Energy technology networks for smart cities

ENER2I Project

ener2i Training Workshop

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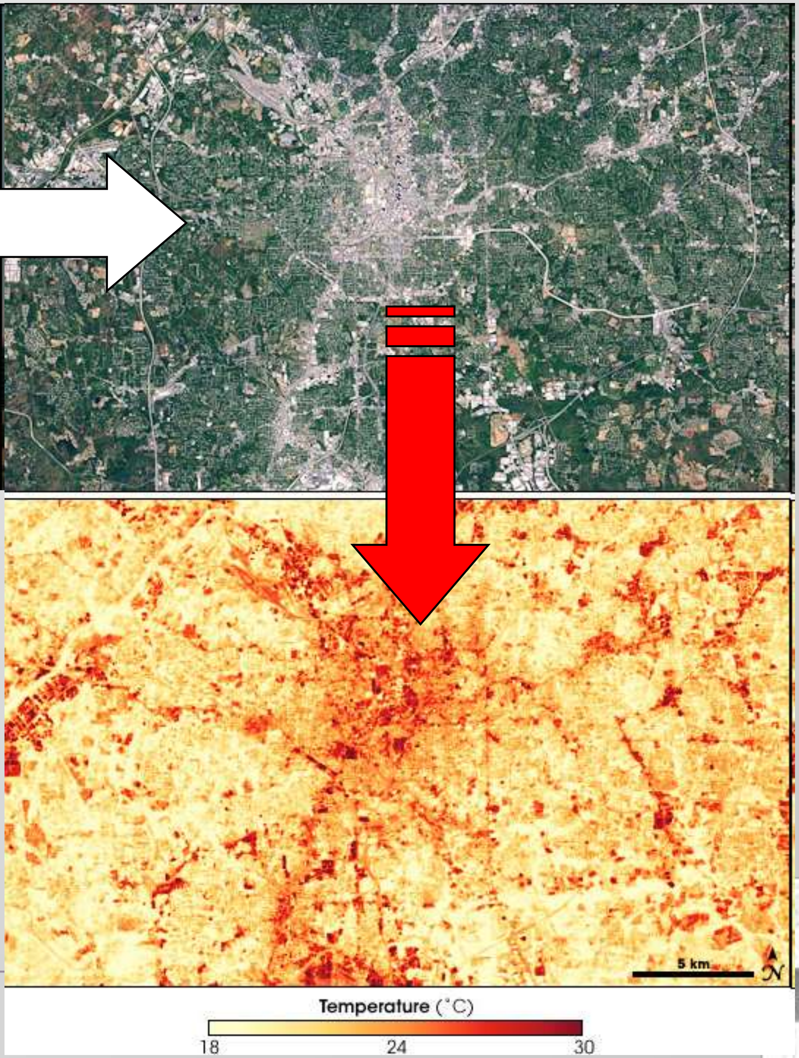
eseia Secretariat

What you can expect

- Smart cities, smart regions, smart what?
- Methods to optimize energy systems for cities and regions Integration of industry and smart cities
- Case studies
  - Integrating industry in smart cities
  - Creating a smart city quarter
- Institutional setting for smart city projects

The Smart City Challenge



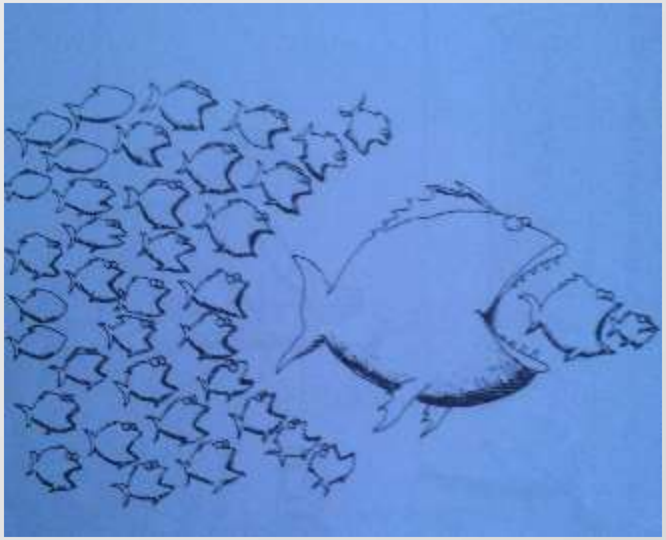
- Cities are „hot“
- Cities emit CO_2

Consequence:

Do away with cities??

Opt for Regions?

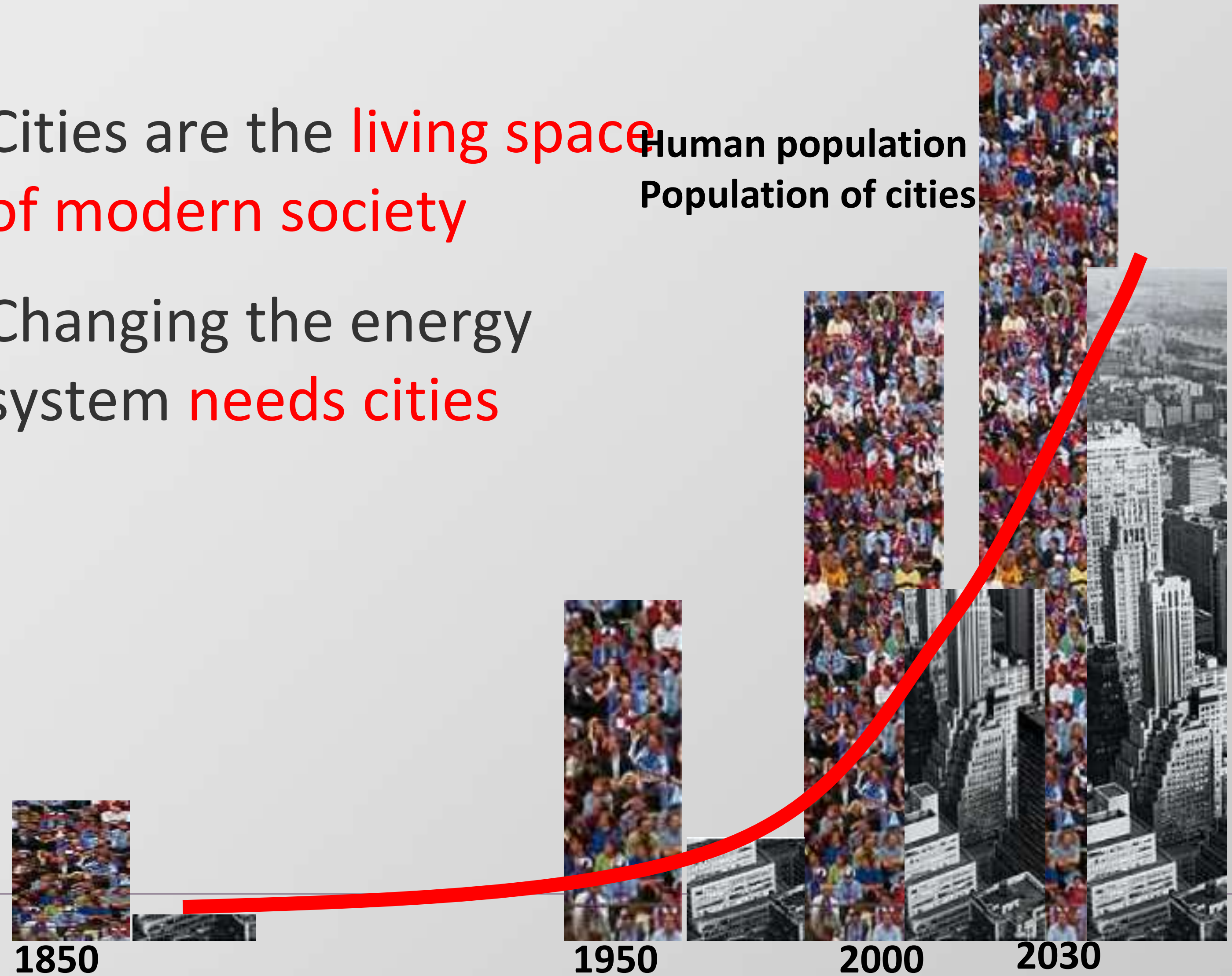
They offer land to capture „natural income"



They are the next step after „big is beautiful"

The truth: Cities are our future…

- Cities are the living space of modern society
- Changing the energy system needs cities

