BioBoost

Modelling, Simulation and Optimization of a European-Wide Logistics Network

Erik Pitzer and Gabriel Kronberger

FH OÖ (University of Applied Sciences, Upper Austria)

Geleen, 5. June 2015

UNIVERSITY OF APPLIED SCIENCES UPPER AUSTRIA

HEAL
Heuristic and Evolutionary Algorithms Laboratory

This project has received funding from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No 282873

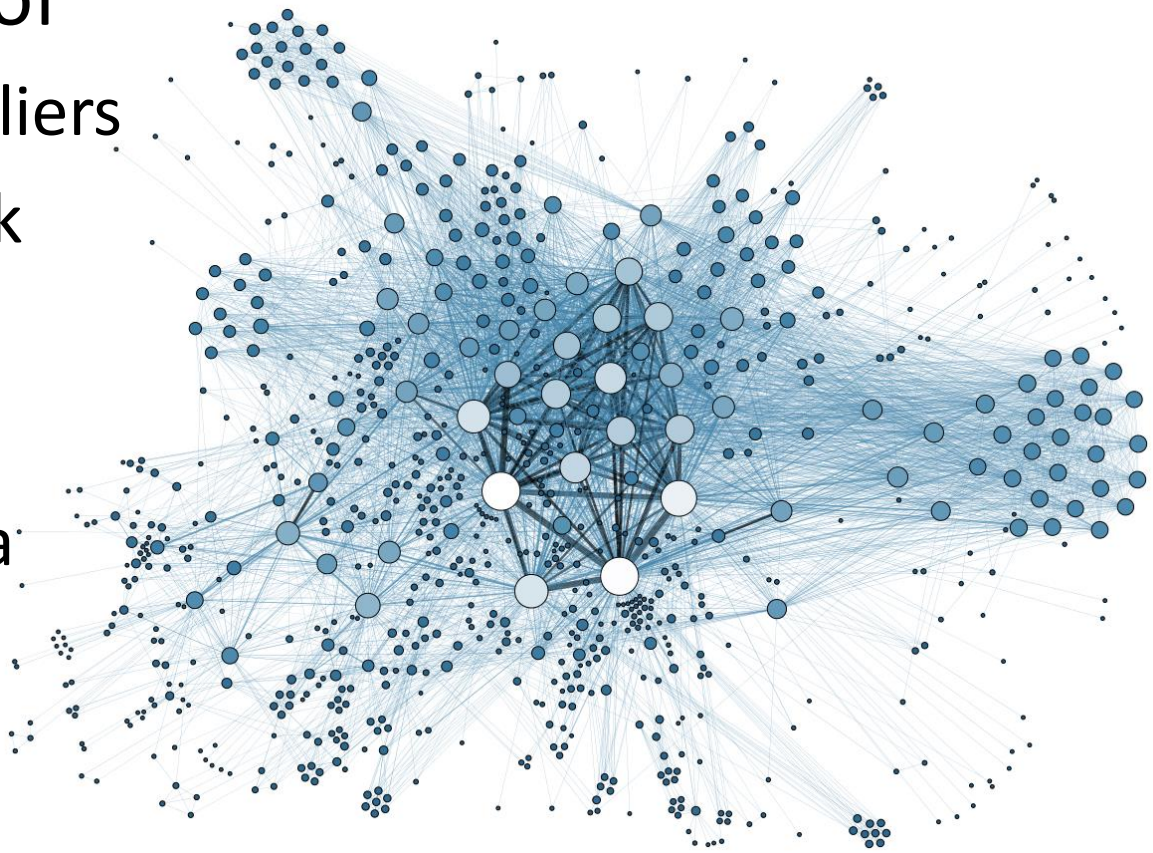
Motivation

- Is decentral biofuel production economic?
  - limited economies of scale

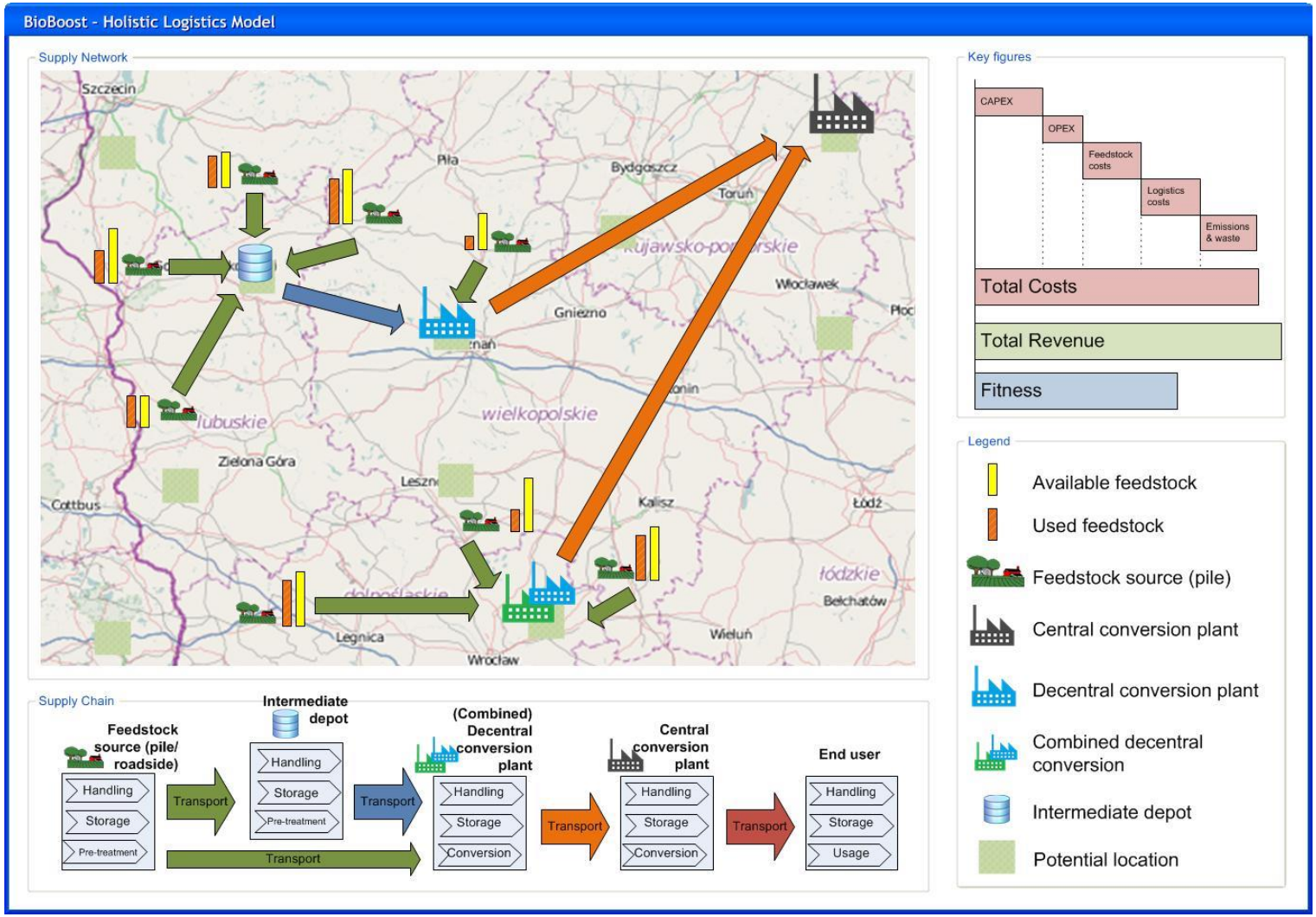
- possible advantages
  - regional added value
  - mitigate transport volume
  - mitigate
    low energy density

Vision

- optimal choice of
  - feedstock suppliers
  - logistic network
  - plant location
  - plant size
  - catchment area
- many factors to consider



