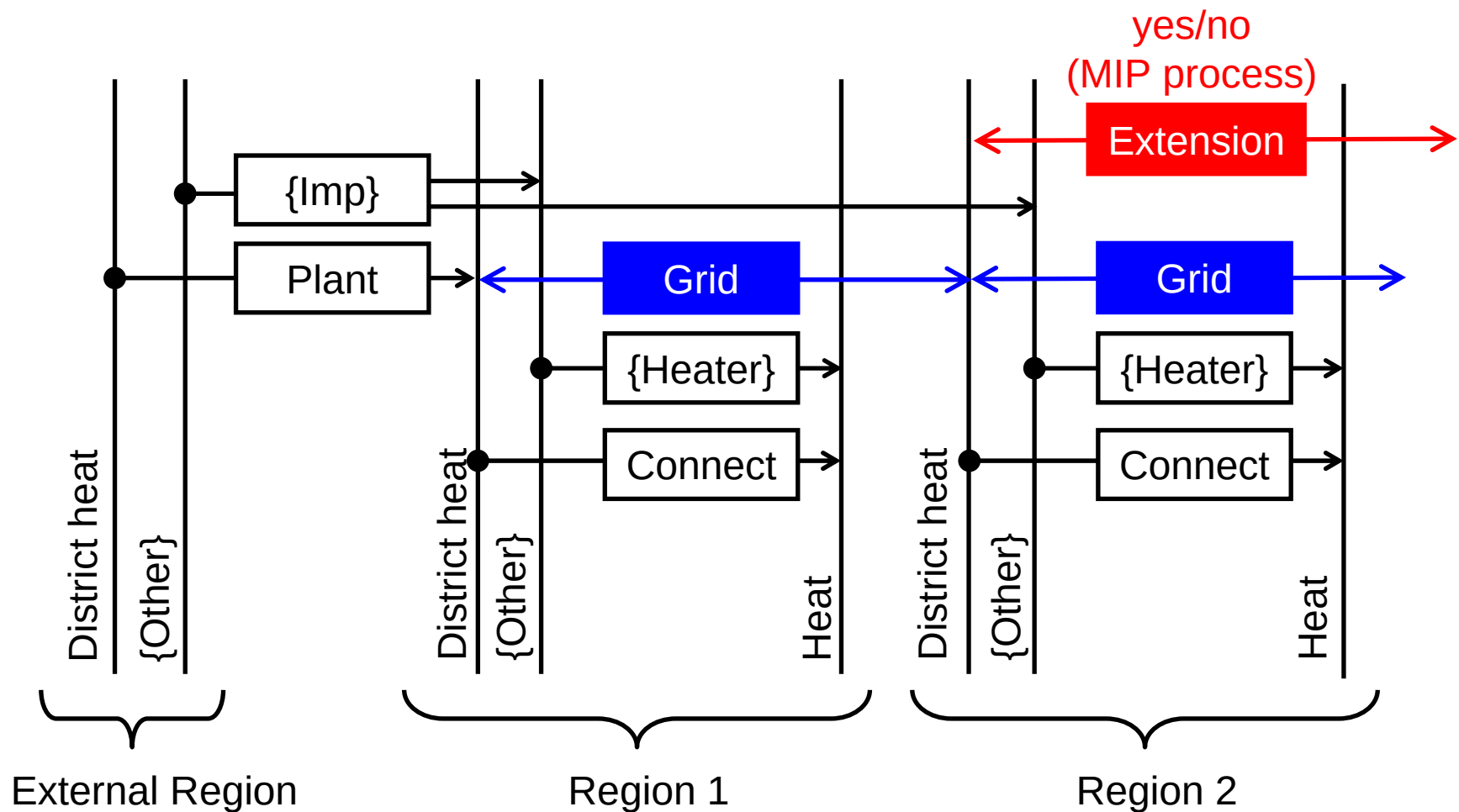
RES – Grid module



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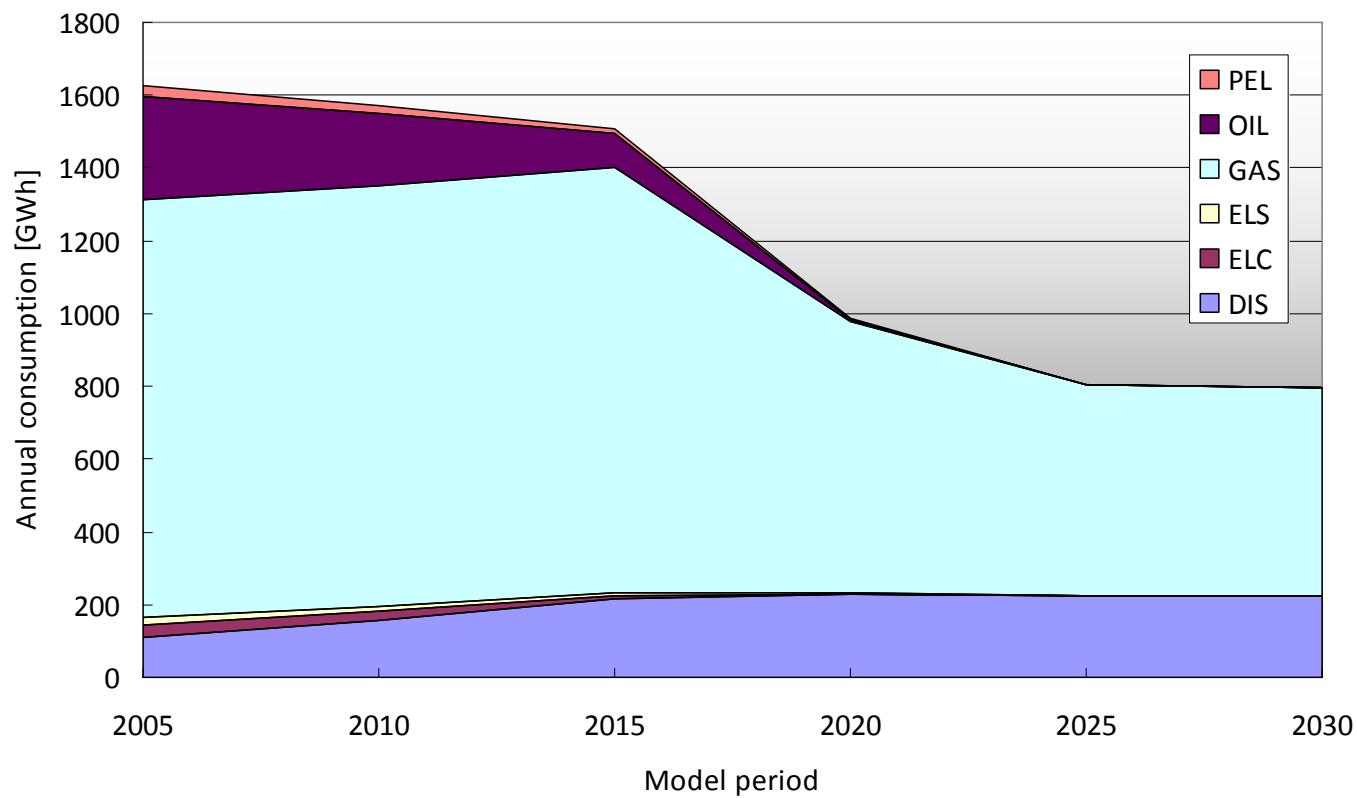
RES – Grid module



- Base year data
 - Fuel consumption
 - Existing grid structure
- Projection
 - Heat demand: Demand module
 - Energy prices
- Technical data
 - Heating systems
 - Potential for grid connection: GIS based model
 - Cost structure: Lifecycle assessment
- Grid extension projects