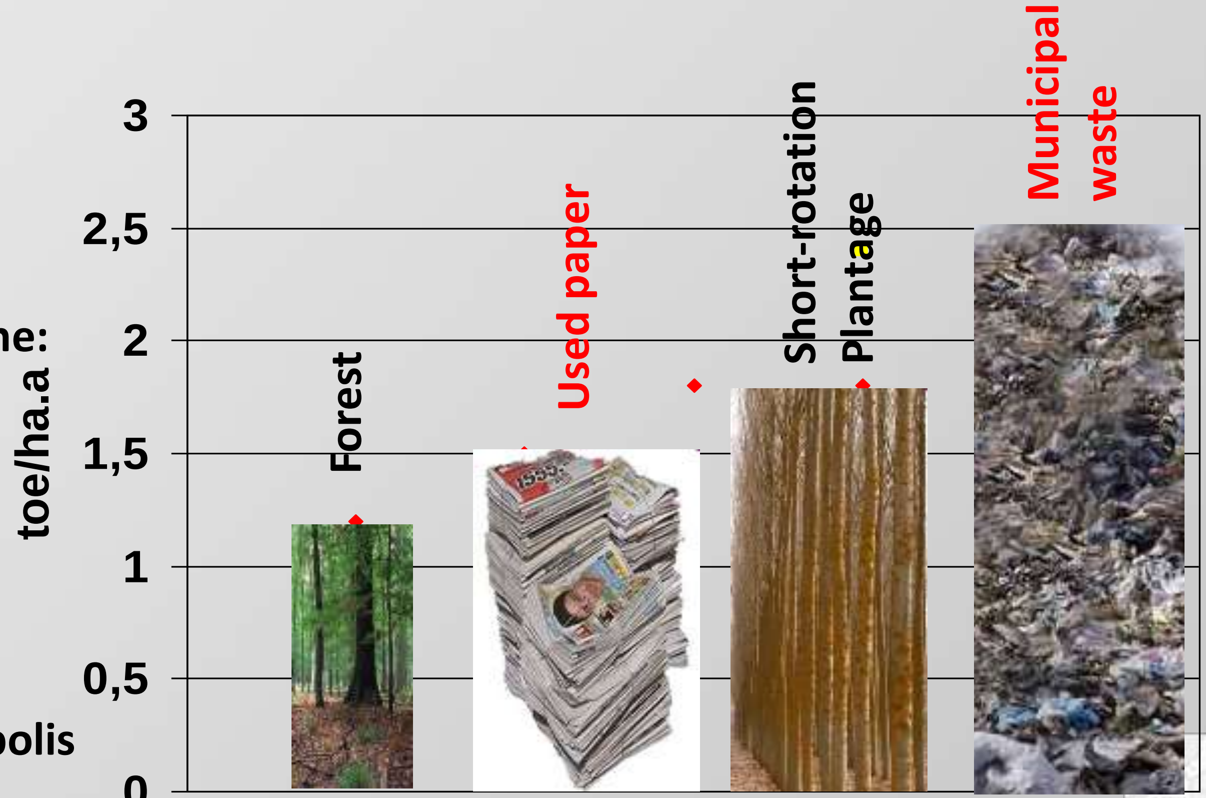


…and they still have hidden resources…

Solar radiation on Cologne:
397 MWh/cap

Demand:
49 MWh/cap

Sun delivers 8 times the energy a bustling metropolis uses!



…but they will inherently …

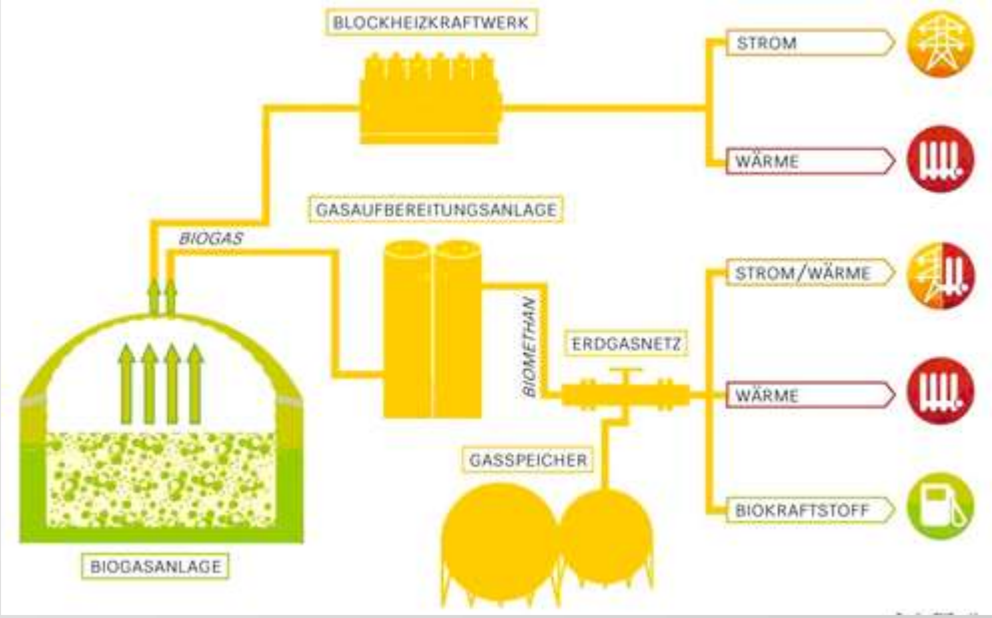
…need resources and create waste…

…to offer jobs and opportunities

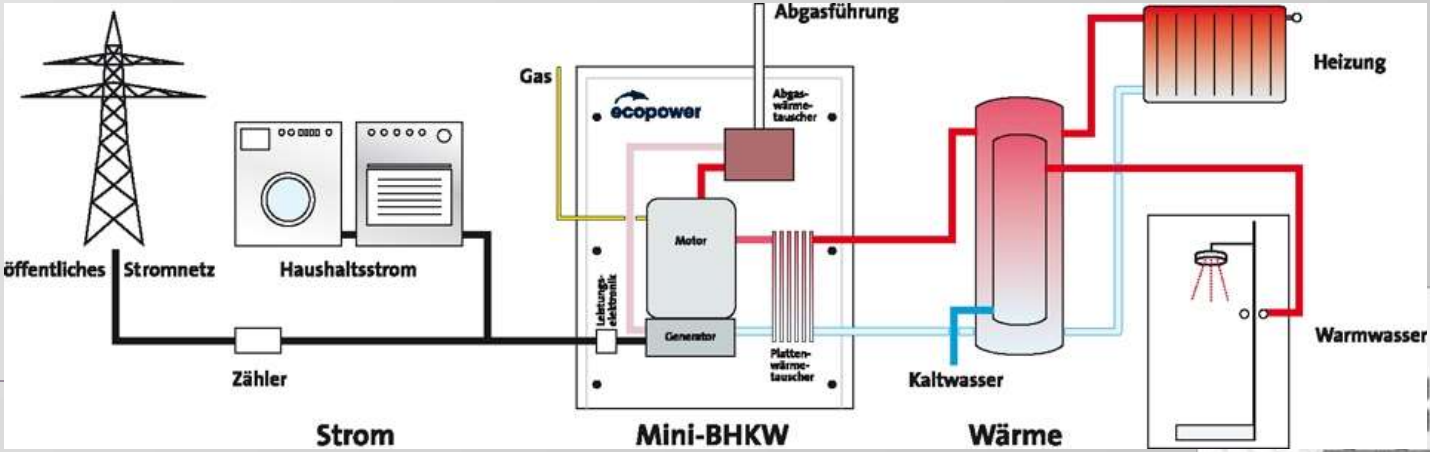
Regions have these resources!

They must become active links between resources and grids

We need Smart Systems



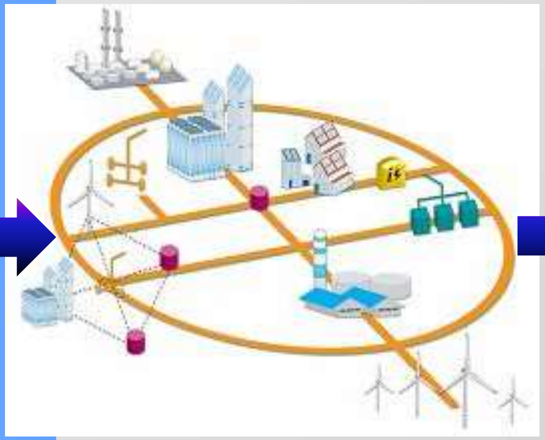
Regions linking grids with smart energy provision



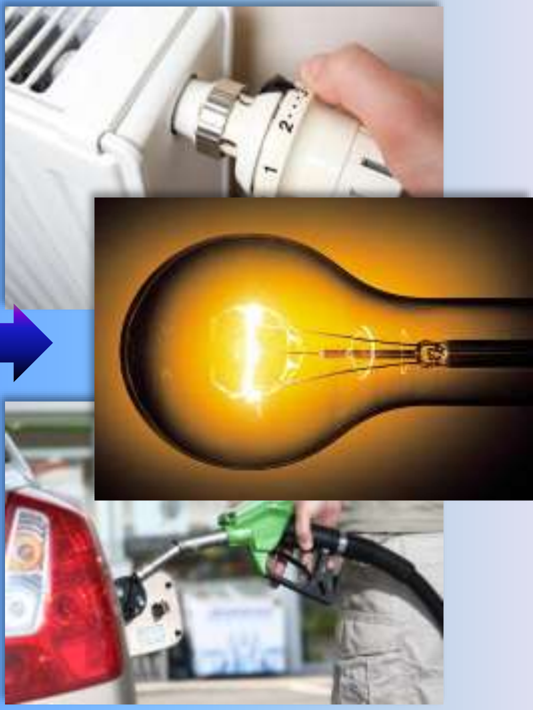
Cities linking grids with smart energy „prosumption“

