Better Airport Regions

Final report

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Andy van den Dobbelsteen & Geert-Jan Verkade (editors)

On behalf of the BAR team

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1. Introduction to BAR

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Table of Content

1.1 Background

Problem

An airport is a focal point for flows: humans, water, food, materials, energy and their respective waste flows. The throughput of these is enormous and largely linear: humans, primary resources and products originate from (far) outside the airport and waste is being processed (far) from it. This coincides with a great squandering of energy, water and materials, while the airport – because of its general dynamics and character as a focal point – seems ideal to close and connect cycles of resources.
In order to solve this, or make it more effective, interaction with the airport's region is recommended. This requires new technical, spatial, organisational and participative models for airports and their regions. The project of Better Airport Regions aims to provide these.

What if business as usual is continued?

We may then expect a strong material, organisational and economic dependence: resources and products have to come from elsewhere, waste needs to be processed elsewhere, leading to a stark reliance on external parties. This implies economic vulnerability.
Another disadvantage of continuing as we do now is that opportunities will be missed. By that we mean opportunities to create new business at the airport and the surrounding region, to optimise the resource usage and control, to create more effective collaboration in the region and to turn nuisance into mutual qualities.
All in all this will lead to unsustainable development, regarding air traffic and handling, resource management, social-economical perspectives of the region, and (not least) quality of the environment, spatial developments and liveability.

Imagine a different situation

We imagined a more positive future: an airport that is a leading global player based on local strengths, that is strongly independent in the provision of resources and products, that creates new economies that beforehand were unimaginable, that leads to sustainable development of airport and surrounding region, developments that are mutually beneficial to the airport and its region, where people living and working in the area see the airport as a blessing and where regional stakeholders focus their effort on joint actions. In that airport all future alterations and extensions will make the region only better.

Presumption

The researchers and societal partners involved in this project believed that an improved reciprocity between an airport and its surrounding metropolitan region can offer a transformation path to a more sustainable, better airport region.
This may all seem utopistic, but it comes down to some simple steps. Isolated improvement of side of the story (e.g. the airport alone) may make 1 become 2. Improving both sides (also the region) then adds 2 to 2, with 4 as sum. Rather than separation, zoning, efficiency and summing, this Better Airport Region (BAR) project is about integration, interaction, symbiosis and synergy.

2 + 2 = 5

Mutual benefits make 2 and 2 become 5. Even BETTER.

Domains of better

Basic (academic or professional) domains and the qualities we find essential to improved airport regions are:

- Mobility → accessibility and connectivity
- Organisation, policy and governance → participation and regional reciprocity
- Economics → benefaction and viability
- Spatial planning and design → spatial and ecological quality, liveability
- Technology, technical flows → circularity

Thus we come to a description of a better airport region.

Better airport regions
A better airport region is well accessible and connected to both the world and local region. It has participatory and reciprocal relationships with its region. It serves a viable economy beneficial to the local and global environment. It offers excellent spatial and ecological quality, and therewith ensures the best conditions for a liveable region, which is closely linked to the circularity of essential flows in the region.

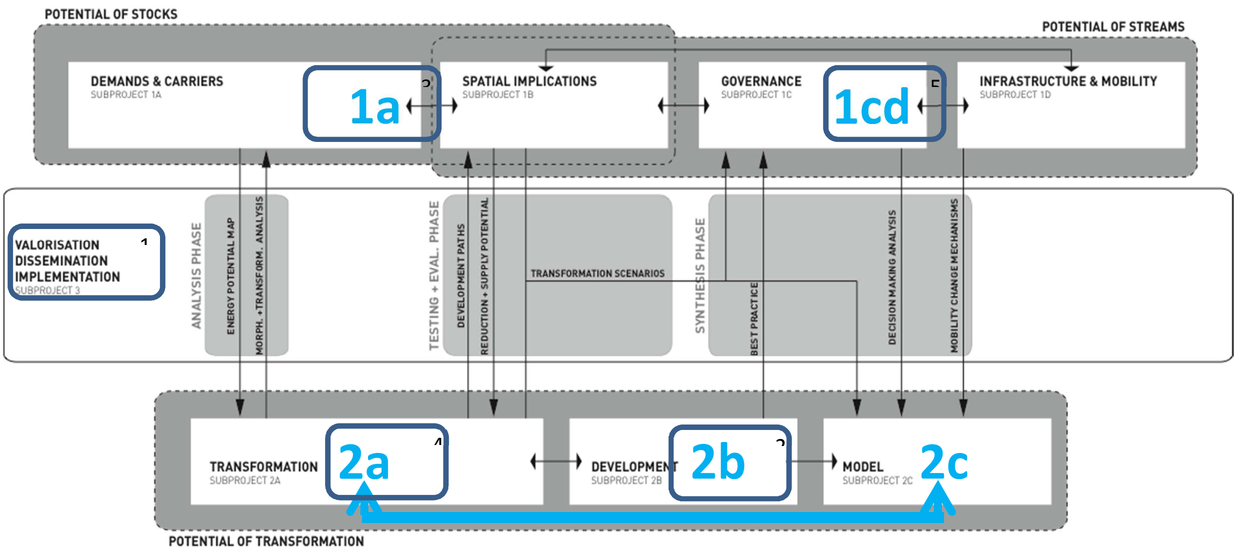
1.2 Framework of the project

Research questions
The main question from the original research proposal was as follows:
What are important transport, urban landscape and governance characteristics for the sustainable development of airport regions?

This main question was subdivided into two perspectives. Informed by applied science the first needs to deliver guidelines for decision-makers and is served by the following questions:
1.a. What are the reciprocal relationships between airport and urban regional developments?
1.b. How can both develop sustainably at all circumstances (growth, shrinkage, etc.)?
1.c. How can a transition towards this sustainable development path be facilitated?
1.d. What development guidelines can be given to decision-makers to enable this transition?

At a more fundamental scientific level the research goes further than current models for airports and cities – such as the "Airport City" (Schiphol Airport), de "Airport Corridor" (Schaafsma), and the "Aerotropolis" (Kasarda), which are considered as inadequate – and for which the following questions are raised:
2.a. What is the adequate conceptual model for the integrated airport region?
2.b. What is the adequate conceptual urban model for this?
2.c. What is the adequate conceptual model for sustainable essential streams for this?
2.d. What is the adequate conceptual governance model for this?

Organisation of the project



BETTER AIRPORT REGIONS: DIAGRAM OF MAIN INTERACTION BETWEEN SUBPROJECTS IN RELATION TO RESEARCH PHASES

The project was originally organised in 7 work packages, 4 led by TU Delft, 2 by ETH Zürich and 1 by TU München. See the scheme below. Soon after starting the two technical work packages 1a (essential flows – closing cycles) and 1b (patterns and complexity) were merged, as were 1c (governance) and 1d (mobility). Work package 2a and 2c (regional design development) were practically already integrated, and 2b (international reference cases) got connected to these.

Throughout the project all work packages collaborated and cooperated their actions, Frequent meetings were held with the research teams and with societal partners and stakeholders.

1.3 Report outline

In this final report of the BAR research project, the following parts will be consecutively presented:

2. International reference cases, the outcome of work package 2b, led by TU München
3. Essential flows – closing cycles, part of the outcome of work package 1a+b, led by TU Delft
4. Patterns and Complexity, part of the outcome of work package 1a+b, led by TU Delft
5. Urban regional development, outcome of work package 2a+c, led by ETH Zürich
6. Governance, outcome of work package 1c+d, led by TU Delft

2. International reference cases

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Table of Content

2.1 Introduction

2.1.1 What and how to learn from International Reference cases?

Within the context of BAR project, the research module 2b aims at providing a catalogue and a synoptic review of strategies and projects followed by European hub-airports on their quest for better integration with the structural context of the surrounding metropolitan region. Considering the integration of the airport and the urban regional context in a coordinated planning approach being a strategic and viable option to tab synergetic and reciprocal potentials of the system, the work package focus on projects and “better practises” where the joint approach can be regarded critical for success. The catalogue cannot be considered comprehensive and should be extended in future project.

In a strictly interdisciplinary approach integrating sustainable urbanism and planning, transportation planning and regional economics and development as core disciplines in the research team while integrating additional external expertise in case-study workshops and sounding boards the project aims at examining exemplary conceptual and technical approaches towards more sustainable development solutions at the airport and the airport region as well as mirroring critical success factors of project conception and organization in real world implementation. Indeed, the strategies and business plans observed at the various airports as well as the technological solutions implemented vary substantially, even if the airport service and organizational processes are relatively comparable to each other.

This calls for a focussed research which integrates contextual conditions in a spatial, an organizational or procedural as well as a resource perspective. By taking up this challenge, work package 2b provide information on the critical interface of theoretical potential and specific implementation context, valuable for future planning and development.
What project contexts and organizational set-up support productively the implementation of what kind of sustainability solutions?