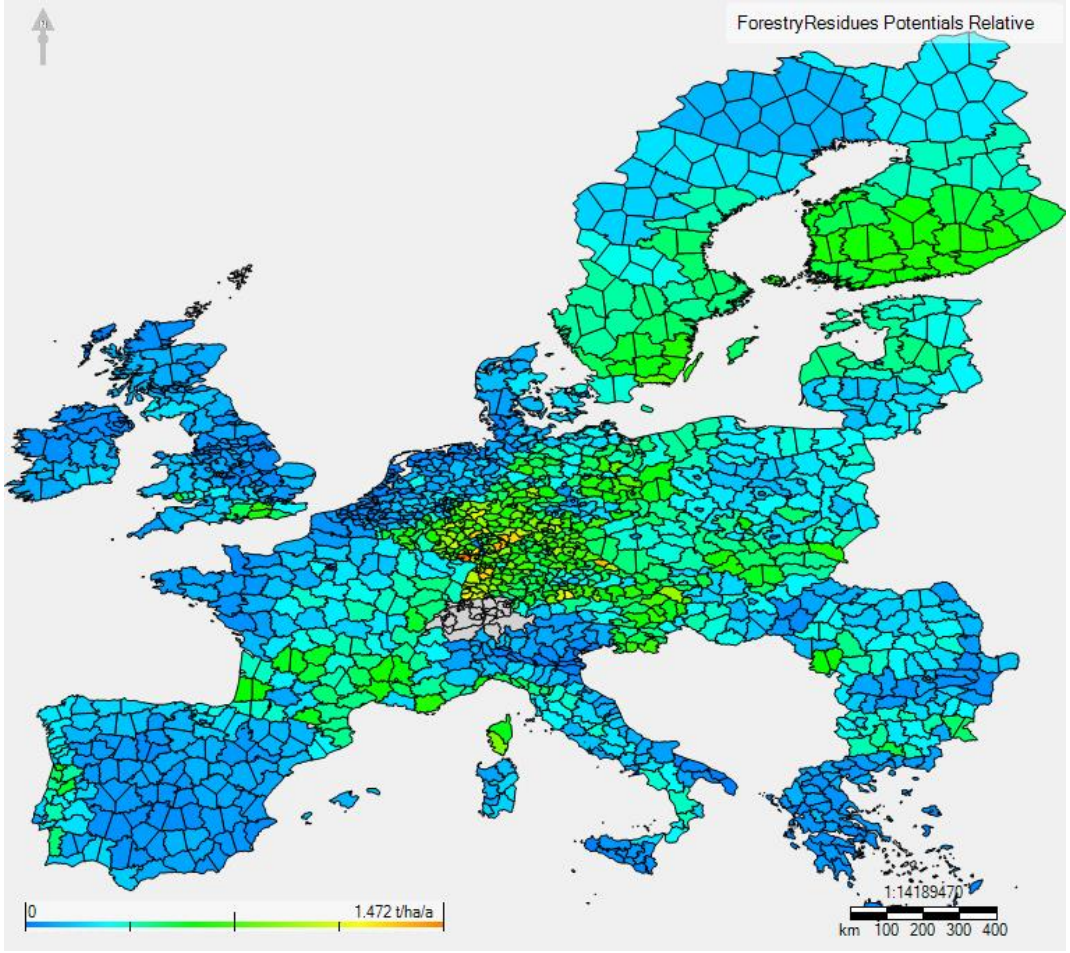
Vision


BioBoost - Holistic Logistics Model
Supply Network
Szczecin
Piła
Bydgoszcz
Toruń
Włocławek
Gniezno
lubuskie
wielkopolskie
Zielona Góra
Cottbus
Kalisz
Łódź
łódzkie
Bełchatów
Legnica
Wrocław
Wieluń
Supply Chain
Feedstock source (pile/ roadside)
Handling
Storage
Pre-treatment
Transport
Intermediate depot
Handling
Storage
Pre-treatment
Transport
(Combined) Decentral conversion plant
Handling
Storage
Conversion
Transport
Central conversion plant
Handling
Storage
Conversion
Transport
End user
Handling
Storage
Usage
Key figures