The Challenge: Planning Sustainable Energy Networks

resources



Energy demands

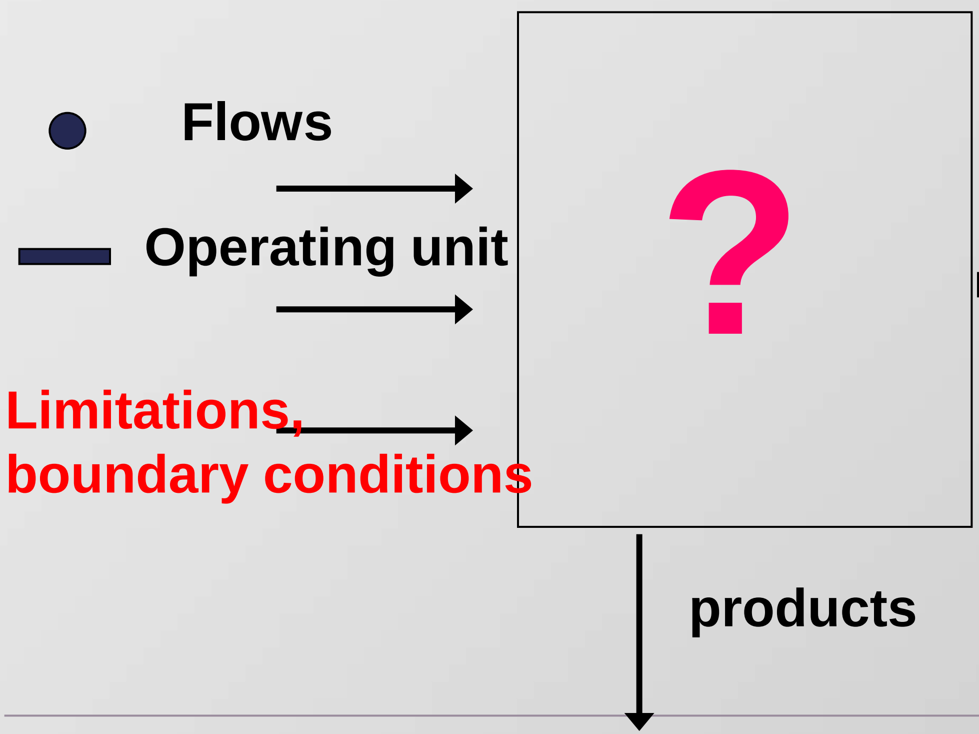


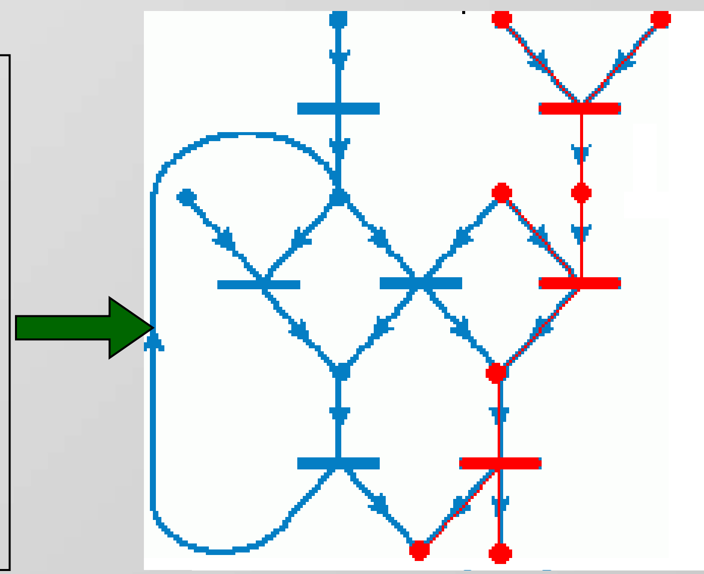
Can profit be reconciled with sustainability?

First step: build credible scenarios …

- Starting with building blocks…
- … create comprehensive scenarios…
- **… that help stakeholders in their decisions!**

Using Process Network Synthesis to generate technology networks





Optimal Process

Optimal to costs, environmental targets, ...

Maximum structure

All possible and feasible arrangements of process units

Evaluating ecological impact with the Sustainable Process Index (SPI)

- „Advanced“ ecological footprint
- Compares full life cycles
- Includes infrastructures
- Is sensitive to different energy systems
- Can compare efficiency and provision alternatives

Free software available

- PNS:
  - PNS-Studio: http://www.p-graph.com/pnsstudio/
    General PNS program
  - RegiOpt: http://www.fussabdrucksrechner.at/en
    Calculation of regional/local technology networks
- SPI:
  - SPIonWEB: http://spionweb.tugraz.at/
    General ecological evaluation program
  - ELAS Calculator: http://www.elas-calculator.eu/
    Ecological evaluation of settlements

The Freistadt-case:
a brewery supplies beer and heat

Historic Centre
13,800 MWh/a

Brewery

3,300 MWh/a

The contextual framework

- Brewery:
  - Refurbishing key elements of the brewery energy system is inevitable
  - Future energy system has to accommodate increased demand
- City:
  - Strong cultural preservation restrictions on buildings
  - Brewery is owned by citizens (Braucommune)
  - 11,200 MWh/a currently supplied by natural gas; 2,600 MWh/a supplied by individual heating systems (fossil oil)

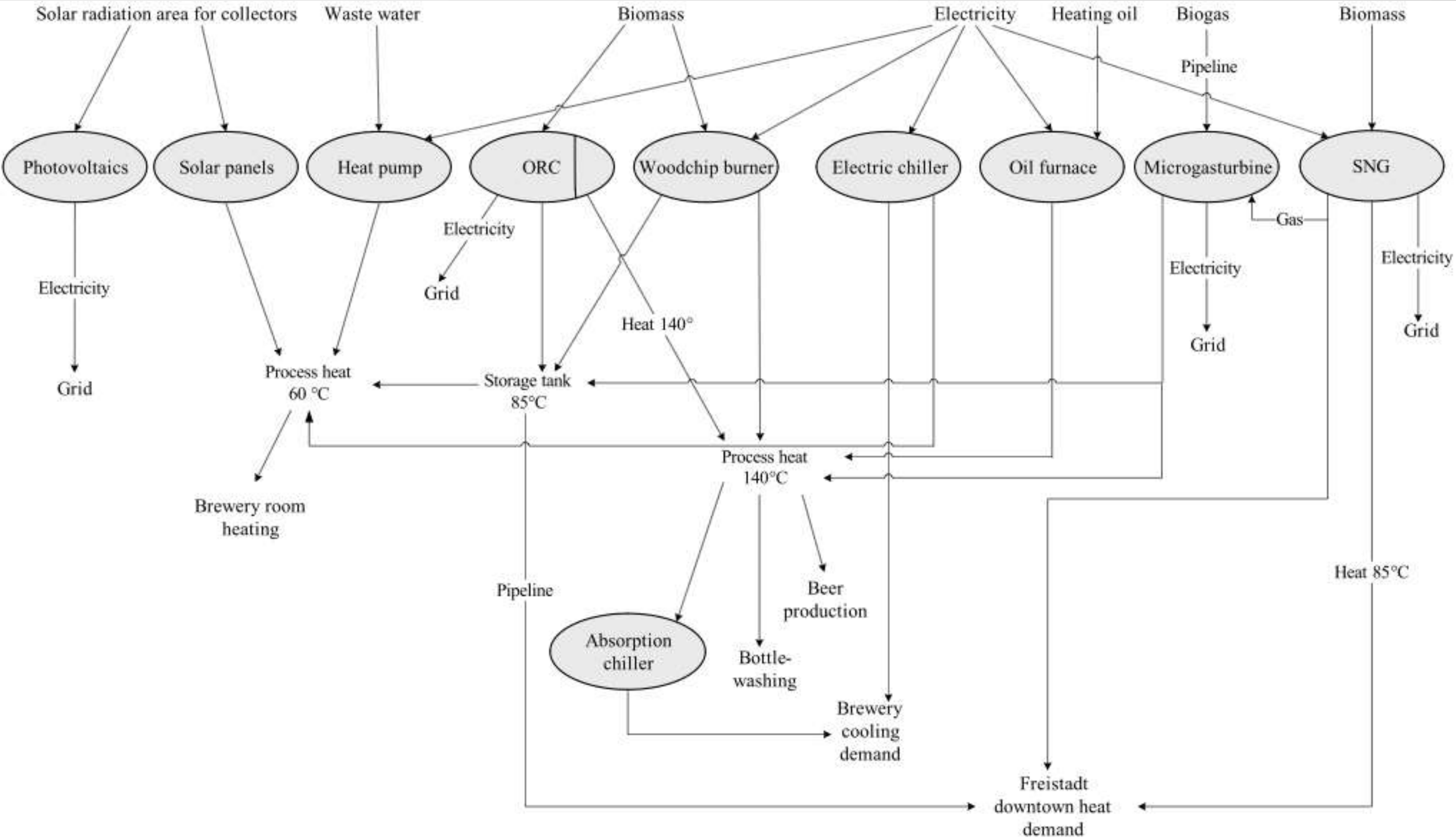
The crucial questions

- What optimal technology network meets future demands of brewery and city?
- What are the costs and benefits for this structure in economic and ecological terms?
- What "costs" are incurred by "going green"?