Since findings and considerations on specific cases might not be transferred easily into other local set-ups, a synopsis of international better practises being part of research module 2b aims at identification of typical effects and patterns, which allows for a more abstract recognition of generalizable modes of operation. In specific planning process the strategies identified can be applied as indicators towards more sustainable solutions for a better airport region and might be deduced in stakeholder recommendations.
To broaden the base of reference, the catalogue should be extended in future project and a comprehensive publication in the form of an Atlas of Better Practises on Urban Regional integration of Airports is under preparation with partners from academia and industry.

However, the first collection of reference projects presented here already exposes the extensive diversity of fields of engagement, ranging from e.g. technical approaches like coupling infrastructural system in energy provision to “softer” approaches e.g. joint communication and decision-making process organization for smoother and quicker implementation of projects and new technologies or regimes (e.g. regional noise management). In a series of factsheets the strategic ambitions developed around five major European hub-airports a documented in their specific project context and assessed along different certification scheme or guidelines on sustainable development like the Dutch “Omgevingswijzer” which in this particular now-project on “Better Airport Regions” was considered the initial framework of evaluation linking to the normative understanding of the term “better” (see below). While in the specific European contexts not only the concepts of “better”, but also the respective assessment tools (indicator systems or certificates) differ quite substantially, not every single project can be transferred back directly to this reference system and (serious) comparative study methodologically seems to be impossible and a direct re-translation to the Amsterdam-Schiphol case and Dutch planning environment might not be possible. However, the detailed description of the cases allows for understanding the complex interdependencies between the spatial, organisational and procedural set-up of the references as well as identifying key strategies followed by the stakeholders to make projects for urban regional integration of the airport happen. The findings of the individual case studies are thematically categorized and synoptically arranged in an overview chart, which allows for later extension. In this initial collection strategies followed in several cases are exemplified in one case only to avoid redundancies in the catalogue of factsheets. However in the list of references as well as on the synoptic chart they are mentioned as correspondent examples. A more detailed presentation on the outcomes of the synoptic review can be found in the section "Research Outcomes" of this report. For illustration a selection of the reference case catalogue and excerpts of the synoptic review please refer to the appendices attached to this report.

2.1.2 What is "Better"? – a particular challenge for evaluation

In recent international research on the topic of sustainable urbanism (or urban systems) often the term "sustainable" is complemented with or even substituted by other attributes like "resilient", "desirable" or "better". While sustainable solutions technology often is already on the market, its implementation is surprisingly slow due to either economic reasons or the missing acceptance for the products. Here the normative nature of the terms mentioned adds a new layer of understanding critical for implementation to the debate.

A technology or solution might not only be "sustainable", but also "desirable" (Yes, …we want it!), "resilient" (it develops productively an (already) existing, in common understanding positively valued system in a plausible path, thus: Yes, …we want it!) or "better" (in comparison to other options the proposed solution is most beneficial within our set of values, thus: Yes, … we want it!).

This is not a rhetoric knack but fosters an understanding, which recognizes not only technical aspects but also the societal will to act and to invest into newly implemented infrastructure, which is key for success in (relatively liberal) market environments typical for the European context.

"Better" integration -as a normative concept in the project Better Airport Region- aims at using synergetic potentials between the two sub-systems "airport" and "urban region" to follow a path to more sustainable developments by 1. Reducing consumption of primary resources like water, energy, but also land, and 2. Lowering or avoiding emissions, like CO_2 or noise, in the system. Complementary to this ecological perspective, also a socio-economical and functional perspective is integrated in the term "better", it also integrates the concept of "desirability", "feasibility" and "robustness" embedded in a specific context.

Against this backdrop, the multitude of different solutions examined in the catalogue on international reference cases is not surprising, since the socio-economic and cultural context at the various locations has be to be considered in a very differentiated manner.

However, the knowledge by reviewing the reference cases provides valuable information on links between theoretical potential, technology solutions and the "real world" application in the specific context. While the theoretical potentials might be the same at two metropolitan airport locations might be the same, already the technical solutions might differ due to path-dependencies given by the already existing systems and context. Ultimately the solution proposed might work in one case, while in a second one the business plan does not work out, e.g. because of different price levels on energy or local legislation and administrative set-up or even differing understanding of desirability of the effects caused by the project implementation. Especially when discussion comes to the management of systemic dependencies caused by integration of (up to now independently operating) infrastructural systems a deeper and nuanced understanding of the concept of "better integration" is vital for success.

2.2 Project approach and Outcomes

In this section the research set-up and methodologies followed during the learning journey are presented. All formats forming the final outcome of the project are illustrated in this section exemplarily. For the different formats (star maps, factsheets, synopsis of strategies) please refer to the respective section. Additional and more detailed material can be found in the appendices. A full publication of all project findings is under preparation.

2.2.1 Project idea and structural set-up

In the context of BAR project, module 2b should screen European airports on activities and projects towards a more sustainable development of the airport and its close regional context, often densely urbanized. Since spatial and functional conditions as well as operational logics differ substantially between smaller airports and larger hub-airports, which have to cope with completely other patterns of flows of passengers, goods and information, in the initial project scan the was limited to hub-airports in Europe.

By this the significance of the study for later implementation into the specific situation of the Amsterdam-Schiphol airport regions was assured, however the scope of analytical work limited to a manageable amount of data to be processed, without omitting different perspectives (see below) already in the initial phase. This limitation immediately exposes the necessity to decide for an international reference case study, since the hub-airport infrastructure of e.g. AMS airport has to be considered a singular phenomenon on the national level, which is a typical set-up in the European context, only in Germany two major hub airports, FRA and MUC can be found. In the logics of the global flight network these two are strongly linked together, like AMS and CDG they form an airport system. On a first glimpse national boundaries might seem to be irrelevant in this systematics of air services and airport operations if looking from the airside or from a very technical perspective, which assumes a global accessibility to particular technologies.
However, all airport developments have been strongly informed by the specific territorial context, economic or juridical constraints, social aspects expressed in a series of plans and regulations developed over generations. Especially when the boundaries of the airport development and the surrounding urban fabric grow closer to each other, competition for remaining development potentials grows, debate on conflicts gets more aggressive, often calling for development solutions unrolled in integrated plans for urban and airport development in the regions. So even if the airports are relatively comparable to each other in their airside operational logics and business ambitions throughout Europe, the integrated plans differ substantially due to the specific conditions set by the local context in infrastructure (including physical infrastructure as well as organizational and administrative set-up) and socio-economic goals pursued.

The research in BAR-Module 2b was structured in four phases:

- Phase 1. Initial scan for identification of projects and feasible case-study regions/airports (mainly desk research and literature and database research), July 2012 - November 2013
- Phase 2. In-depth research on selected case-study concepts (field and desk research, interviews and expert workshops, compilation of data in standardized database formats), November 2012 - March 2013.
  Product: Star Maps
- Phase 3. Systematic review of selected better practises in their context (field and desk research, systemic analysis), February 2013 - April 2014.
  Product: Factsheets
- Phase 4. Synoptic review of cases and practises for drawing recommendations for the practise of planning in the “better airport region” (synoptic review expert workshops), October 2013 - June 2014.
  Product: Synopsis of Strategies for Better Airport Regions

2.2.2 Research Phase 1: Scanning European Hub airports for sustainability projects/solutions

Period: July 2012 – November 2012
Goals:
1a. Get to know sustainability projects and activities at European airports
1b. Define case-study locations from first scan

The first scan on projects followed the Stocks and Flows model presented in the Singapore-ETH Zurich Centre (SEC) on Future Cities as critical categories for sustainable development of urban contexts and urban systems:

- Stocks and Flows of Energy
- Stocks and Flows of Water

- Stocks and Flows of Materials
- Stocks and Flows of Space
- Stocks and Flows of Capital
- Stocks and Flows of Information
- Stocks and Flows of People

These categories developed from a scientific perspective, however, turned out to be difficult for scanning, since the reporting on sustainability activity at the different locations often is developed along more qualitative categories. While for "hard" categories like Energy consumption or CO_2 emissions quantitative data is available (see also section on data quality, below), "softer" categories like "flows of information" are tough to isolate.
To tackle this problem in the screening, in addition a secondary categorization was used in the initial phase of the project, which was developed in the "Airport Next" white paper and conference organized by Amsterdam Schiphol airport operating company as an antecedent activity to BAR project held in June 2012. Here a concept consisting of nine fields of engagement into sustainability are identified for airport regional urban integration (Salewski et al. 2012). These categories integrate the normative aspect of "better" (see above) and, instead of breaking down sustainability concepts to essentials stocks and flows target aims at different types of projects anchored in sustainability planning documents and reports.