CAPEX
OPEX
Feedstock costs
Logistics costs
Emissions & waste
Total Costs
Total Revenue
Fitness
Legend
Available feedstock
Used feedstock
Feedstock source (pile)
Central conversion plant
Decentral conversion plant
Combined decentral conversion
Intermediate depot
Potential location

Required Data

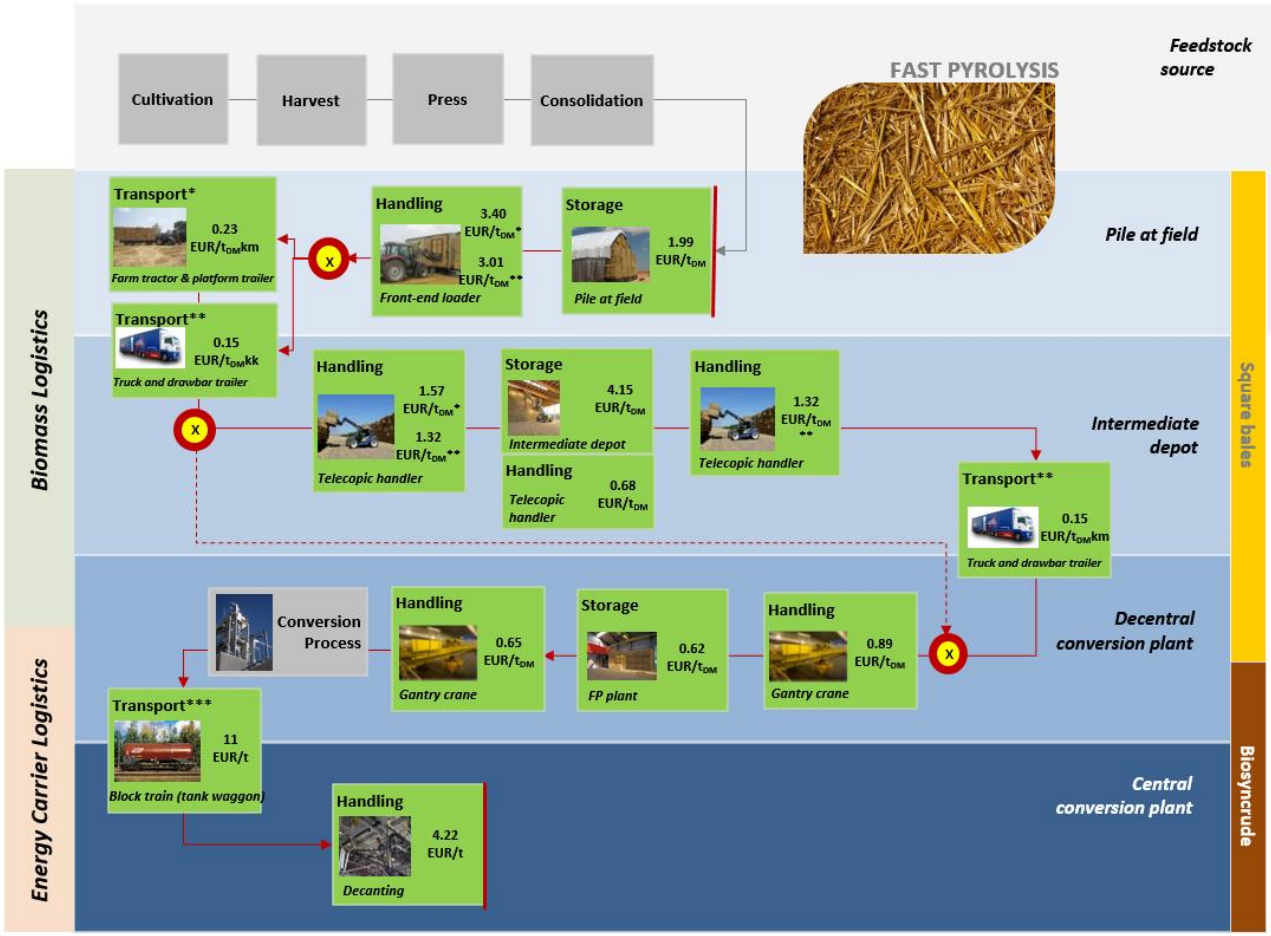
- feedstock potentials (technical)
- market price (and development)
- transport modes & costs
- routes
- conversion possibilities (and scaling)
- product costs (feedstock, output, wastes)
- regional influences (labor, invest., infrastructure)