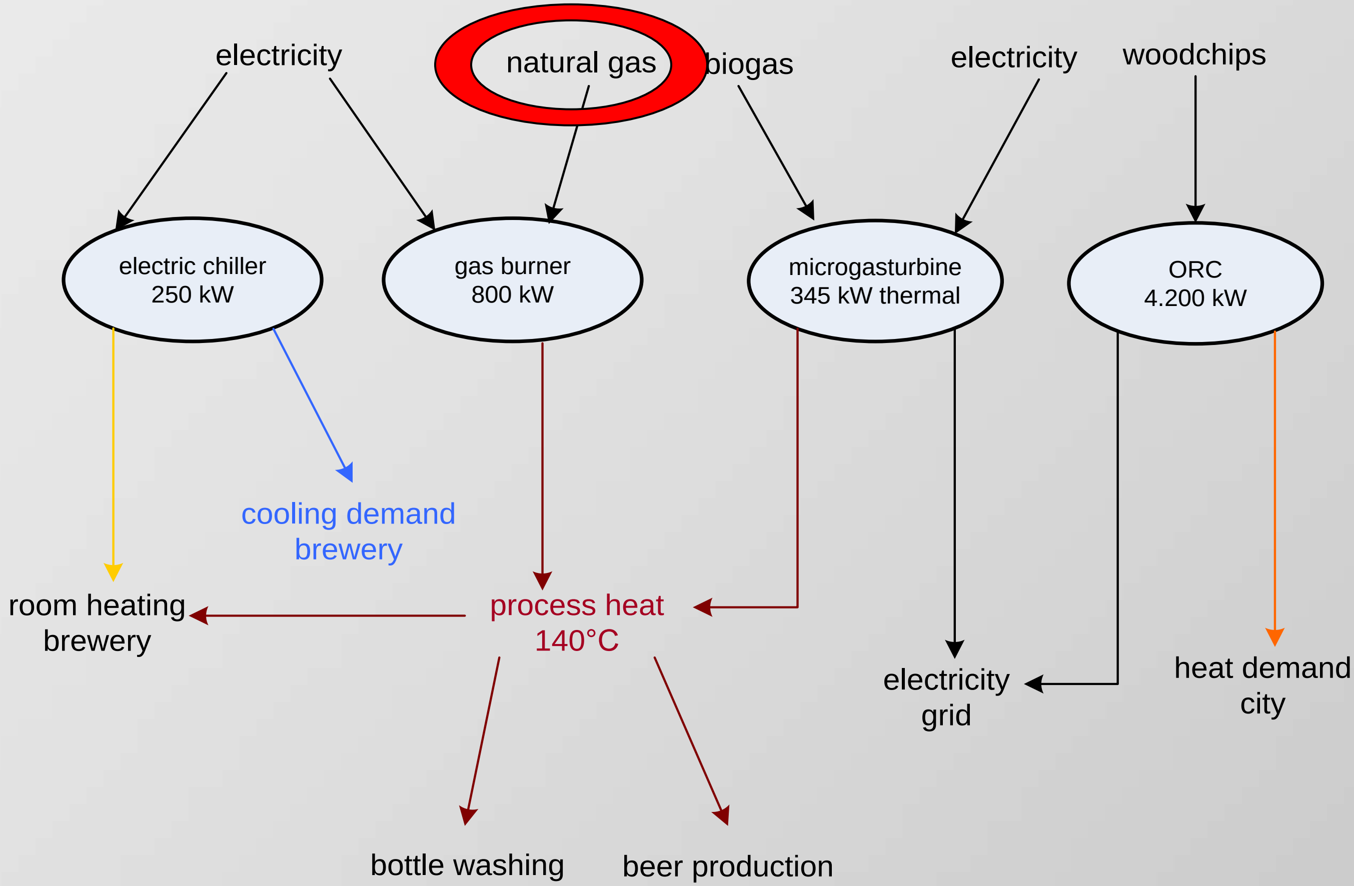
Planning framework

- Heat MUST be produced and used fully by the technology network
- Renewable resources shall preferable come from the region (using the surplus biogas as well as wood); direct solar energy is restricted to brewery roofs
- Heat supply must follow time lines of brewery and city
- Electricity is completely sold to the grid (using actual feed-in tariffs)
- Additional investment in apparatus is depreciated over 10 years, long term infrastructure (distribution grids) is depreciated over 30 years.