Adapted to the BAR Module 2b needs six categories were used for "cross-scanning" in the first work package:

Projects dealing with
– connectivity, accessibility and proximity within spatial structure
– synergetic or reciprocal effects of airport and surrounding urban structures
– challenge of public support, acceptance and socio-cultural and socio-economic integration
– adaption of governance strategies in the region
– quality and value creation
– living and working conditions in an airport

Despite the fact, that between these dimensions a overlaps and redundancies might happen, this second set of indicator categories turned out to be very supportive in the research, since it reflects more closely the typical topics and organizational set-ups of companies and governmental institutions and competences. Thus it facilitates the identification of activities from public documents like business or governmental reports.

A total of 18 European airports were scanned in the initial phase on the base of these methodologies, 16 of which hub-airports. Two with comparable size in passenger flows (DUS and BCN) additionally were integrated into the study because of specific activity known to the researchers.

Additionally two publically accessible databases on international best practises in the field of sustainable development of infrastructures in the airport and city context were accessed in the first phase:
– "New York, Global Partners", City of New York
– "Airportmediation Database", Verein Dialogforum Flughafen Wien

At all addressed locations in Europe the airports show a noteworthy activity in the field of integration of the airport into the surrounding urban regional context can be identified. However, fields of interaction vary, as well as the systemic depth of interaction is quite different in the cases..

While reliable data on e.g. passenger flows easily can be drawn from publically accessible statistics (e.g. from IATA), most of the reporting on sustainability aspects and airport development is not standardized on a European (or even global) level.
Only if regulated by national standards like in Germany or Denmark, or if the airport operating companies commit themselves (voluntarily) to certain certification or reporting standards (like the Global Reporting Initiative) the reports follow a comparable structure and provide not only aggregated or summarizing information helpful for the research. As a result the quality of reports available differ substantially an for some of the airports no activities which can be considered "best" or "better" in their respective category in comparison to other case-study could be identified. A number of case-studies had to be dropped in the second phase due to negligible activity or non-availability of material on sustainability strategies followed.

Illustration 2.1. Overview of European hub-airports

2.2.3 Research phase 2: "Star Maps" – Examining the airport context and the spatial framework

Period: November 2012 - March 2013
Goals:
2a. Acquiring data on case-study regions, set-up of synoptic data-base
2b. Identifying and geo-referencing "better" practises in selected airport regions (star maps)
2c. Complementary first scan on AMS reference regional challenges
2d. Deployment of a refined list of critical indicators for "better" development in the regions (together with module 1ab)

In the second phase a short list of eight (later reduced to five "core") reference case studies were defined. The initial decision for AMS, FRA, MUC, ZRH, CPH, (VIE), (HEL), (DUS) was led by knowledge on better practises identified during research phase 1. While some comparable airports were excluded due to the lack of availability of information on projects, the airport systems in Paris and London as leading hub airports in Europe where excluded because of complexity reasons. However, specific projects e.g. energy production in Paris (see factsheet ORY001EN) found their way back into the study later. Other case studies were excluded later in the process, since the addressed agencies relevant to planning and spatial development in the airport and the regions could not provide sufficient material for the study.

However, limiting the study to eight case-studies in Phase 2 allowed for more in-depth profiling of the specific conditions at case-study location. For all regions a standardised representation in maps and statistics on key figures on airports and regional aspects were produced. (goal 2a)

Illustration 2.2: Amsterdam region in the standardized, GIS-based geographical database developed in BAR-Module 2b

This follows the aim of the project to make the case studies as comparable as possible, however (within this project) knowing about and accepting limitations like the inconsistency even of “standardized” material provided by Eurostat or commercial databases like information on enterprises in the region.
Airport regions profiling the work phase 2 is mainly based on data sets available in all regions, some of them harmonized in international programmes like Eurostat.

Except for information on workspace allocation or enterprises, most of the data was provided by public agencies on EU, national or regional level. Complementary to this the publically available material of Open Street Map and satellite imaging (especially sequences to get an insight into structural development) provided by Google Earth were used. To assure comparability in the representation of economic sector, this particular data was retrieved from Dunn and Breadstreet´s Bisnode Databenches, retrieved July 1st, 2013 (see remarks below).

Main sources for airport region mapping used in Phase 2:

– "European Environmental Agency Database", European Environmental Agency (data retrieved: Oct 8, 2012)
– "Eurostat Statistical Database", Eurostat (data retrieved: Oct 8, 2012)
– Open Street Map (data retrieved: Oct 8, 2012)
– Google Earth Satellite Imaging (data retrieved, June 2012 – March 2013)
– “Bisnode Basisdata“, Bisnode D&B Deutschland GmbH (data retrieved: July 1st, 2013)

Additional for AMS case (Netherlands):

- "CBS Open Data Database", Centrale Bureau voor Statistiek (data retrieved: March 22nd, 2013)
- "Nationale Georegister", Nationaal Georegister (NGR) (data retrieved: Jan 7th, 2013)
- "Noord Holland Dataportaal", Province Noord-Holland (data retrieved: Jan 7th, 2013)

Additional for CPH case (Denmark):

- "Danmarks Statistik Database", Danmarks Statistik (data retrieved: March 22nd, 2013)
- "EnergiData Online", Energistyrelsen (data retrieved: March 22nd, 2013)

Additional for FRA and MUC cases (Germany):

- "Govdata Datenportal für Deutschland", Bundesministerium des Innern (data retrieved: Jan 7th, 2013)
- "Geoportal", Bundesamt für Kartographie und Geodäsie (data retrieved: Jan 7th, 2013)
- "Regionalverband Rhein Main Datendienste", Regionalverband FrankfurtRheinMain (data retrieved: March 22nd, 2013)

Additional for VIE case (Austria):

- "Open Data Österreich", Bundeskanzleramt (data retrieved: Jan 7th, 2013)
- "Airportmediation Database", Verein Dialogforum Flughafen Wien (data retrieved: Jan 7th, 2013)

Additional for ZRH case (Switzerland):

- "swisstopo", Bundesamt für Landestopografie swisstopo (data retrieved: Jan 7th, 2013)
- „GIS–Amtliche Vermessung des Kanton Zurich“, Amt für Raumentwicklung des Kantons Zurich (data retrieved: Jul 22th, 2013)

With the focus on special thematic aspects, mainly in future planning and on business models (e.g. in energy systems), some of the airport planning departments provided additional material on special request. Typically this type of material is not publically available and handed over to the research group only on the base of signed NDAs.
As an additional source thematic material was retrieved from existing synoptic or comparative research on airport regions and selected non-profit organisations
All regional planning agencies as well as airport operators, airport region communication centres (where existing) and other critical stakeholders, like industries providing infrastructure in the region where contacted to provide reporting material and (if possible) raw data on sustainability activities and essential stocks and flows.

A comprehensive overview of all material included into the BAR module 2b studies is attached to this report in the appendices.

All practises observed and projects relevant to the study were geo-referenced and integrated into the so-called “star maps” indicating spatial patterns (goal 2b, see below).

Note: Challenges in data processing and consistency of data
Critical for the research is the spatial definition of the airport region, since the perimeter forms the reference for all statistical and geographical examinations following in the study. While other modules (e.g. BAR-Module 1ac) follow a relatively tight approach with understanding the airport region as the airport location and the neighbouring municipalities, BAR Module 2b chose for a larger reference region following the idea, that functional systems of the metropolitan regions typically are much larger and span far into the hinterlands. This idea was also followed in the EU-wide approach on creating a standard on statistics reflecting urban regions. The European harmonization in so-called LUZs (Larger Urban Zones) however is not a feasible approach for this (synoptic) study, since the definition of LUZ differ substantially from country to country, often reflecting administrative boundaries rather than functional regions. Especially in cases where the airport is relatively distant to the urban cores of the region (e.g. in MUC) this causes serious troubles in data processing, which leads to a relative incomparability esp. of topological pattern (e.g. accessibility maps of the region). Since the LUZ are typically defined within a national strategy, national borders have a critical effect on the shape of the airport region. While this makes sense when it comes to questions like settlement structure or administrative set-up, categories like noise landscapes or even organisation of e.g. logistics are represented inadequately.

Thus BAR-Module 2b decided for a definition or the airport region, which is substantially bigger than the LUZ by reviewing a circular perimeter, concentric around the airport terminal location at a distance of 50 km. Except for extremely large conurbations like in the Rhine-Ruhr area, Paris or London metropolitan areas, or airports extremely distant to the urban cores like Moscow Domodedovo Airport, this size allows for a relatively good coverage of the functional region. However most of the functional regions, esp. in FRA (in the south and the north), AMS (esp. in the south and the east, but also Zeeland) and ZRH (in the tri-national region of Basle) exceed in some parts even this large reference territorial. Where necessary for understanding additional material from outside the region was integrated into the study. Full structural data sets (maps, statistics, data benches) exist only from inside the 50km radius.
In case that the circle crosses national borders, maps and mapping styles were harmonized, a particular tricky challenge along the Swiss-German border, which exposes not only very different settlement patterns, but also completely different set-up of territorial governance and administration, however is critical for understanding airport functionality in the ZRH case study region.