Feedstock Potentials



http://iung.neogis.pl/geoportal/

Logistics Concept



Conversion Parameters

```yaml
conversions:
  - label: FastPyrolysis
    feedstock: Straw
    safety-stock: 365 # days
    dry-matter-loss: 0.08 # fraction
    storage:
      investment: 0.15
      labor: 0.35
      other: 2.1
    products: # [t/t]
      Biosyncrude: 0.675676
      CO2-green: 0.324324
      WaterVapor: 0.108108
      CoolingWater: -0.344595
      ElectricityIn: -0.087838
    main-product: Biosyncrude
    cost: 0 # [EUR/t]
    design-capacity: 219123.38028 # t/a
    construction: 11003716.52 # EUR/a
    maintenance: 7278442.59 # EUR/a
    construction-scaling-exponent: 0.7
    maintenance-scaling-exponent: 1 #factor
    utilization-factor: 0.913 # 8000 h/a
    available-maintenance-factor: 1
    max-capacities: { Default: 660000 } # 300%
    min-capacity: 125853 # 57%
```

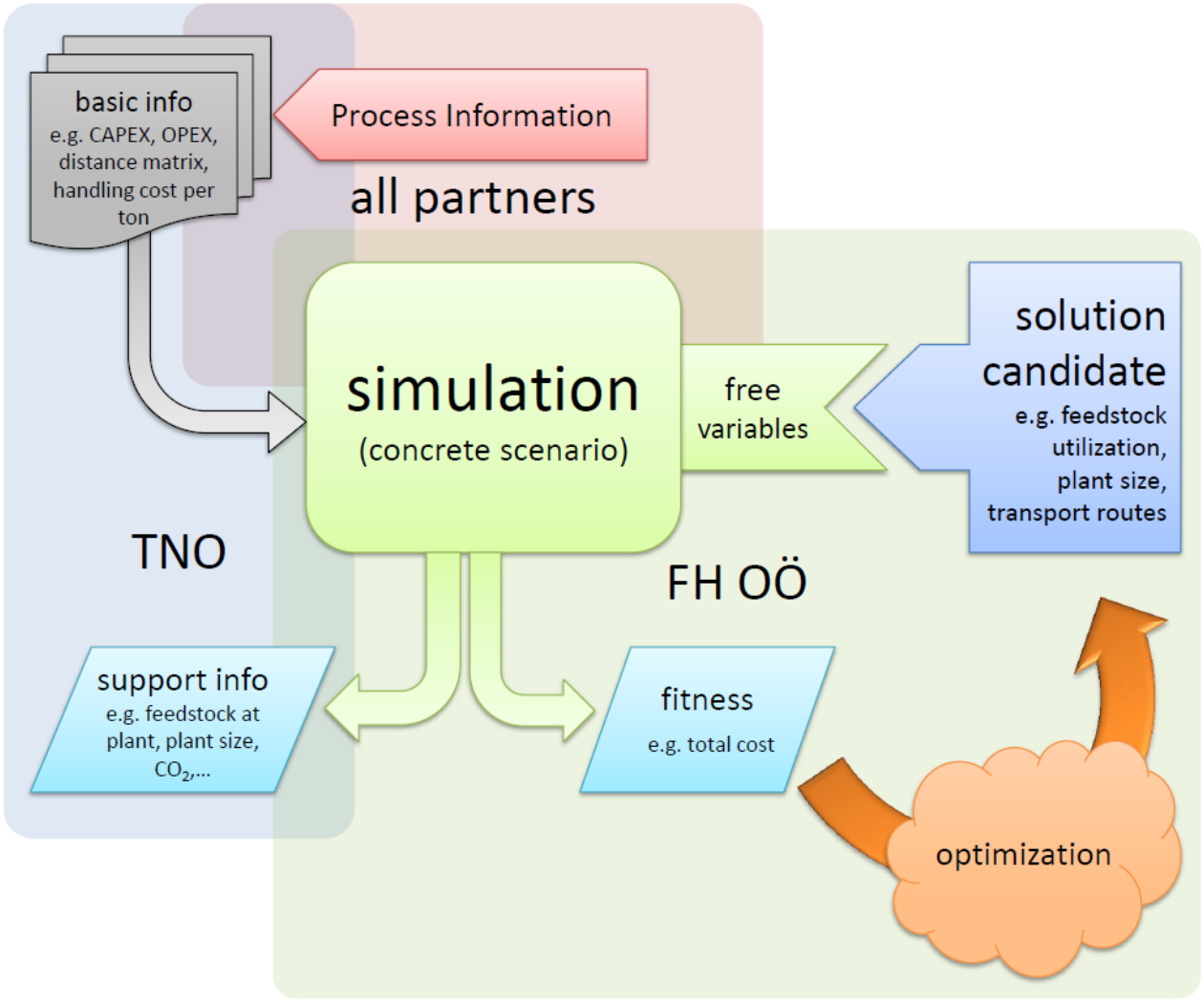
Scenario Simulation

- target values
  - return on investment
  - total amounts (ramping up)
- many free variables
- many more variations

Simulation Efficiency

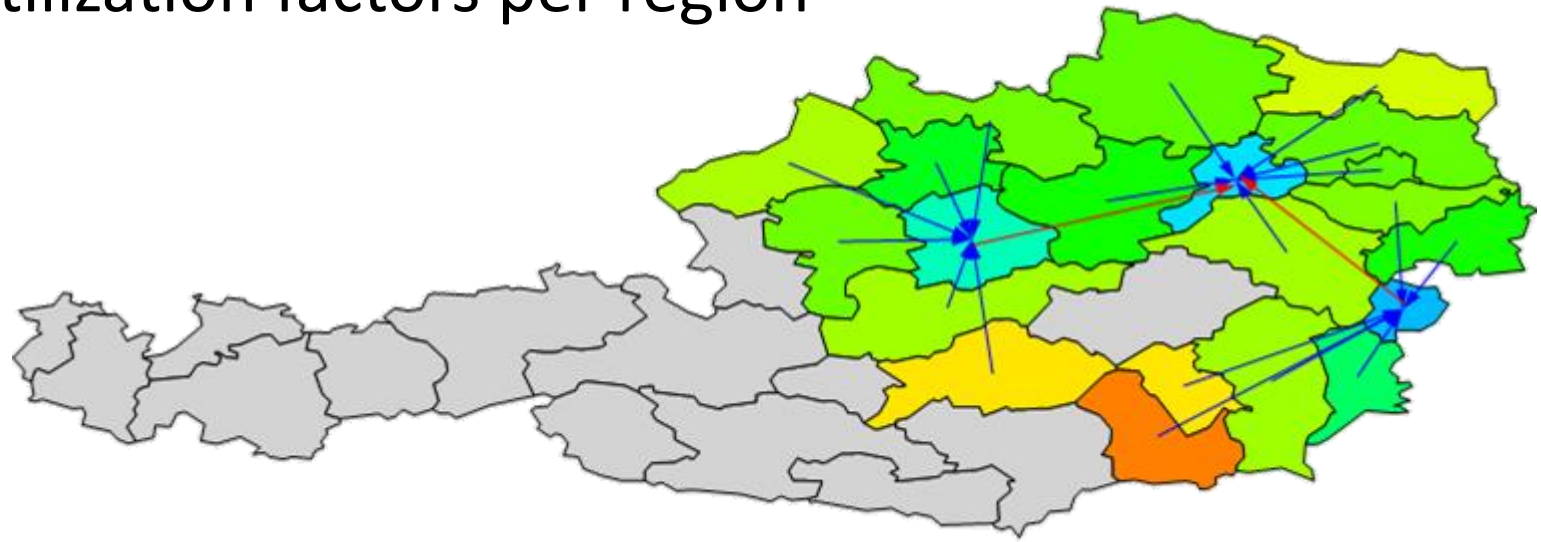
- aggregations
  - yearly averages
  - NUTS3 regions
- route pre-calculation (distance matrix)