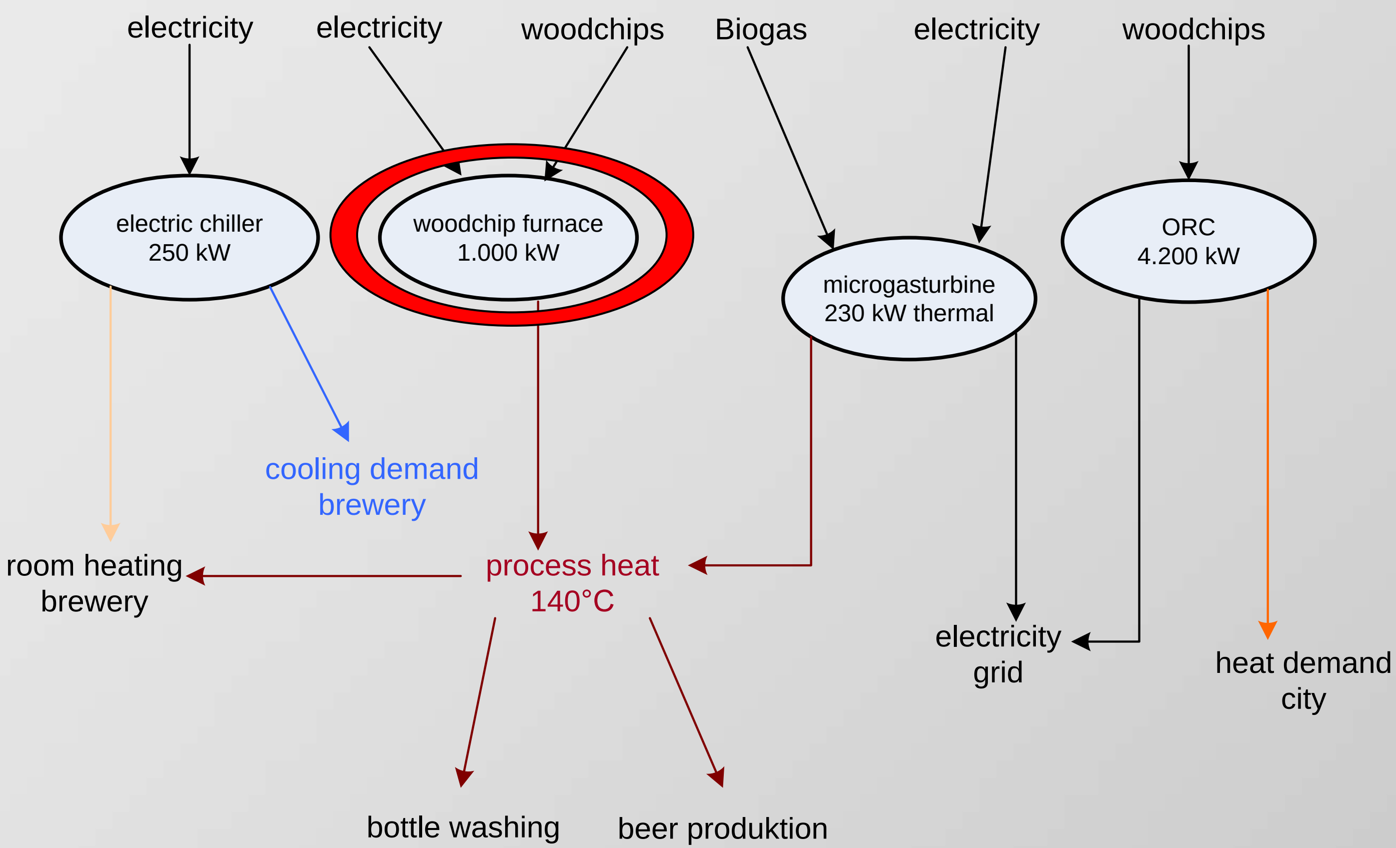
The maximum structure



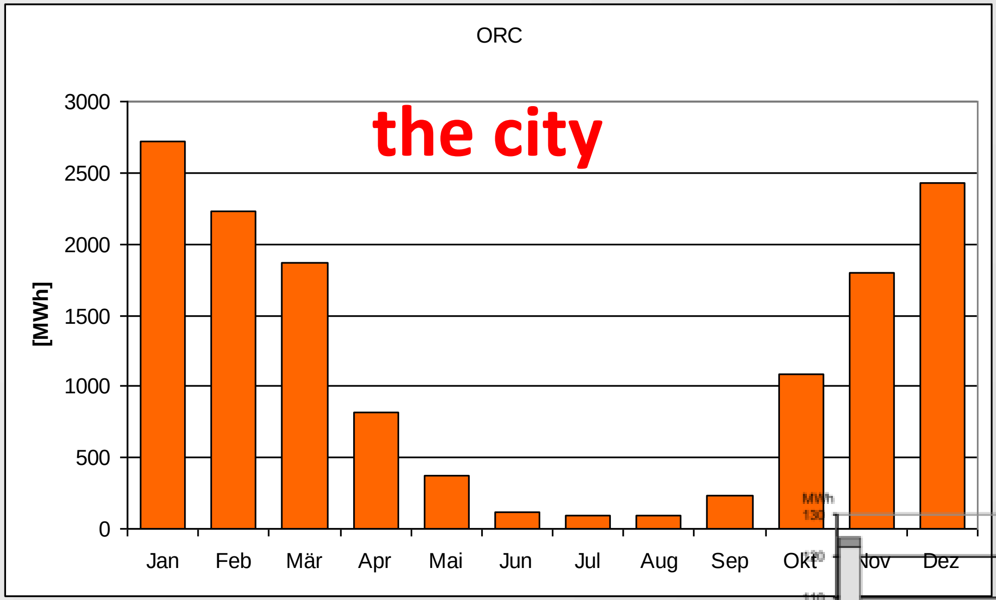
The “optimal” optimum structure

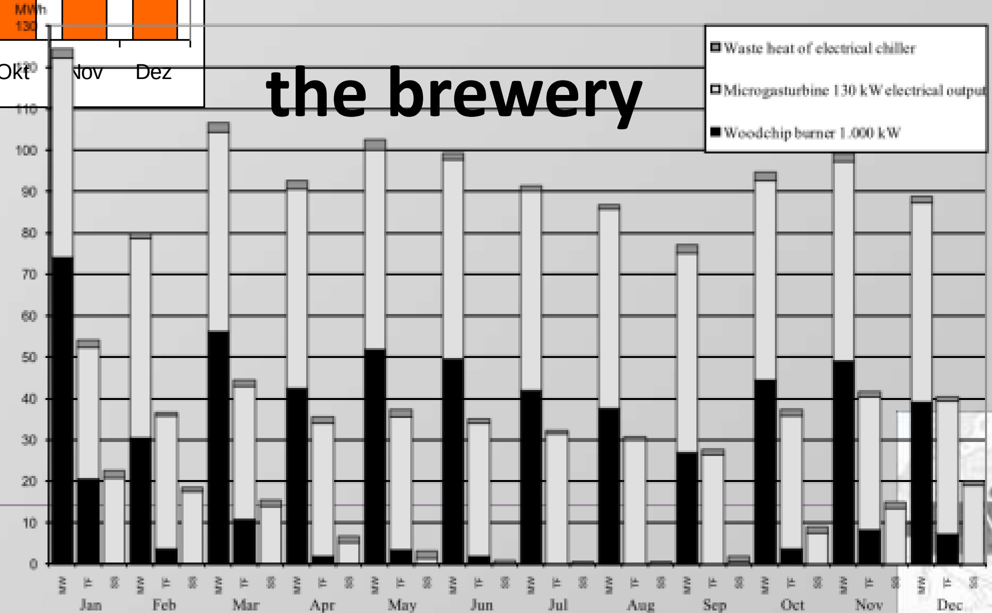


The “green” optimal structure



A major challenge: following load profiles





Comparing the new scenarios

Scenario	SPI [km²]	CO_2 Savings potential [%]	Costs during the payout period [€/yr]	Profit after the payout period [€/yr]
Optimum structure with gas burner	535,9	69,78	755.357	22.271
Optimum structure without fossil energy resources	503,7	73,32	781.471	35.157

Conclusion

- **The environment:**
  - Linking industry and cities offers a possibility to increase environmental efficiency of energy provision considerably
- **The economy:**
  - It makes long term economical sense
  - Going entirely "green" leads to short term disadvantage but long term profit
- **The challenges:**
  - Methodological: matching time profiles with technologies
  - Implementation: finding the right business model and dispel industry resistance to increased responsibility

City District Graz-Reininghaus

Baseline data:

- Project area 110 ha
- Full capacity 12.000 inhabitants
- max. 560 000m² net floor area

~ 50 GWh heat demand (demand for warm water and heating) per year

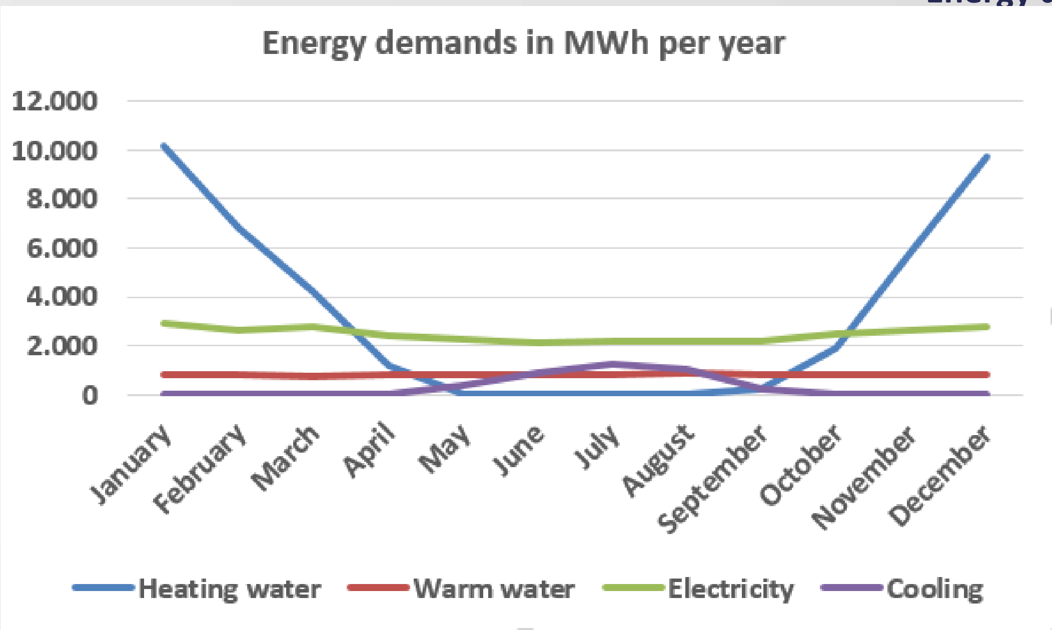
~ 30 GWh electricity demand per year

Active house standard

Process-Network-Synthesis
Taking different load situations into account

Periods

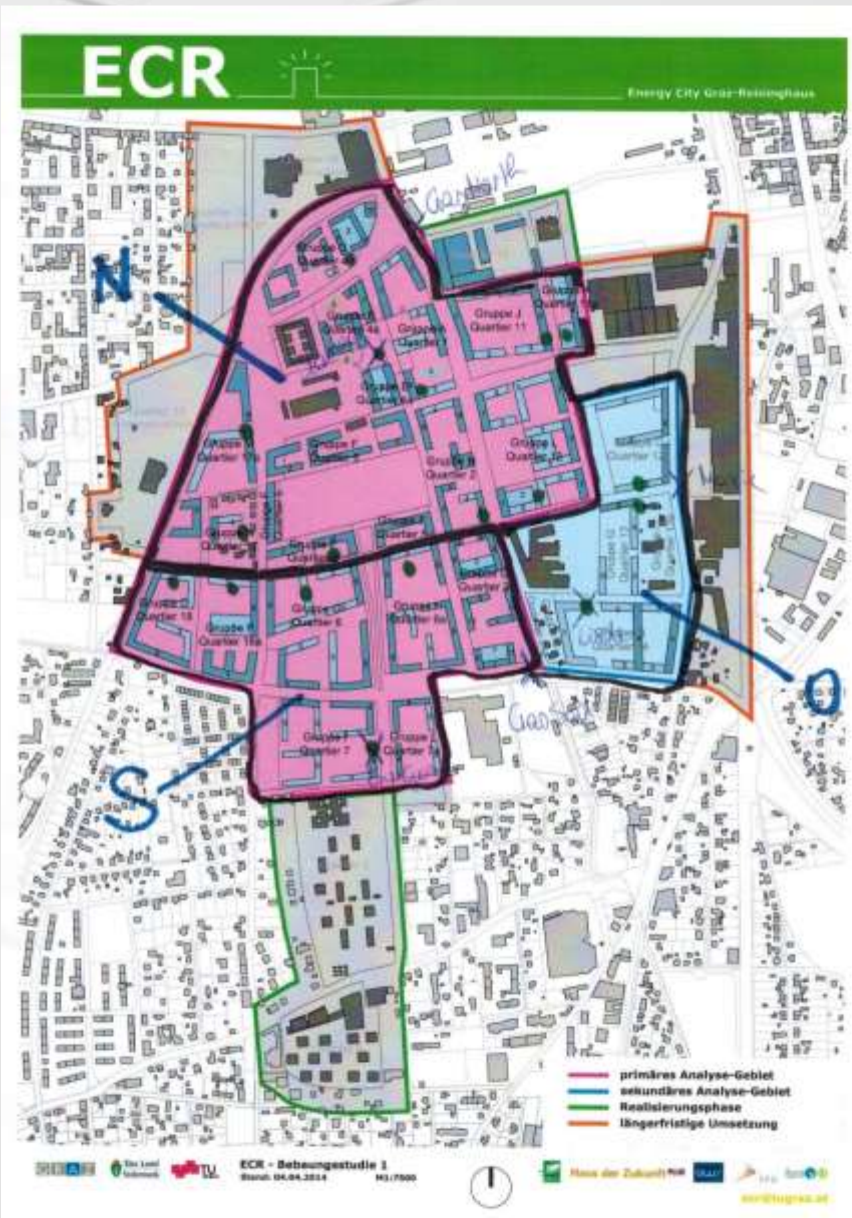
Period	Months	Hours	Hours in %
Winter	January, February, November, December	2.880	32,9%
Midterm	March, April, September, October	2.928	33,4%
Summer	May, June, July, August	2.952	33,7%
Total year		**8.760**	**100%**