In comparison to other cases in Europe especially the Swiss case in ZRH as Switzerland not being a member of European Union, and thus not following quite a lot of standardisation programmes in (geo-)data representation turned out to be challenging. Here the project reworked provided material tailored to (EU-)European standards e.g. in representing GIS–information in comparable maps. In an outstandingly supportive process and with the active help of ETH Zürich the regional government of the Canton of Zürich and the airport operator provided the requested material. Due to this process, the maps of the ZRH airport region represent a situation in July 2013, while all other material reflects the situation in January 2013.

Surprisingly the Dutch case in Schiphol AMS also turned out to be critical, since the information on economic and spatial structure of enterprise location follows a different systematics in reporting than in other countries. So locations identified in the region by standard indicators like workspaces at a certain geo-referenced location turned out to be (only) virtual hubs representing e.g. offshore locations or holding activities, creating artefacts in the maps. According to these data sets, Amsterdam region would house four times more enterprises than any other comparable region in Europe. Without having access to more comparable datasets (e.g. like social insurance or taxation data representing the actual workforce (people) located at one location), which couldn´t be provided within this project by the respective (public) agencies this substantially limited not only the research of reference cases, but also in the initial project statement declared, ultimate goal of the work package 2b: to re-translate the international finding in the AMS case. The lack of consistent GIS-data on workplaces locations compromised the project ambition to mirror locational qualities in relation to existing urban services and capacities (e.g. in transportation) accurately in the region of AMS, as done in the other reference locations. This asked for a reframing of the synoptic review in project phase 3 and 4 (see there) and lead to a stronger integration of finding from the disciplines of spatial development /regional economics and transportation planning into the overall project descriptions on reference practises and strategic recommendations drawn from the project. A spatially more concrete re-projection into AMS region however is also affected by the lack of the structural map drawn from the locational review (see section on Research Phase 3).

In general the availability of reliable statistics, e.g. on energy or traffic flows, was different from case to case, it differs in quality, reliability and consistency Especially in contexts with strong (restrictive) legislation towards ecological reporting or even ecological compensation for infrastructural projects, the reporting was more extensive than in cases with a lower degree of reporting duties. This finding goes not only for information provided by the airport itself, but also the public agencies.

Especially in reporting to the wider public the high degree of simplification and aggregation (of data) made it necessary to ask for access to raw, non-aggregated information. Due to various reasoning (e.g. confidentiality, data volume, even availability of raw data to the partners, since the processing was outsourced in previous projects (often the case with airport companies planning departments)) not all the partners were able to provide this data within the scope of the BAR – work package 2b.

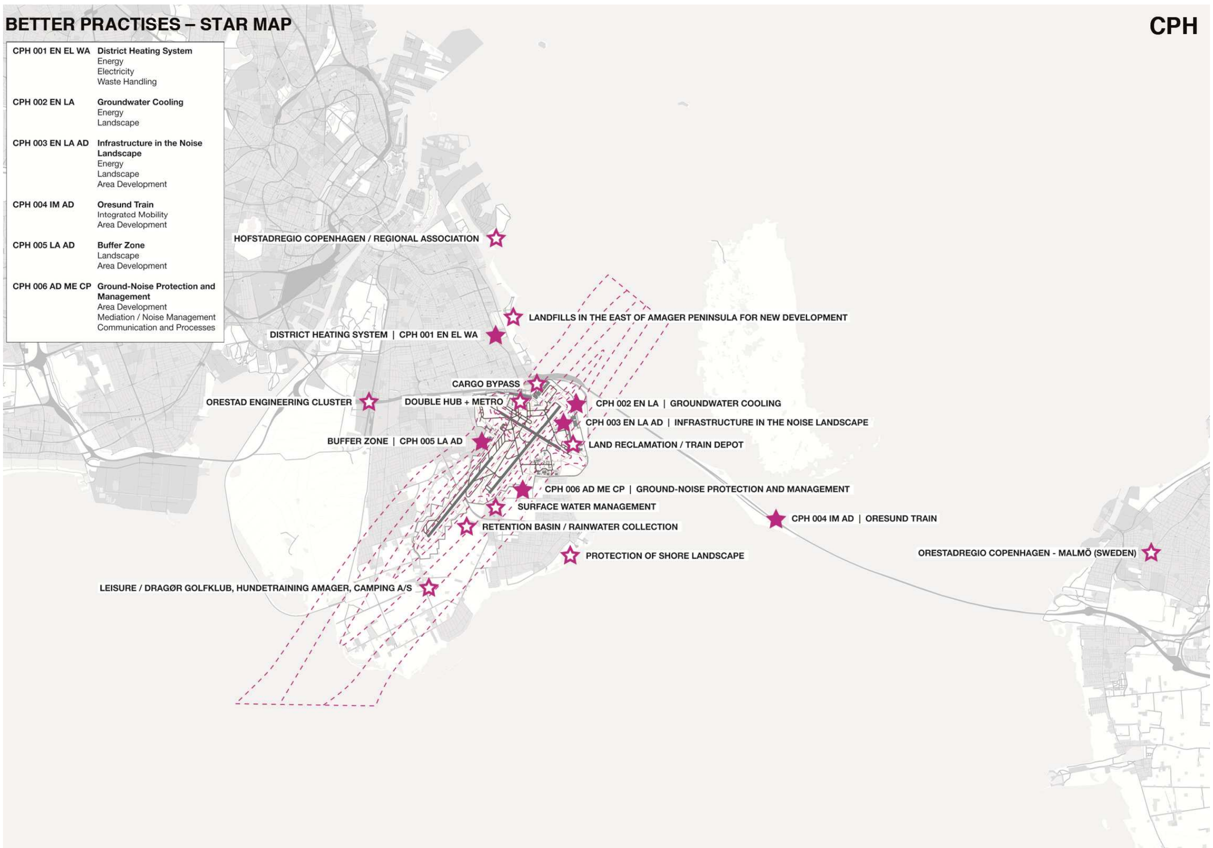


Illustration 2.3: Star Map Copenhagen

As a second goal (goal 2b) in the second project phase all sustainability activities and projects identified in the first phase of the BAR project were localized in the standardized GIS-datasets ("star maps"). This allowed for researching on typical spatial distributions and pattern for particular types of projects. Which projects are typically located within the precincts of the airport, which occur outside the airport fence? What are critical distances, e.g. in the network lengths for energy provision? Which elements should be developed in critical or direct proximity to other infrastructures for exploiting synergetic effects (significant e.g. in waste-water handling or district heating concepts, as well as in location development in real estate)? What is the scale and regional hinterland of the "better" infrastructures observed in the region?

While most of the research of the first phase was performed as desk research complemented with expert interviews, the second research package was mostly performed as a field research, following the concepts of research-by-design (see also sections on “methodology” in BAR-Module 2ac report). Performed in the AMS region in two semesters between Oct 2012 and 2013, the aim of this was the acquisition of more relevant local knowledge and to explore the specific context in regards to the different categories chosen in the initial phase of the research (goal 2c).

Together with students of the TUM Masters programmes in Architecture and Urbanism, Urbanistics and Transportation Planning, specific in-depth research was performed along the following themes:

- “Accessibility, Connectivity and Proximities in the Greater Amsterdam Region” (focus: sustainable urbanism, regional economic development, spatial planning, transportation planning (Yen/Huang))
- “Spatial-Economical dependencies in the AMS region” (focus: sustainable urbanism, regional economic development, urban services (Zeng/Yuen))
- “Local Value and Production Chains in the AMS region with a focus on airport related industries” (focus: regional economic development, urban services (Bartl/Hammes/Solano))
- “Locations of the knowledge economy in the AMS region” (focus: sustainable urbanism, landscape development, urban services (Russ))
- “Living and work environments in the AMS Region” (focus: sustainable urbanism, landscape development, urban services (Russ))
- “Landscapes in the AMS Region with a special focus on the noise landscape” (focus: Landscape planning and land-use (Artmann/Nitsche)).
- “Governance and Stakeholder Structures in the AMS Region with a special focus on organization of metropolitan rapid transit systems and (a missing) transportation association” (focus: governance and planning, regional economy, (transportation planning) (Koller/Schreiber))
- “Essential flows in the European airport regions in a synoptical perspective” (in reference to Module 1ac and goal 2d, see below (Balling/Koller))
- “Projecting European sustainability projects back into AMS region with a special focus on implementation and business plans for green energy around Schiphol airport” (Balling/Koller).