Simulation-based Optimization



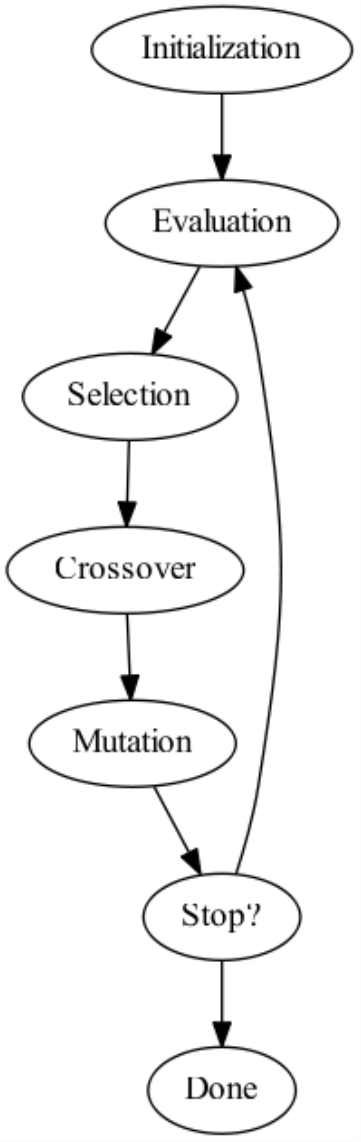
Solution Space Reduction

- implicit (“smart”) choices for variables
- limits variables to
  - transport targets per product
  - utilization factors per region



Scenario Evolution

- evolution of scenarios
  - population based ("Evolution Strategy")
  - mutation i.e. moving/scaling plants
  - crossover



Results: Generic Model

- open-source software tool
  - plugin for HeuristicLab
  - http://dev.heuristiclab.com
- adaptable to other situations
  - e.g. raise transport tonnage allowance and reduce transport costs