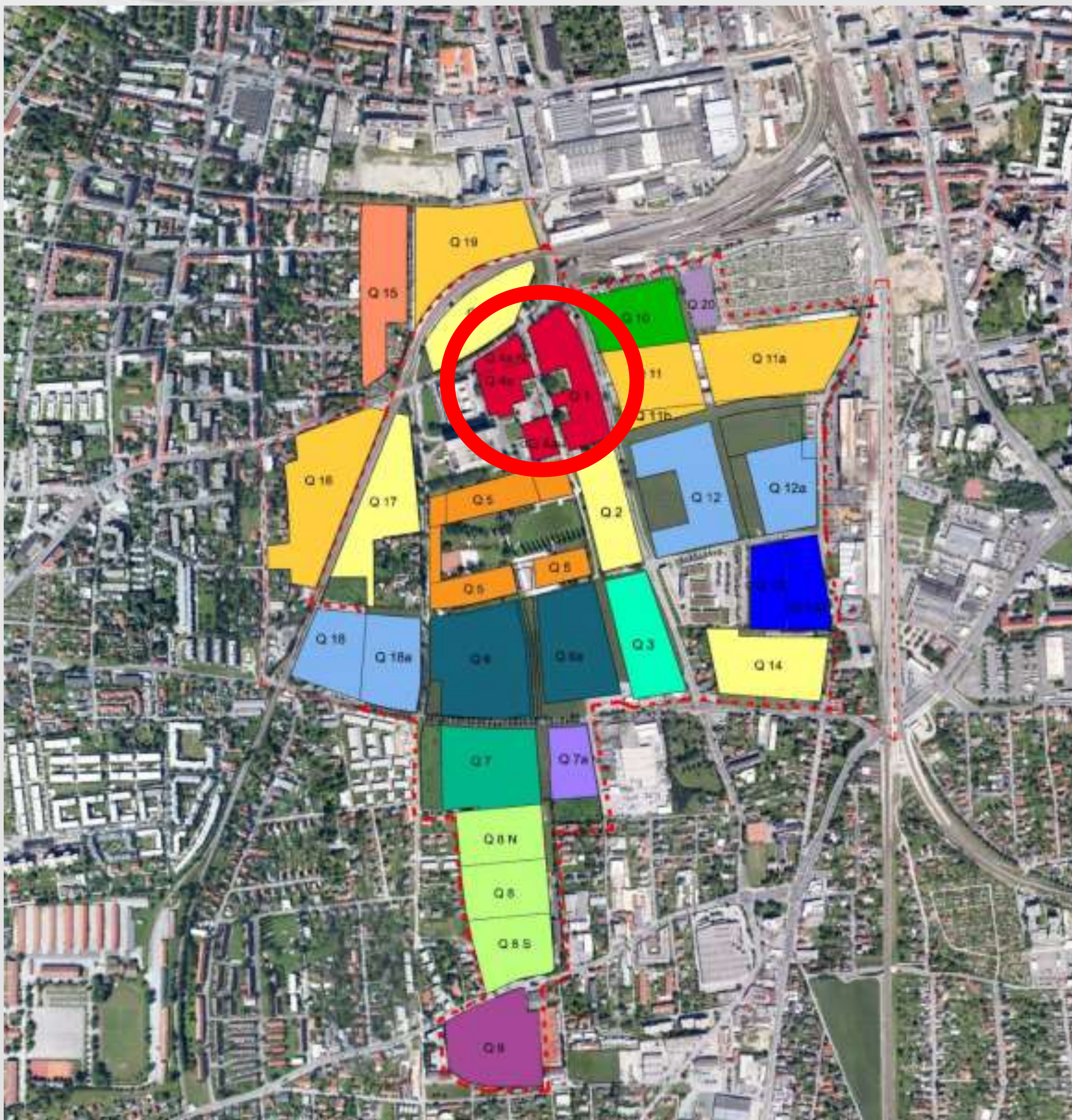
Energy demand low energy buildings (for all quarters)

	ENERGY DEMAND by period and type in MWh			
Month	**Heating water**	**Warm water**	**Electricity**	**Cooling**
January	10.167	824	2.910	1
February	6.808	822	2.607	0
March	4.249	755	2.739	0
April	1.144	848	2.398	4
May	0	838	2.292	399
June	0	811	2.121	893
July	0	812	2.172	1.277
August	12	853	2.195	1.043
September	198	840	2.212	201
October	1.885	819	2.473	3
November	5.788	831	2.640	0
December	9.709	805	2.736	1
Year	**39.960**	**9.856**	**29.495**	**3.823**

Case study Graz/Reininghaus: a smart city quarter planning



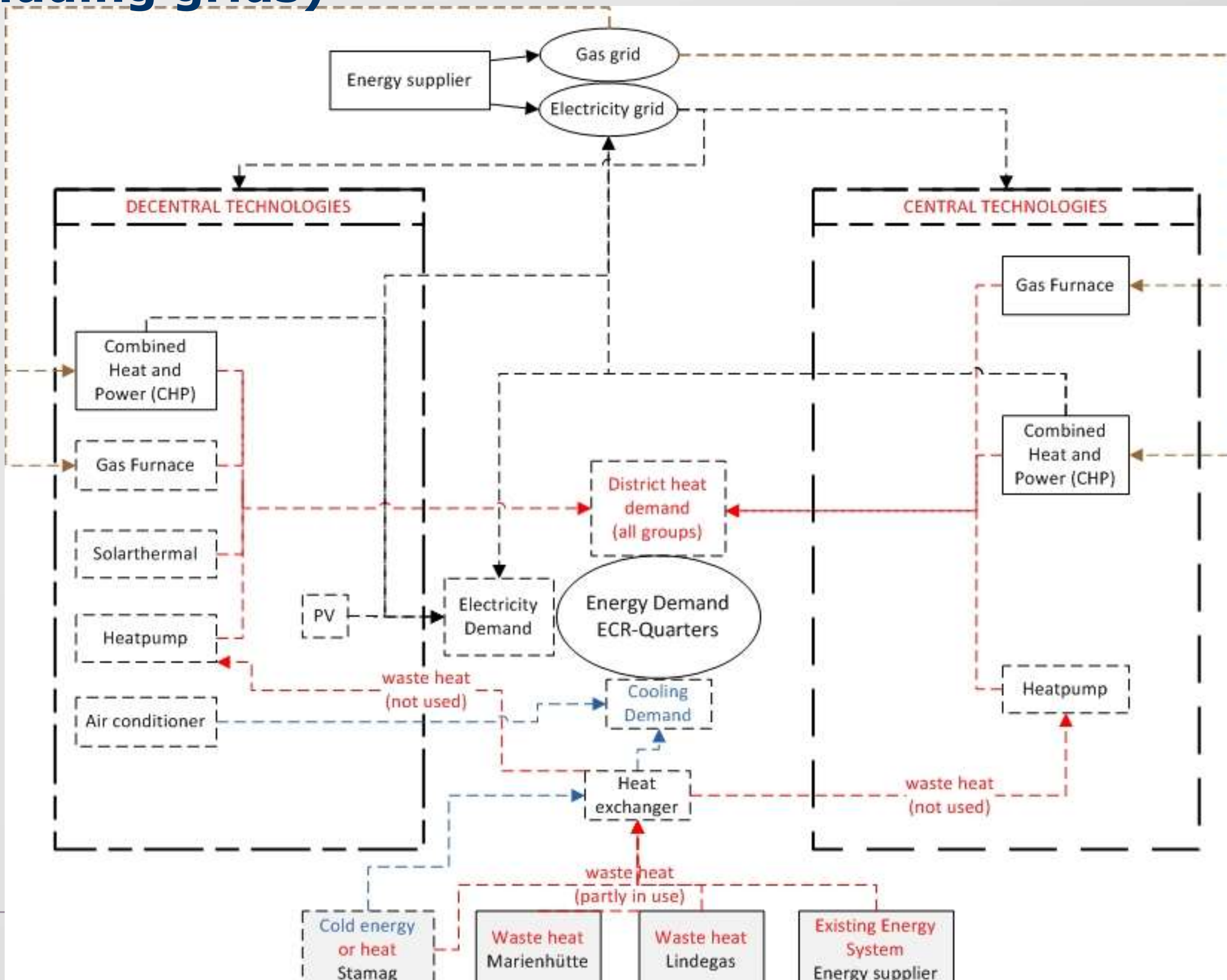
Dividing into „sub-quarters“



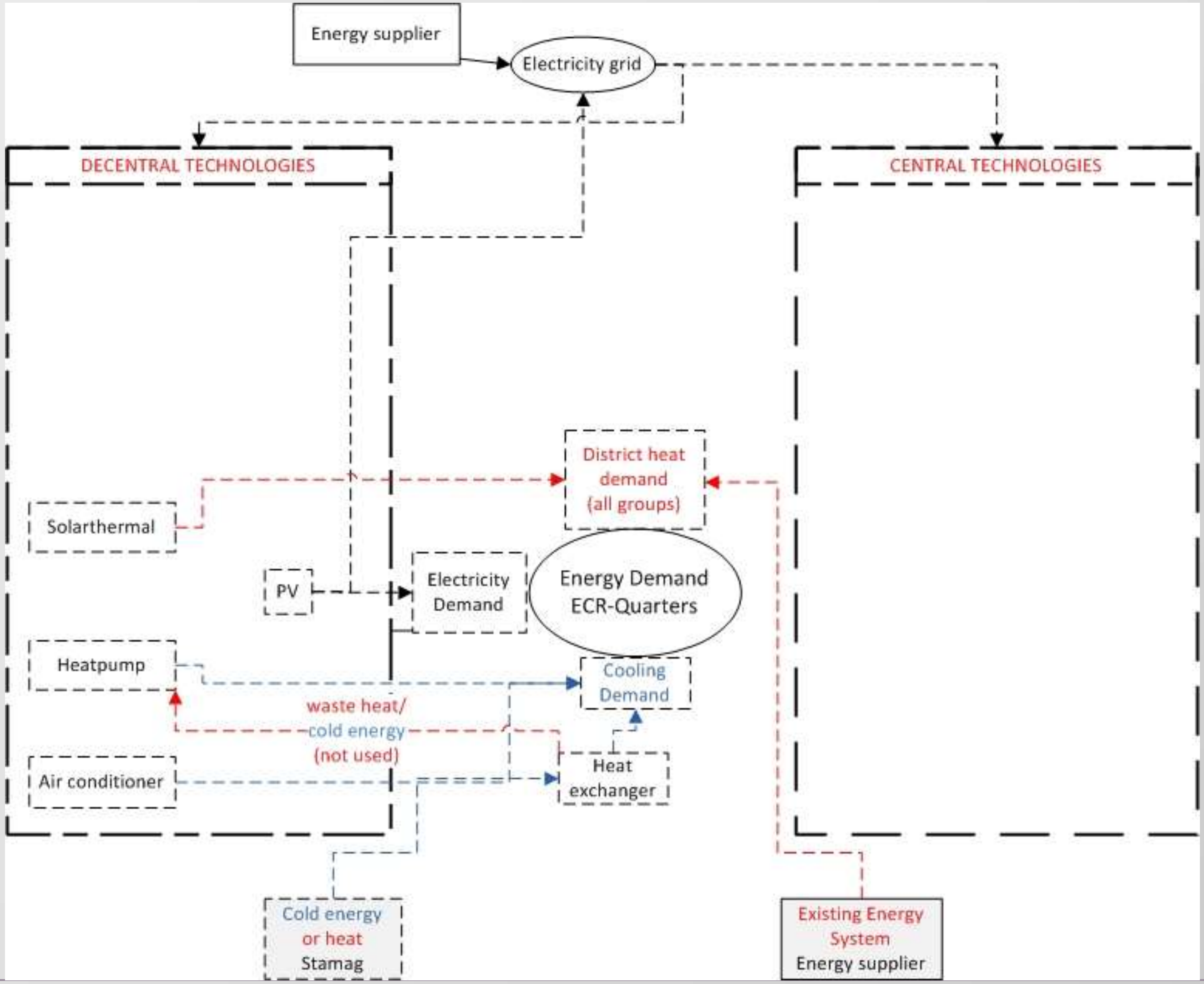
Quarters are defined by:

- Same energy need per square meter
- Same load profiles
- Averaged grid length
- Circled quarter: start of construction

Maximum Structure of technologies (excluding grids)



Optimal Structure

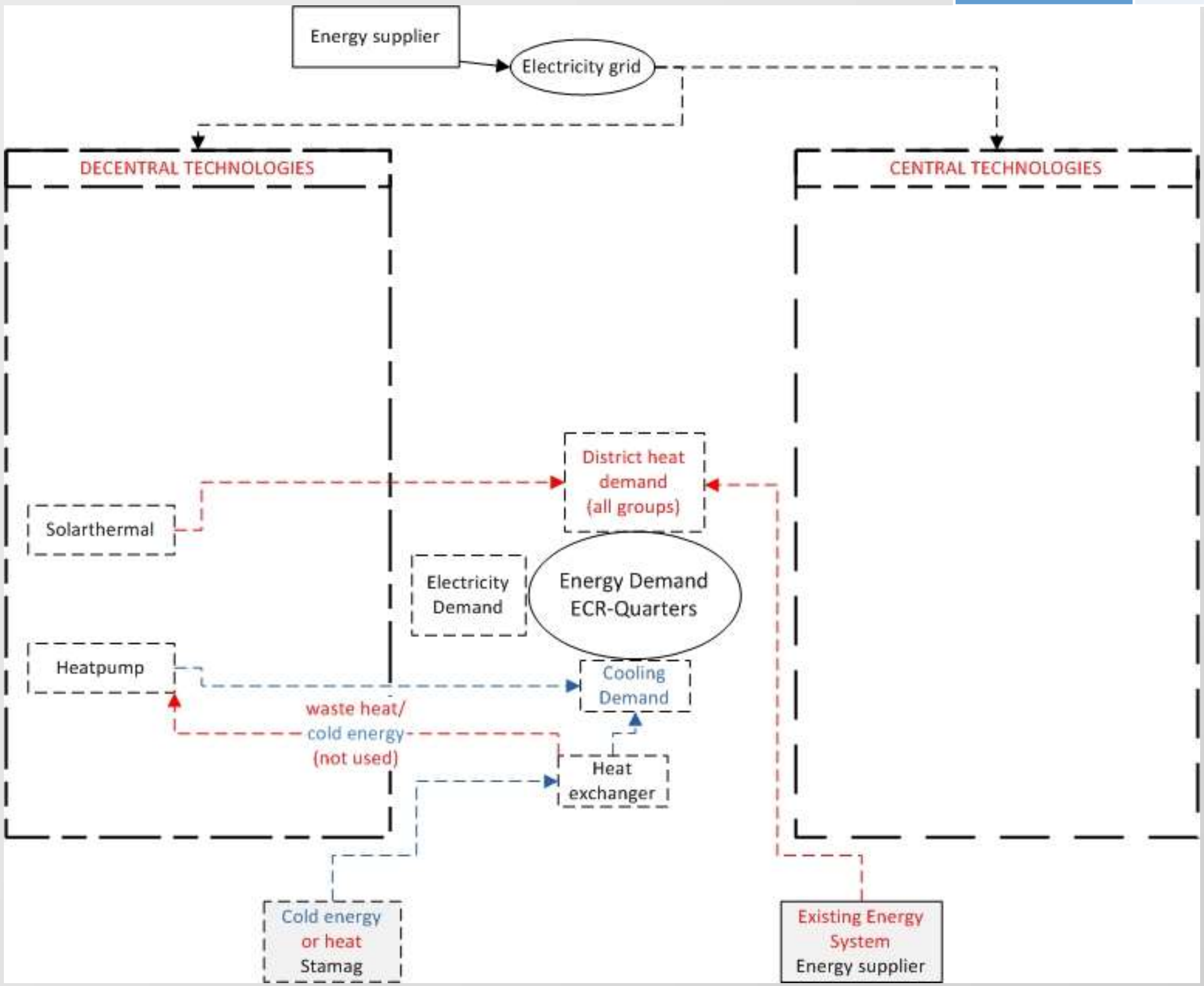


The interesting point: Scenarios for discourse with stakeholders

Scenario	Low energy house (LEH)	Passive house (PH)
Basic scenario all cost/prices actual, ressources by real availability, no further limitations	• Existing district heat cost: 35 €/MWh Supply with: • Supply district heat (external) (54460 MWh) • Cooling Stamag (decentral, use of total capacity) 3186 MWh • Rest of cooling with elec. AC, total 258 MWh • PV in quarters F, G, L, Q (gesamt ca. 275 MWh per period) • Solar heat for warm water in quarters F, G, I, L, Q (gesamt 800 MWh)	• Existing district heat cost: 35 €/MWh Supply with: • Supply district heat (external) (19489 MWh) • Cooling Stamag (decentral, use of total capacity) 4962 MWh • Rest of cooling with elec. AC, total 905 MWh • PV in quarters F, G, L, Q (gesamt ca. 275 MWh per period) • Solar heat for warm water in quarters F, G, I, L, Q (gesamt 800 MWh)
Basic scenario + adjusted cost of district heat Rise of cost for district heat to the point where no existing district heat will be used	• Adjusted district heat cost: **46 €/MWh** Supply with: • Wate heat Marienhütte 78°C (use of total capacity) and gas (external) with external gas furnaces • Cooling Stamag (decentral, use of total capacity) • rest of cooling with AC • PV in quarters F, G, L, Q (approx. 275 MWh per period) • Solar heat in all quarters except K and M	• Adjusted district heat cost: 47 €/MWh Supply with: • Marie 78°C (use of total capacity), 25% gas (external) decentral, 6% Linde decentral • Cooling Stamag (decentral, use of total capacity) • rest of cooling with AC • PV in quarters F, G, L, Q (approx. 275 MWh per period) • Solar heat in all quarters except K and M