Two additional master theses in the field of urbanism, landscape and city extend on special topics within the BAR-Module 2b research:

- “Knowledge intensive business locations between urban centres and airport” (Benjamin Russ, accepted as MSc of Urbanism (TUM), accepted January 2014). This synoptic analysis integrates accessibility in the airport regions and the development of industrial structures with a special focus in the requirements of knowledge intensive industries. By this review (which due to reasons explained before) had to exclude Amsterdam region the spatial formation of airport corridors and their specific layout in the reference regions were examined. Building on a number of sources on spatial-economic development in the airport regions this thesis also integrates findings from the module 2ac (Airport backyard) in specific types of mapping the region and explains the relevance of integrated transportation concepts for the region.
- “Land-use certificates as strategic instrument of managing the noise in the airport vicinity” (working title) (Mathias Schreiber, MSc of Urbanism (TUM), to be handed in July 2014. This study expands on a planning instrument known from the US-American context to deal with the noise landscapes in the airport region. As an additional tool in land-use planning and zoning it should provide more flexibility to the municipalities neighbouring the airport to solve problems caused by airport operations.

All materials delivered by the students were reviewed within the project group and with integrating international partners (esp. form AMS region) in expert workshops. The planning department of Schiphol airport reflected the finding in workshops held at TUM. In the moment summaries of findings from these projects are under final editing and should be published as a collection in the near future together with the factsheet catalogue of BAR Module 2b.

Research Aspect	Indicator	Data needed
Carbon footprint* of ground transportation	trips to/from the airport by all "ground" modes and of different user groups: • Passengers (flying in and out) • Visitors (shopping, other) • company (drop off, pick up) • employees • freight	• Number of trips • Traveled distance • travel modes • trip purposes
Carbon footprint of air based traffic (flights and supporting vehicles like shuttles from check-in to plane)	Fuel consumption Km traveled by airplanes (on air, take off, landing, t axing?) and shuttles	• Number of flights and destinations • Type of airplanes • Distance to destinations Emission factors for different planes • Fuel consumption statistics
Definition of catchment area	Commuting of employees Commuting of passengers	• Land use maps • Population density • Location of business areas • Origin and destination of transport users (passengers, visitors and employees) • Freight hubs (last before and next after) airport?
Node	Trips to/from airport… (same as for carbon footprint of ground and air-based transportation)	•

Illustration 2.4: Excerpt (Transportation) of Critical Indicators of Sustainable Management of Essential Flows (Chart jointly developed of Module 1ab and "b).

As a fourth goal in research phase 2 (goal 2d) Module 2b worked on a coordinated list of critical indicators for sustainable management of essential flows. Due to challenges in acquiring comparable raw data on flows an amended list of indicators was agreed with Module 1ab, the collection of this material initiated as first step of phase 3.

2.2.4 Research Phase 3: Factsheets and preliminary synopsis

Period: January 2013 - April 2014
Goals:
3a. selection and in-depth review of better practises (recognition of principles, set-up and productive contextual conditions) in factsheets
3b. extraction of typical patterns and mechanisms
3c. provision of (preliminary) synoptic chart to project partners (esp. Module 1ab) for cross-integration, for 3d
3d. reframing of project categories (if needed)

The first scan of sustainability activity along the guidelines of the stocks and flows-model in project phase 1 and 2 identified a collection of approximately 120 projects in the five core case-study regions and a few more observed in other (hub-)airport regions throughout Europe. Since the fields of engagement as well as the types of projects were doubling up redundantly in the different regions examined. However, in some regions, the integration of projects seems to be more plausible or more effective than in others. In phase 3 the catalogue of practises was limited to the ones to be best in their respective categories or particularly special (as a set-up) in European comparison.

The short list of "better" practises and projects to be reviewed in the phase 3 contains 46 elements involving them in a variety of fields of the sustainable development debate in the metropolitan and airport region. (for a listing see below).

For all of the projects reviewed a standardized factsheet was produced, providing not only facts and descriptions on project set-up and functional principles, but also an indication spatial (and scale) aspects (in maps and diagrams), stakeholder set-up and "betters", reflecting on performance in indicators for more sustainable development in the airport region (goal 3a and 3b). The section "appreciation of values" discusses potentials of the respective approach. All major sources for the information are indexed on the factsheets. Where relevant, linkages to other better practises or comparable approaches at other airport locations are mentioned, which allows for better comparability.

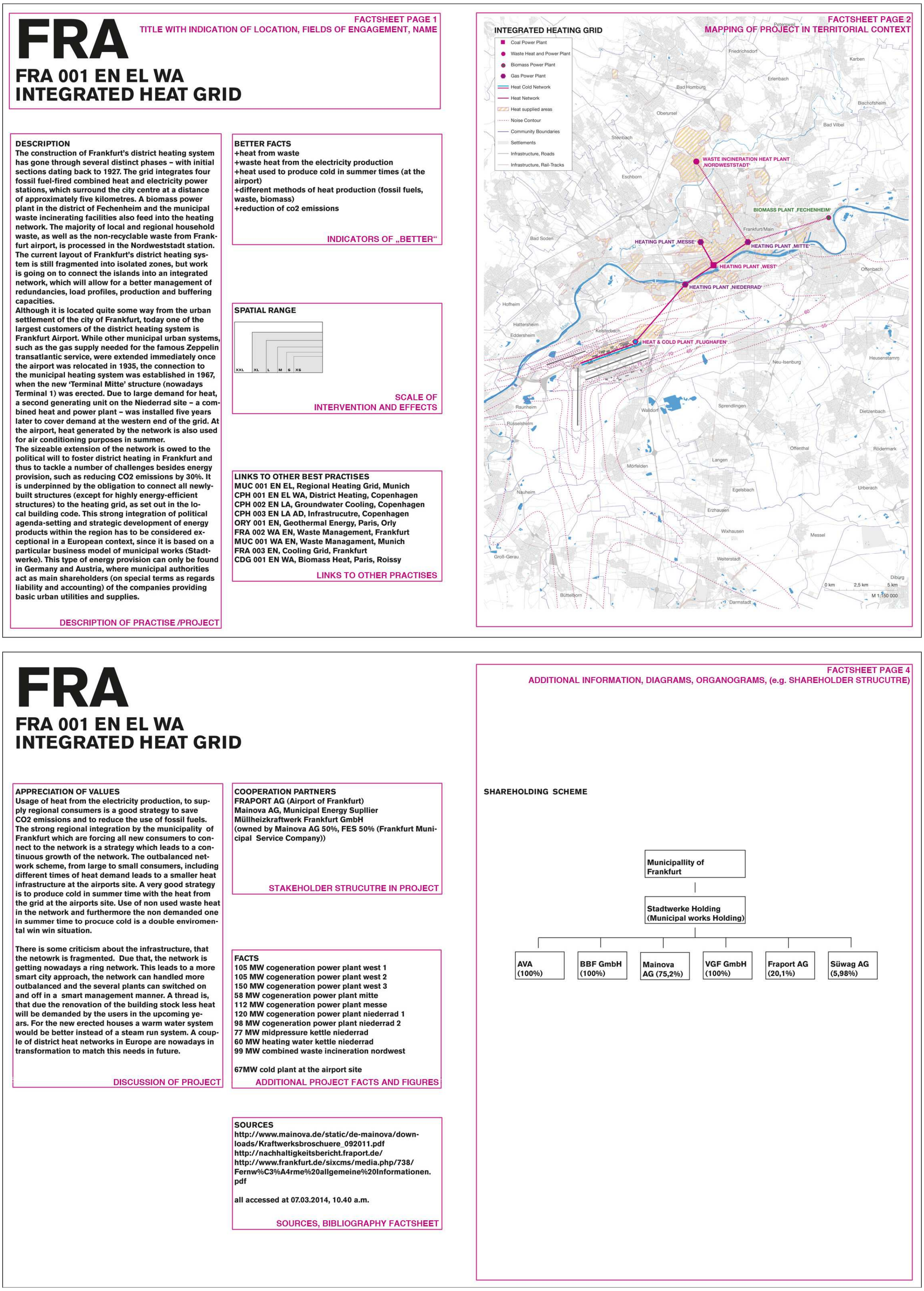
As already assumed in phase one of the project only a few projects have an effect only in one category of the stocks and flows, indeed all "better practises" and projects address a multitude of topics, which made a reframing of categories necessary.
On the base of a preliminary synoptic overview chart of reference practises observed presented to the partners from BAR-Module 1b in October 2013 an final proposal was prepared for the scientific workshop held by all partners in Munich in January 2014 (goal 3c). Here comments from all researchers were integrated into the reframing of categories for the final catalogue of reference practises and project in the following manner (goal 3d).