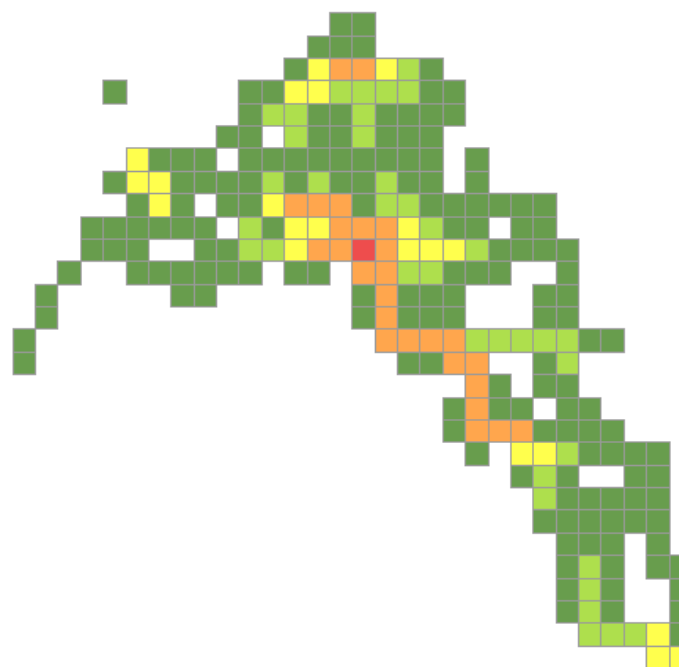


Results: Energy consumption



Results: Heat flow

2005



GWh/a

0 – 2

2 – 5

5 – 10

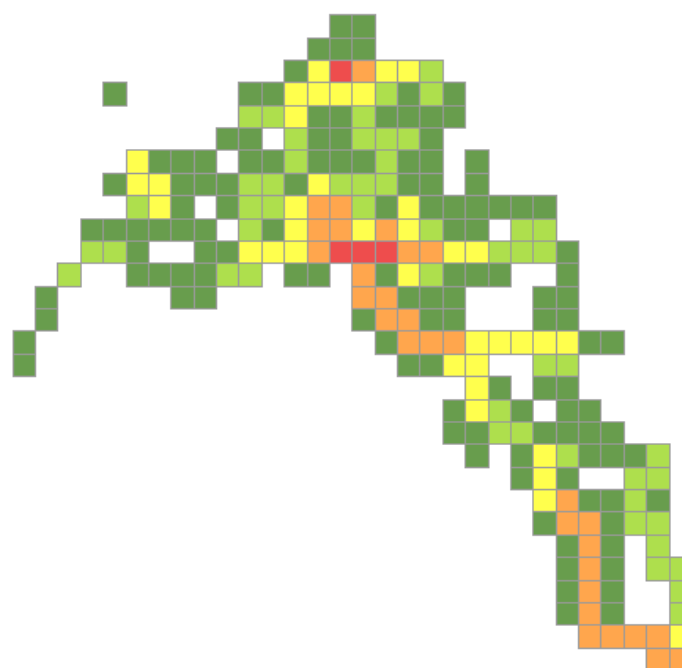
10 – 25

25 – 100



Results: Heat flow

2010



GWh/a

0 – 2

2 – 5

5 – 10

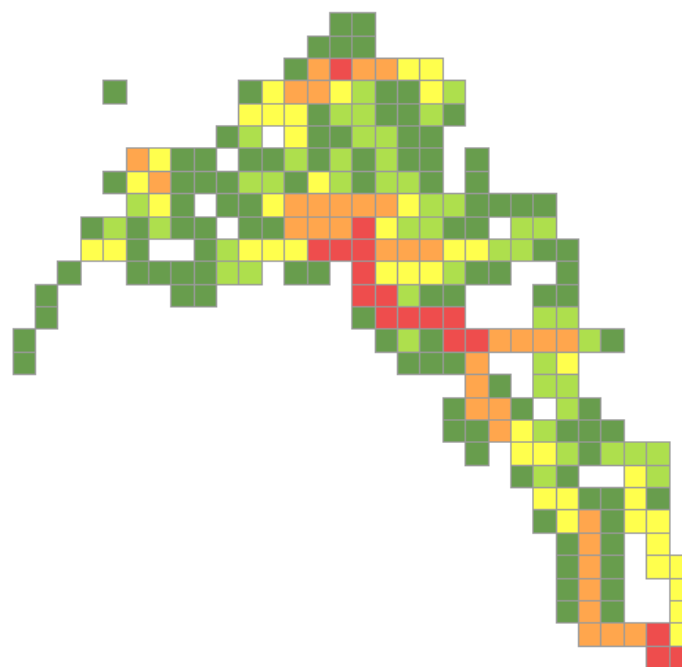
10 – 25

25 – 100



Results: Heat flow

2015



GWh/a

0 – 2

2 – 5

5 – 10

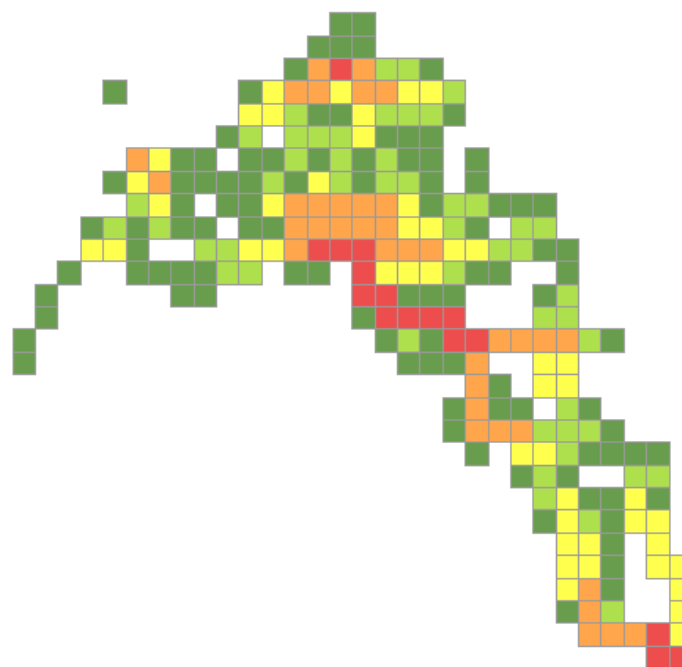
10 – 25

25 – 100



Results: Heat flow

2020



GWh/a

0 – 2

2 – 5

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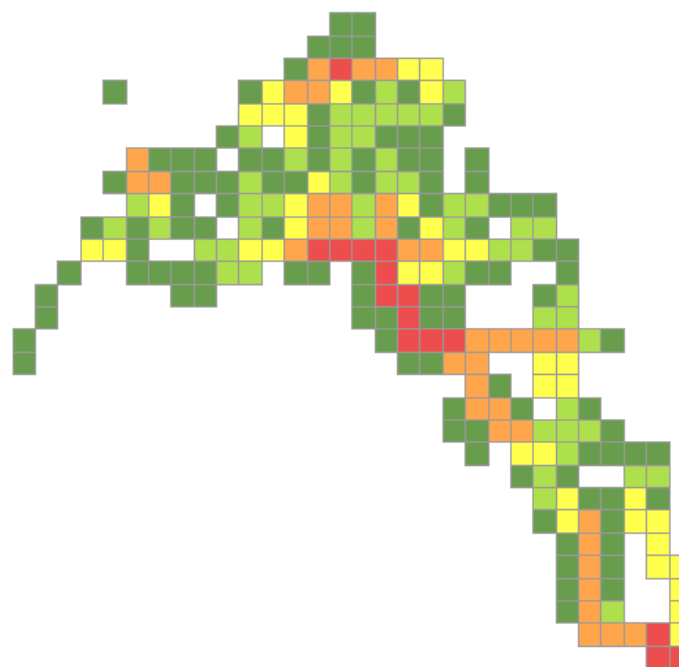
10 – 25

25 – 100



Results: Heat flow

2025



GWh/a

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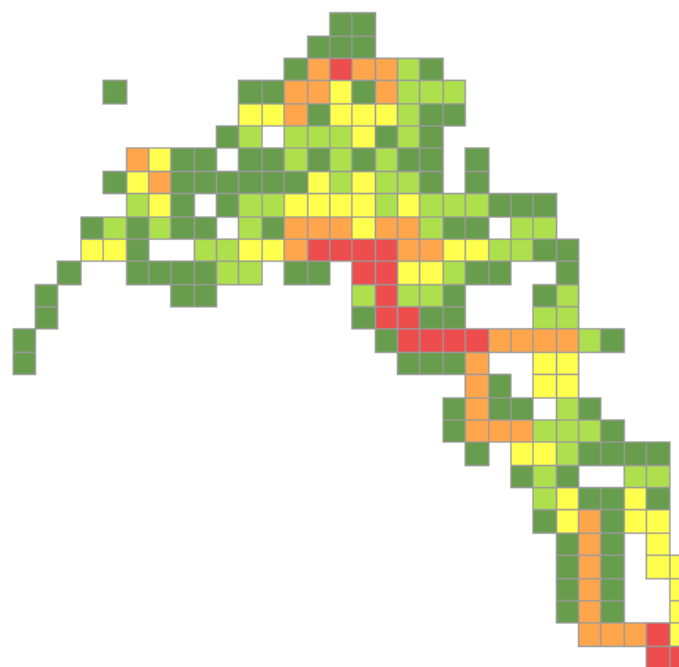
10 – 25

25 – 100



Results: Heat flow

2030



GWh/a

0 – 2

2 – 5

5 – 10

10 – 25

25 – 100



- Summary

- Spatially resolved heat demand projection
- Allocation of optimal reconstruction sites
- Grid activities
- Allocation of grid extension sites

- Outlook

- Coupling to lifecycle assessment
- Emissions
- Electricity sector
- Gas distribution grid



- A unique tool has been developed to ...
 - analyze in detail and with high spatial resolution the heat demand, supply and distribution system of any city
 - provide a well-founded basis for decisions on future energetic urban planning activities
- To be done: Make this tool available to as many cities as possible!

Thank you!



Thank you!



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für Plasmaphysik