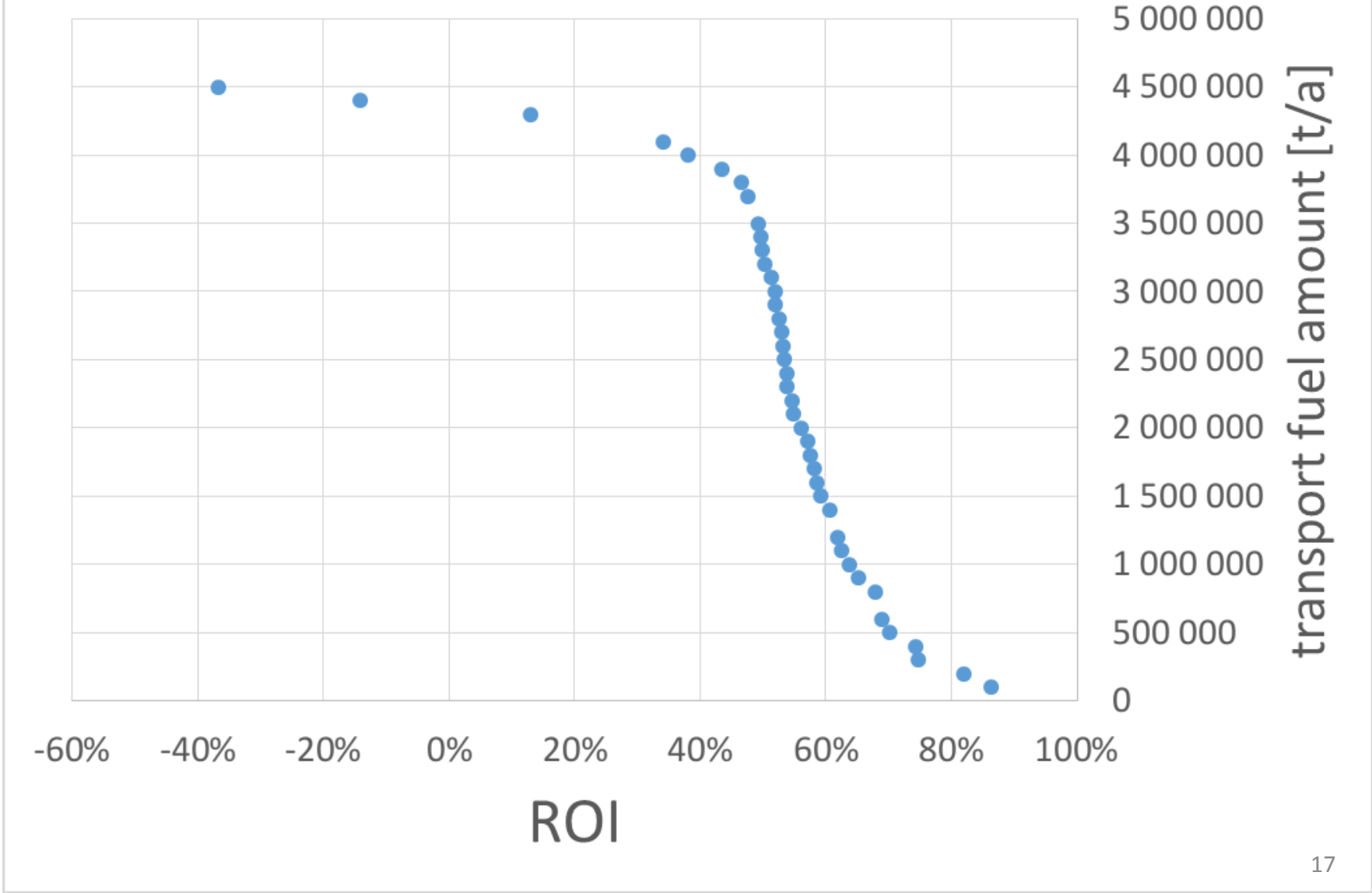
Results: Fast Evaluation

- several hundred scenarios per second
  - extended EU scenarios (1500 regions)
  - two echelons (decentral + central)
  - ROI and/or total amount