Project Categories: Better Airport Regions Reference Case studies

- EN – Energy (heat & cold provision, geothermal energy usage, lowering consumption, energy production and buffering, load peak management for making better use of capacities in the network)
- WA – Waste handling (waste avoidance, recycling, local waste handling scheme, waste incineration)
- WH – Water handling (surface water management, groundwater regime, grey water/ process water usage, waste water regeneration and management, special focus on the environmentally and economically critical de-icing liquids)
- EL – Electricity (efficiency, central provision of electricity/AC at airside, electrification of process e.g. on ground transportation for reduction of CO_2 emissions, solar power production)
- IM – Integrated mobility (regional transport authorities or regional transport association, integration into high performance rail networks (local to international), regional and area development following TOD schemes, provision of alternative transportations modes like cycling, car sharing, enhancing landside service quality by integration of processes, e.g. check-in, handling of goods)
- LG – Logistics (smoother handling of flows of goods and organisation of logistics both air- and landside, freight concepts and integrated services esp. for perishables and high-value goods.
- AS – Provision of Additional Services on the landside in the airport location (service hubs, collaborative retail concept in conjunction with regional development and planning, horeca-services, conference and office locations)
- AD – Area development (TOD, integration and redevelopment strategies with existing urban fabric, co-founding strategies for development of public infrastructure, alliances for joint development, strategic planning and marketing, development of recreational spaces with strategic direction of (ecological) compensation funds and budgets from the airport, leisure zones)
- LA – Landscape (securing and developing ecological and socio-economic value of buffer zones, responsive zoning in security and nuisance perimeter, production and recycling of biomass, landscape design for ground noise control)
- ME – Mediation/ Noise management (assessment, planning and qualification programmes for structures within the noise perimeter, monitoring and controlling programs, flight regime optimization
- CP – Communications and Process management (advanced concepts in reporting monitoring and planning processes, mediation or participation processes, new governmental set-up for airport regional challenges)

Factsheet titles are composed by, 1. an indication of the airport region by IATA code, 2. a sequence number which allows for easy reference in the star maps and future extension of the collection of factsheets. As a third element the significance within the fields of engagement is indicated by the use of the abbreviations indicate in the listing presented above. If relevant for more than one category, more elements can be integrated into the title. The last element is the specific name or label of the project (e.g. ZRH 001 EN EL AC/400Hz Network).

While in the reporting documents only an overview of projects can be provided, a selection of detailed factsheets is attached to the document in the appendices.



FRA

FACTSHEET PAGE 1

TITLE WITH INDICATION OF LOCATION, FIELDS OF ENGAGEMENT, NAME

FRA 001 EN EL WA
INTEGRATED HEAT GRID

DESCRIPTION

The construction of Frankfurt's district heating system has gone through several distinct phases – with initial sections dating back to 1927. The grid integrates four fossil fuel-fired combined heat and electricity power stations, which surround the city centre at a distance of approximately five kilometres. A biomass power plant in the district of Fechenheim and the municipal waste incinerating facilities also feed into the heating network. The majority of local and regional household waste, as well as the non-recyclable waste from Frankfurt airport, is processed in the Nordweststadt station. The current layout of Frankfurt's district heating system is still fragmented into isolated zones, but work is going on to connect the islands into an integrated network, which will allow for a better management of redundancies, load profiles, production and buffering capacities.

Although it is located quite some way from the urban settlement of the city of Frankfurt, today one of the largest customers of the district heating system is Frankfurt Airport. While other municipal urban systems, such as the gas supply needed for the famous Zeppelin transatlantic service, were extended immediately once the airport was relocated in 1935, the connection to the municipal heating system was established in 1967, when the new 'Terminal Mitte' structure (nowadays Terminal 1) was erected. Due to large demand for heat, a second generating unit on the Niederrad site – a combined heat and power plant – was installed five years later to cover demand at the western end of the grid. At the airport, heat generated by the network is also used for air conditioning purposes in summer.

The sizeable extension of the network is owed to the political will to foster district heating in Frankfurt and thus to tackle a number of challenges besides energy provision, such as reducing CO2 emissions by 30%. It is underpinned by the obligation to connect all newly-built structures (except for highly energy-efficient structures) to the heating grid, as set out in the local building code. This strong integration of political agenda-setting and strategic development of energy products within the region has to be considered exceptional in a European context, since it is based on a particular business model of municipal works (Stadtwerke). This type of energy provision can only be found in Germany and Austria, where municipal authorities act as main shareholders (on special terms as regards liability and accounting) of the companies providing basic urban utilities and supplies.

DESCRIPTION OF PRACTISE /PROJECT

BETTER FACTS

+heat from waste
+waste heat from the electricity production
+heat used to produce cold in summer times (at the airport)
+different methods of heat production (fossil fuels, waste, biomass)
+reduction of co2 emissions

INDICATORS OF „BETTER“

SPATIAL RANGE

XXL XL L M S XS

SCALE OF INTERVENTION AND EFFECTS

LINKS TO OTHER BEST PRACTISES

MUC 001 EN EL, Regional Heating Grid, Munich
CPH 001 EN EL WA, District Heating, Copenhagen
CPH 002 EN LA, Groundwater Cooling, Copenhagen
CPH 003 EN LA AD, Infrastrucutre, Copenhagen
ORY 001 EN, Geothermal Energy, Paris, Orly
FRA 002 WA EN, Waste Management, Frankfurt
MUC 001 WA EN, Waste Managament, Munich
FRA 003 EN, Cooling Grid, Frankfurt
CDG 001 EN WA, Biomass Heat, Paris, Roissy

LINKS TO OTHER PRACTISES

FACTSHEET PAGE 2

MAPPING OF PROJECT IN TERRITORIAL CONTEXT

FRA

FRA 001 EN EL WA
INTEGRATED HEAT GRID

APPRECIATION OF VALUES

Usage of heat from the electricity production, to supply regional consumers is a good strategy to save CO2 emissions and to reduce the use of fossil fuels. The strong regional integration by the municipality of Frankfurt which are forcing all new consumers to connect to the network is a strategy which leads to a continuous growth of the network. The outbalanced network scheme, from large to small consumers, including different times of heat demand leads to a smaller heat infrastructure at the airports site. A very good strategy is to produce cold in summer time with the heat from the grid at the airports site. Use of non used waste heat in the network and furthermore the non demanded one in summer time to procuce cold is a double enviromental win win situation.

There is some criticism about the infrastructure, that the netowrk is fragmented. Due that, the network is getting nowadays a ring network. This leads to a more smart city approach, the network can handled more outbalanced and the several plants can switched on and off in a smart management manner. A thread is, that due the renovation of the building stock less heat will be demanded by the users in the upcoming years. For the new erected houses a warm water system would be better instead of a steam run system. A couple of district heat networks in Europe are nowadays in transformation to match this needs in future.

DISCUSSION OF PROJECT

COOPERATION PARTNERS

FRAPORT AG (Airport of Frankfurt)
Mainova AG, Municipal Energy Supllier
Müllheizkraftwerk Frankfurt GmbH
(owned by Mainova AG 50%, FES 50% (Frankfurt Municipal Service Company))

STAKEHOLDER STRUCUTRE IN PROJECT

FACTS

105 MW cogeneration power plant west 1
105 MW cogeneration power plant west 2
150 MW cogeneration power plant west 3
58 MW cogeneration power plant mitte
112 MW cogeneration power plant messe
120 MW cogeneration power plant niederrad 1
98 MW cogeneration power plant niederrad 2
77 MW midpressure kettle niederrad
60 MW heating water kettle niederrad
99 MW combined waste incineration nordwest

67MW cold plant at the airport site

ADDITIONAL PROJECT FACTS AND FIGURES

SOURCES

http://www.mainova.de/static/de-mainova/downloads/Kraftwerksbroschuere_092011.pdf
http://nachhaltigkeitsbericht.fraport.de/
http://www.frankfurt.de/sixcms/media.php/738/Fernw%C3%A4rme%20allgemeine%20Informationen.pdf

all accessed at 07.03.2014, 10.40 a.m.