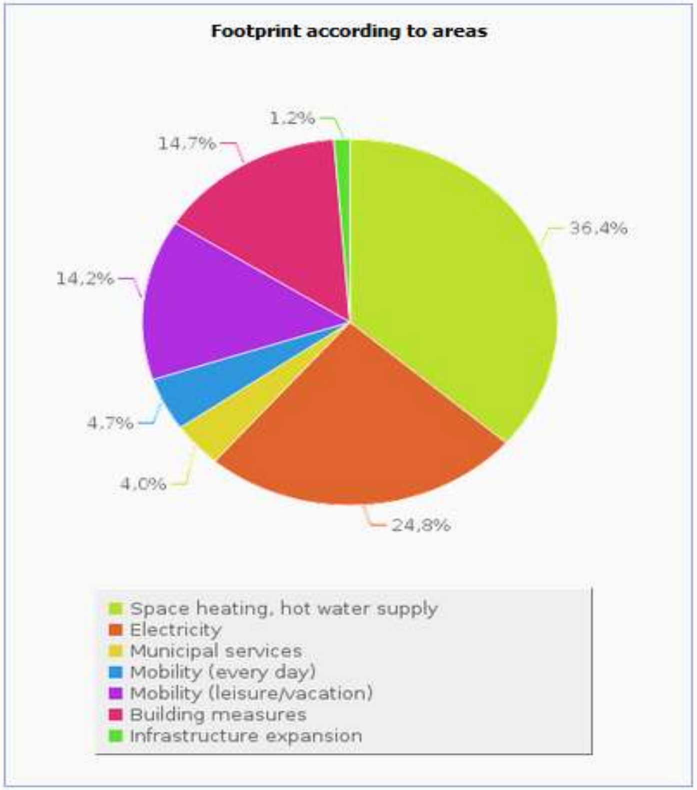
Optimum structure for circled quarter

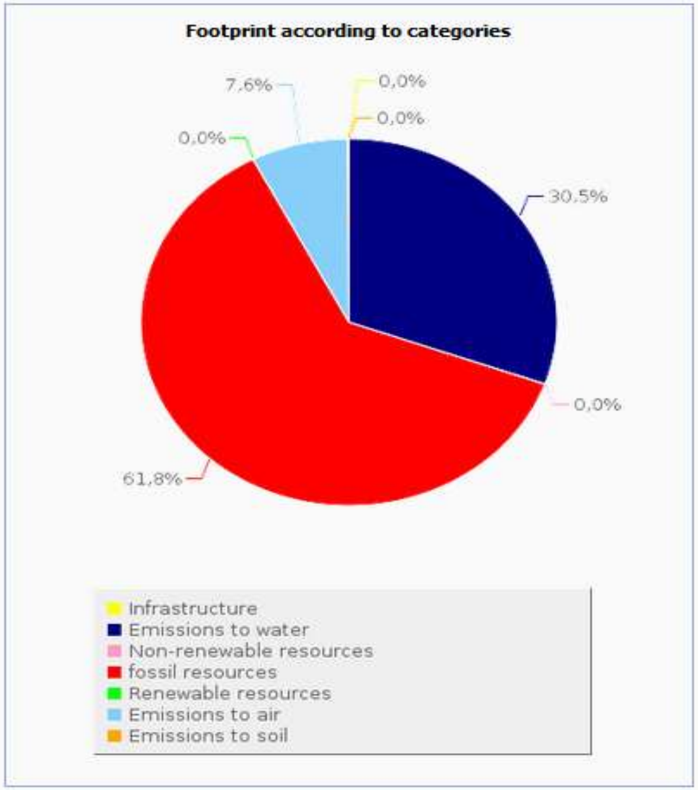
	Gross floor area			
	Quarter 1		Quarter 4a	
Living	56 %	35,744 m²	61 %	21,891 m²
Office	24 %	15,237 m²	16 %	5,913 m²
Commerce	20 %	12,561 m²	23 %	8,348 m²



Ecological evaluation (SPI)

Ecological Footprint (SPI) minimize





Result area	Result	Distribution
Space heating, hot water supply	3,322,745,643 m^2	36.4 %
Electricity	2,259,165,729 m^2	24.8 %
Municipal services	364,567,147 m^2	4.0 %
Mobility (every day)	430,872,442 m^2	4.7 %
Mobility (leisure/vacation)	1,294,302,062 m^2	14.2 %
Building measures	1,344,741,593 m^2	14.7 %
Infrastructure expansion	106,809,953 m^2	1.2 %
Total	9,123,204,568 m^2	100 %

Result area	Result	Distribution
Space heating, hot water supply show	3,322,745,643 m^2	36.4 %
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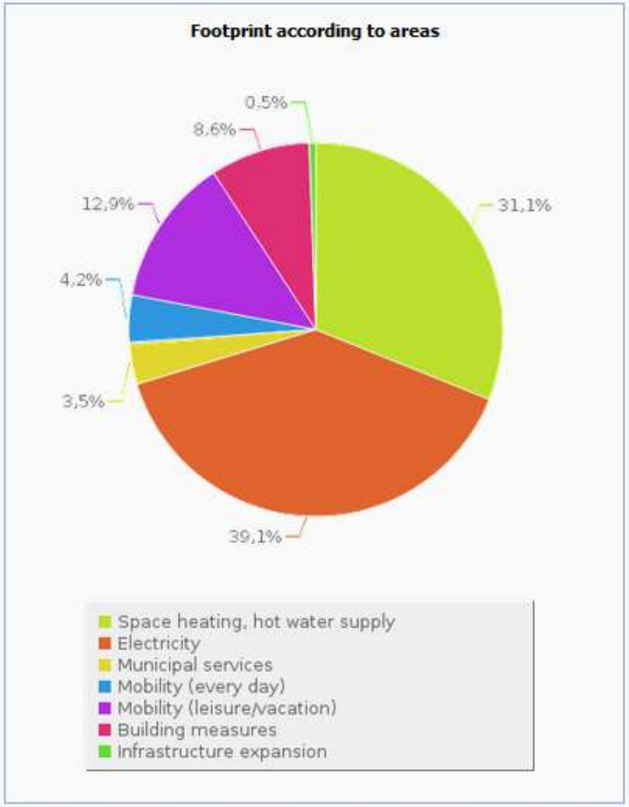
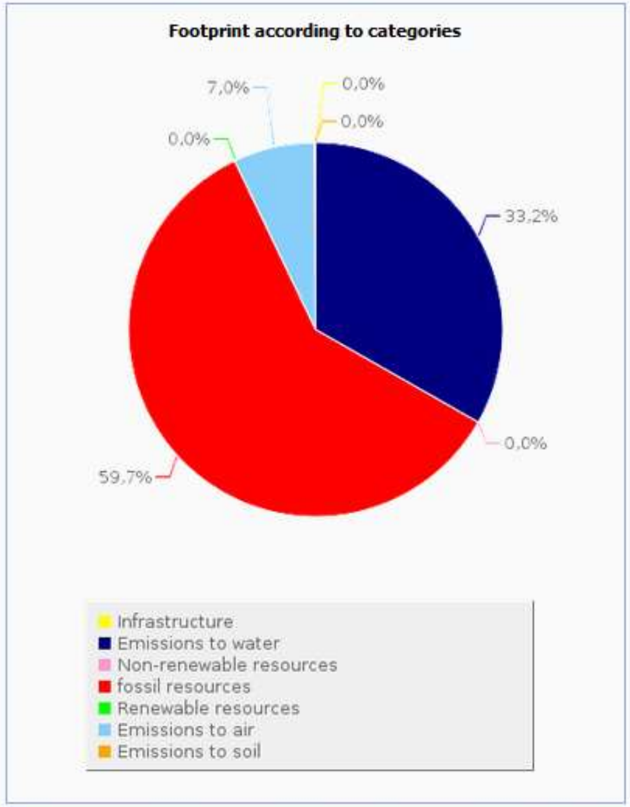
Ecological evaluation, circled quarter

Ecological Footprint (SPI) minimize





Result area	Result	Distribution
Space heating, hot water supply	618,640,693 m^2	31.1 %
Electricity	776,932,802 m^2	39.1 %
Municipal services	70,526,513 m^2	3.5 %
Mobility (every day)	83,329,826 m^2	4.2 %
Mobility (leisure/vacation)	255,846,517 m^2	12.9 %
Building measures	171,596,701 m^2	8.6 %
Infrastructure expansion	10,293,839 m^2	0.5 %
Total	1,987,166,891 m^2	100 %

Result area	Result	Distribution
Space heating, hot water supply show	618,640,693 m^2	31.1 %
Electricity show	776,932,802 m^2	39.1 %
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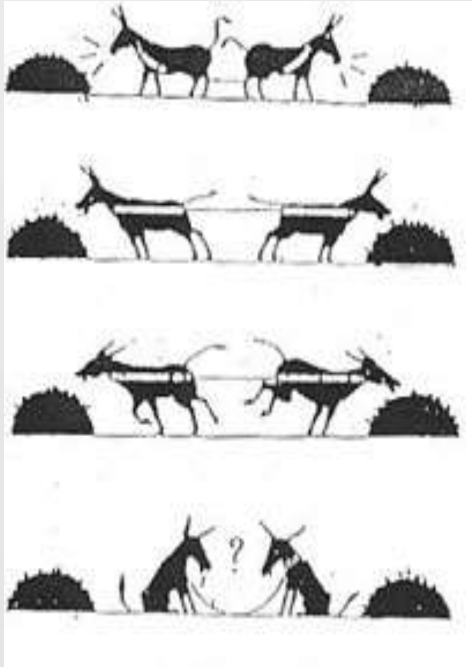
Mobility (leisure/vacation) show	255,846,517 m^2	12.9 %
Building measures show	171,596,701 m^2	8.6 %
Infrastructure expansion show	10,293,839 m^2	0.5 %

The Challenge

We have many actors

How to make them see a bright common future?

What we find



- Decision aversity
- Technology infatuation
- Pseudo-Activity”
- Strategic cluelessness

Industry: Why bother????

- New responsibilities
- Unfamiliar technologies
- Unfamiliar customers
- Long term investment

- New revenue chances
- Better resource utilisation
- Contribution to CSR profile
- Lower green-house gas emissions

Barriers and chances for smart cities

- Splintered responsibilities
  - Energy provision
  - Grids and infrastructure
- Unfamiliar technologies
- Technology lock-in
- Long term investment

- Decreased dependency
- Better utilisation of existing infrastructure
- Lower green-house gas emissions
- Long term profits

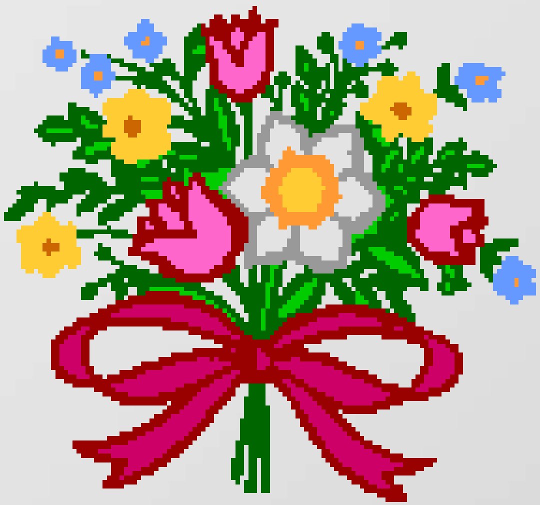
What we need

Information

- Demand profiles/scenarios
- Scenarios that
  - Offer insight into systemic changes caused by resource costs
  - Offer insight into stability of solutions
  - Can mirror realistic building pathways

Implementation

- Agreement between different energy suppliers
- Innovative business models
- Early cooperation between architects, developers and energy planners
- Political framework for (long term) implementation



Thank you!

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