- 1-2 days per optimization (300-600 k generations)

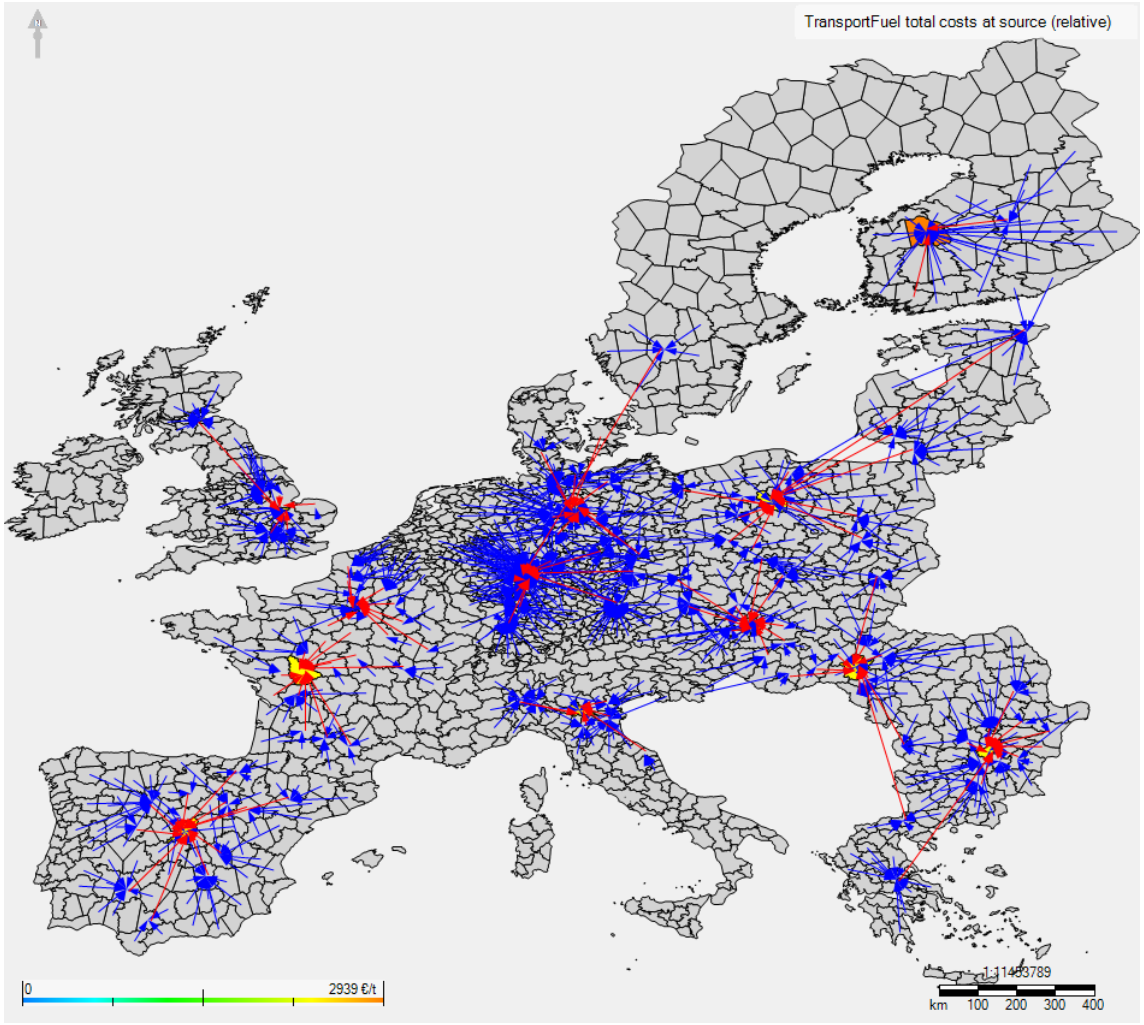
Results: In Depth Analysis

- more than 120 maps with different values e.g.
  - purchased amount in each region
  - conversion costs
  - logistic costs
- CSV export