SOURCES, BIBLIOGRAPHY FACTSHEET

FACTSHEET PAGE 4

ADDITIONAL INFORMATION, DIAGRAMS, ORGANOGRAMS, (e.g. SHAREHOLDER STRUCUTRE)

SHAREHOLDING SCHEME

Illustration 2.5: Miniature of exemplary Factsheet (FRA 001 EN EL WA Integrated Heating Grid

Overview of Factsheets of the reference catalogue (sorted by location):

Amsterdam

AMS 001 LA	Biomass Production
AMS 002 IM AD	Tangential Bus 3xx
AMS 003 LG	Flower Auction
AMS 004 AD LA IM	SADC Development Company
AMS 005 LA AD	Buffer Zoning
AMS 006 ME LA	Ground-Noise Protection
AMS 007 ME CP	Nuisance and Disturbance Monitoring

Copenhagen

CPH 001 EN EL WA	District Heating System
CPH 002 EN LA	Groundwater Cooling
CPH 003 EN LA AD	Infrastructure in the Noise Landscape
CPH 004 IM AD	Oresund Train
CPH 005 LA AD	Buffer Zone
CPH 006 AD ME CP	Ground-Noise Protection and Management

Frankfurt

FRA 001 EN EL WA	Integrated Heating Grid
FRA 002 WA EN	Waste Management
FRA 003 EN	Cooling Grid
FRA 004 WH	Process Water System
FRA 005 WH WA EN	Waste Water Management
FRA 006 EL IM LG	Electric Mobility
FRA 007 IM AD	Transport Association (RMV)
FRA 008 IM AD	Regional Tangent West
FRA 009 LG	Perishable Center
FRA 010 AD AS	Airport City Development
FRA 011 IM AD CP	Co-Funding Models
FRA 012 AD LA IM WA EN CP	Regional Association
FRA 013 LA AD	Regional Park Rhein Main
FRA 014 ME CP	Mediation Center (Umwelthaus)
FRA 015 AD ME CP	CASA Programme

Helsinki

HEL 001 IM AD	Ring Rail
HEL 002 AD AS CP	Aviapolis Development Company

Munich

MUC 001 EN EL WA	Regional Heating Grid
MUC 002 WA EN	Waste Management
MUC 003 EL	Solar Energy
MUC 004 WH WA EN EL	Wastewater Corporation
MUC 005 WH WA EN	De-Icing Recycling
MUC 006 EL	Ramp Lighting
MUC 007 AS AD	Local Products

Zurich

ZRH 001 EL EN	AC/400Hz Network
ZRH 002 IM AD	Glattalbahn Light Railway
ZRH 003 AS AD	Integrated Retail Concepts
ZRH 004 AD AS	Airport City Development

Paris – CDG
CDG 001 EN WA Renewable Heating

Dusseldorf
DUS 001 AS AD Conference and Convention Facilities

Paris – ORY
ORY 001 EN Geothermal Energy

Vienna
VIE 001 IM City Airport Train
VIE 002 ME CP Mediation Strategy

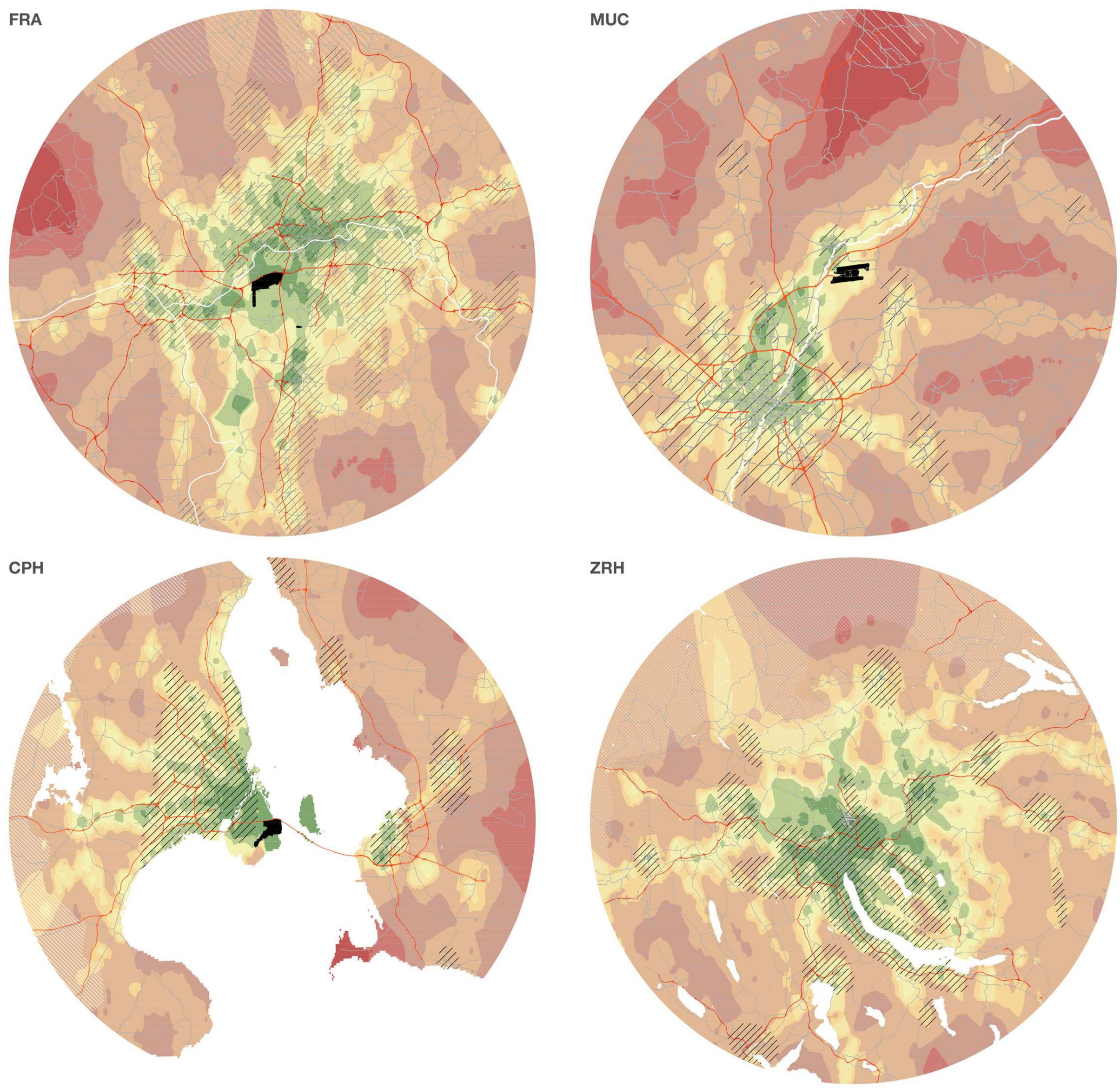


Illustration 2.6: Synoptic review of development potentials for knowledge economy locations in airport regions in conjunction with accessibility patterns in the region.

2.2.5 Research Phase 4: Synoptic Review and Conclusion: Principles for Better Airport Regions

Period: October 2013 - June 2014
Goals:
4a. synoptic and thematic review of references cases
4b. concluding on project types, organizational principles or business plans for sustainable solution by synoptic review of international practises identified.

The theoretical potentials for projects and strategies in the field of sustainability development and projects pursued in practise differ quite substantially. The reasons for that are manifold and cannot be described in this study exhaustively. However, the in-depth review of successfully implemented practises and project at various locations gave an insight into critical aspects, which factor in the decision for or against a project. While in the first research phases the question “What types of projects exist in the European context?” was in in the focus, the synoptic review of phase 4 aimed at: “What particular organisational principles or socioeconomic drivers boost the development of integrated projects in the field of airport and urban regional integration, which hamper collaboration?”

The specific set-up of GIS database allowed not only for creating synoptic sets- of maps on thematic issues but also allows for spatial overlay of reference practises in a region, which might help in the future to identify critical location for system integration. This is exemplarily illustrated in the following two maps, showing, a) synoptic review of development potentials for knowledge economy locations in airport regions in conjunction with accessibility patterns in the region, b) Overlay of infrastructures on Energy and Water handling in the MUC region with labelling of infrastructural elements critical to system integration.