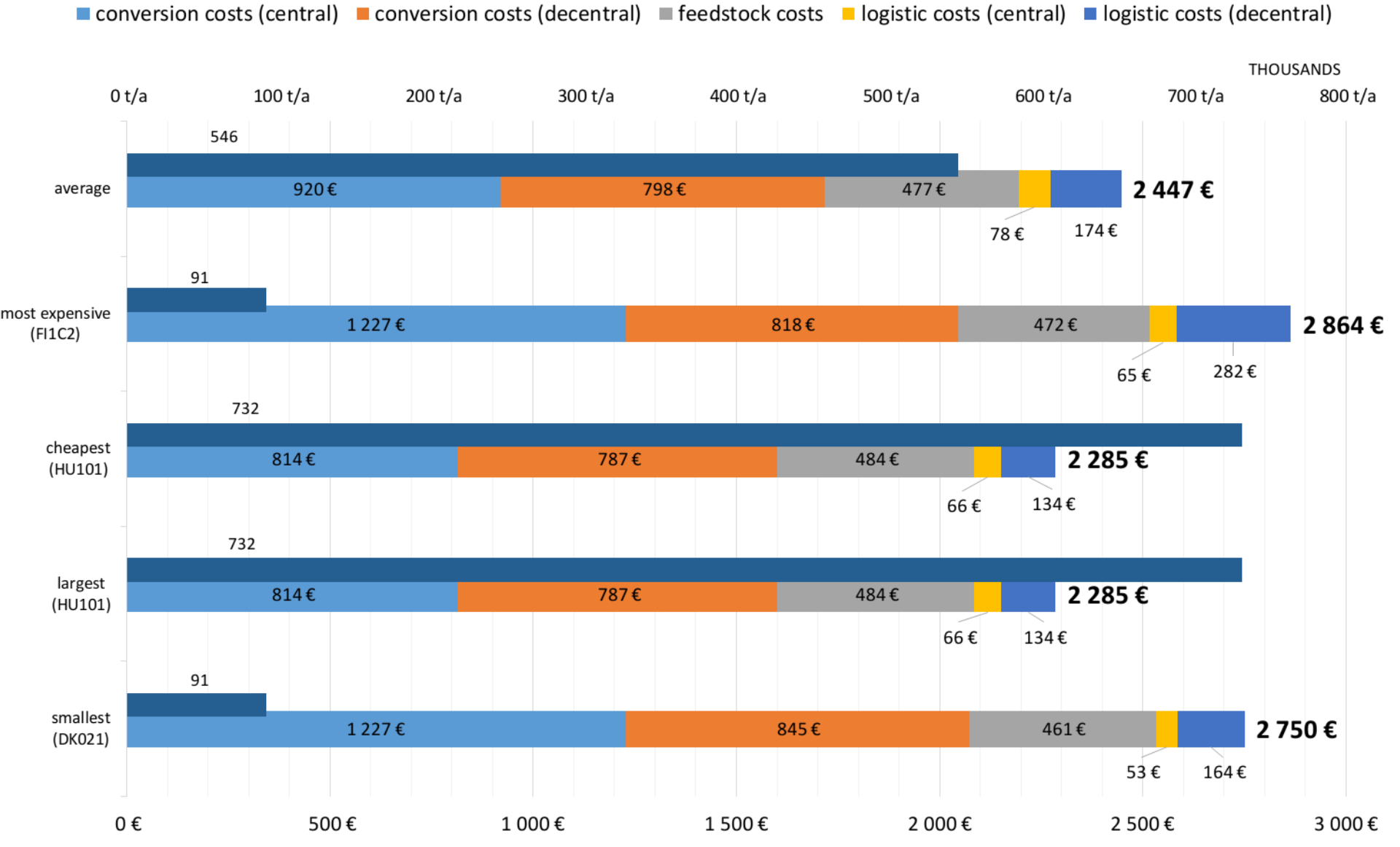
Results: Ramp-Up Analysis



Results: EU FP



Results: Fast Pyrolysis



BioBoost

HeuristicLab

A Paradigm-Independent and Extensible Environment for Heuristic Optimization

http://dev.heuristiclab.com

UNIVERSITY OF APPLIED SCIENCES UPPER AUSTRIA

erik.pitzer@fh-hagenberg.at