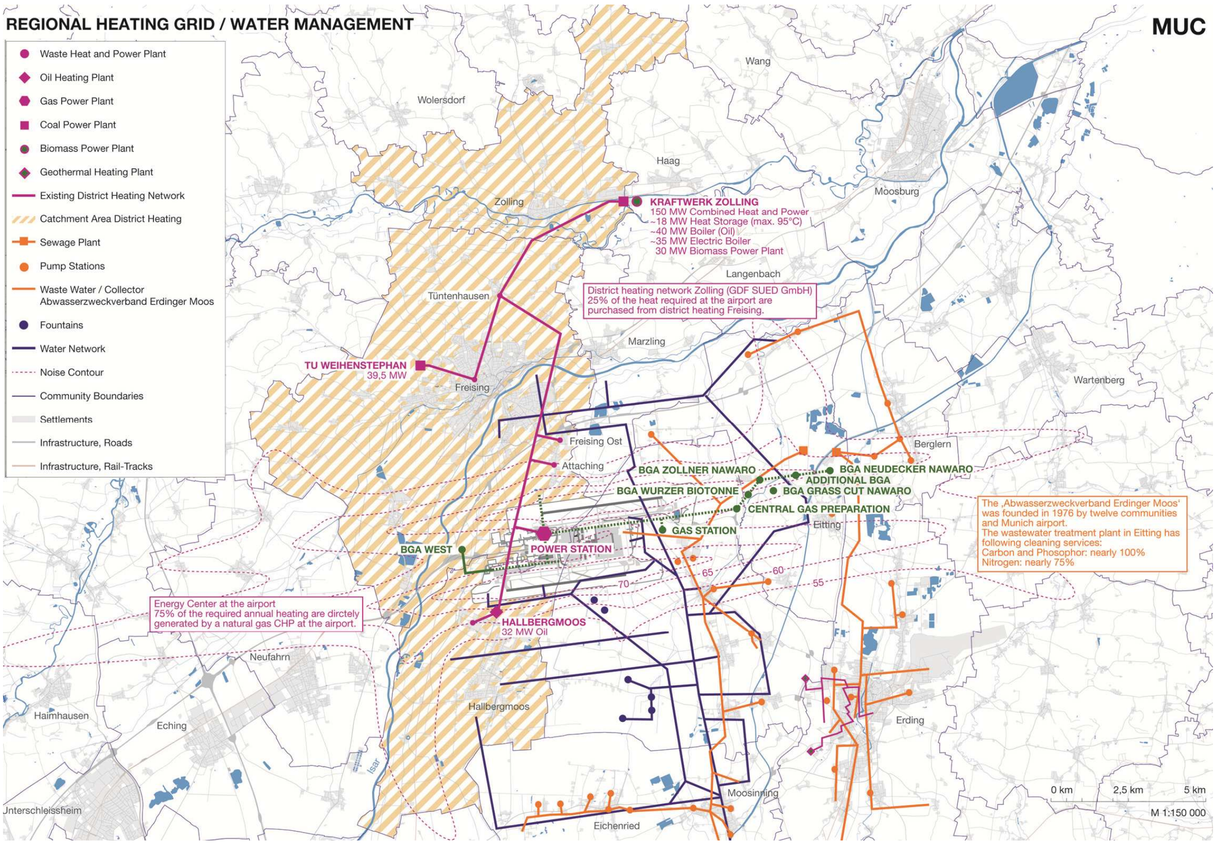


Illustration 2.7: Overlay of infrastructures on Energy and Water handling in the MUC region with labelling of infrastructural elements critical to system integration

In the final phase the findings were distilled into theses, also used in the Serious Gaming workshops (by BAR Module 1cd) in the April 2014 workshops. The results of the synoptic review are presented in this report in a summarizing way as conclusions to the BAR-Module 2b research project..

2.3 Conclusions

2.3.1 Conclusion 1: Governance (Model) matters – What institutional frameworks are most productive towards sustainability projects?

Generally spoken and quite simplified only two types of projects were successfully implemented: Projects are identified in situations, where either

– a clear win-win-situation, beneficiary not only to the (regional) system as an entirety but also each of the contributing parties and stakeholders can be displayed convincingly, or
– new regulations, e.g. on environmental aspects ask for a creative questioning of established paths followed.

Obviously the governance context of the airport region and airport operations legislation especially in this field has a strong influence on the activity towards integration.
Most of the activity towards sustainability projects unfolds in the regions with strong body of regulations, e.g. on ecological compensation (e.g. in CPH, MUC, ZRH) or reporting duties.
Aside from change on (public) legislation on ecological or sustainability aspects, transformation processes like extensions to the infrastructure or operational changes were used by the approving authority to implement new standards (e.g. FRA 014 ME CP Mediation Center (Umwelthaus)). However, this explains only partly the fact, that in sociocultural/-economic contexts tackling the sustainability challenges with a strong regulative framework more and often more comprehensive approaches and projects were identified.

As a second critical factor, the shareholder structure has a substantial influence on activities. In most of the cases researched the public sector is also shareholder in the airport company operating in a private (liberalized) market environment . Facing a lot of challenges in acceptance of the airport, during the last years the shareholders are more aware of public opinion, thus in majority are interested in reflecting on long-term goals discussed in societal debate. How critical an erroneous reflection of the public debate can be in this stakeholder set-up can be observed in the failed public vote on the Munich Airport extension in 2013.
While the dual role of the public sector in this business set-up, being shareholder and, at the same time, acting as the representative of the public authority might be productive for sustainability projects, this duality is also challenging.
The competitive business perspective unfolds on the base of very different goals and timetables. For managing this problem, in most of the airport locations reviewed specific governmental and administrative set-up alien to non-airport-regions where established. While having special regulations in planning and integration at the airport site itself is a standard, in regions like AMS or FRA a more regional and overarching approach was sought after. Represented in all kind of institutions and regulations, but also new forms of public-private collaborations these set-up were most productive in different fields, e.g. in area development as long as collaboration created new value, which then could be distributed to all joint partners. If being only voluntary, consensual set-ups without formalized competences (e.g. in planning) these institutions parallel to official administrative setup turned out to be inappropriate set-ups when managing conflictive topics. The Regionalverband (FRA 012 AD LA IM WA EN CP Regional Association) illustrates a governmental approach to overcome this problem. However, this complex modification to the whole of territorial-administrative set-up of the state of Hesse in a new public institution has to be considered a unique case, most probably possible only against the backdrop of the hefty disputes on airport extensions in the densely settled Rhein-Main region.

2.3.2 Conclusion 2: Stakeholder Structure matters – Who is willing to invest?

As already illustrated in the “governance” section, the stakeholder structure of an airport is crucial for sustainability projects, since it has a critical impact on investment strategies in a market driven environment. Often sustainability projects interdepend critically with reconstruction cycles of airport infrastructures and are economically beneficiary only on the long-run.
For the public sector being shareholder this is less critical, than for private sector investment. Here the (typically) shorter investments cycles limit project activity to projects, which pay off on a short-term base (e.g. MUC 006 EL Ramp Lighting). A review on the potential for future investment in sustainability projects prepared by the Munich Airport Operator strikingly illustrates the necessity to integrate the business perspective stronger into project evaluation.
To overcome this challenge public support in form of subsidies often can have a catalysing effect, however also might be counterproductive as to be observed in some cases where e.g. subsidized energy pricing is affected. As a result projects in this sector often do not pay-off, and substantial activity can only be observed, where a change of e.g. subsidizing system sets an economic pressure on stakeholders in the area. However, subsidy reduction has to be handled carefully, since it can have negative rebound effects. In example, solar power production only makes sense for the airport operators if the produced energy can be fed into the public networks, which already provides moderation and buffering facilities and guarantees a certain feeding remuneration. A local (more direct) use of produced energy would be to cost intensive, low buyback prices however lead to insufficient return on investments.
These finding might lead to the assumption, that the engagement of the public sector in the stakeholder structure is key. Against all odds this assumption is not completely right, since (e.g. in the CPH cases) where a long-term oriented development strategy answers the requests of a (quite particular) shareholder structure, dominated by (international) pensions fund societies, which target a long-term investment strategy, aiming more on securing value of investment instead of high performance and interest rates.

2.3.3 Conclusion 3: Timeframe matters – Incremental investment or big leap forward?

As illustrated in the “stakeholder” section, the timeframe of reference factors critically in the investment balance, often allowing only for small-scale intervention, which pays of quickly. However, a second issue should be raised concerning the design of a smart timeline for implementation of projects. From the review of projects there is no clear statement can be drawn, whether an incremental implementation of projects or a larger “leap” forward is more beneficial in the total sustainability balance of a project. Here a more individual evaluation is necessary. While legislative processes often opt for the first strategy (e.g. 20% savings on CO2 in 2016, 30% in 2020, 40% in 2025) from a business investment perspective this often does not make sense. Investment cycles into infrastructure typically are much longer (e.g. up to more than 40 years in the field of energy and water infrastructure). Incremental escalation of standards thus often leads to “bricolage” solutions, while by larger projects (well integrated into reconstruction/maintenance cycles of the infrastructure) which question the entire concept large yields can be achieved. As demonstrated in the in-depth review of practises (e.g. FRA 004 WA Process Water System), often only a generation after having a technology available the implementation makes sense, since is corresponds with economic windows of opportunity given by rhythms of infrastructural renewal. In such a revolutionary approach systemic gains might be that substantial, that “waiting for” a larger reconstruction might pay-off not only financially, but also in total energy or emissions balance.
It is not surprising that all complex integration processes (e.g. in the energy grid) are in conjunction with new construction (like MUC) or corresponding with redevelopment measures on the infrastructure of the airport or the surrounding urban systems. A clear scenario planning (until now often rejected or underused in its potential by planning agencies) and agenda setting aligned with infrastructural renewal cycles (20/40 years) might help in the future to mirror the upcoming challenges. Here a jointly developed, clear, adaptable and reliable governmental framework might ease situation for private investment into sustainability solutions.

2.3.4 Conclusion 4: System Integration matters – Which systems to be coupled with others?

As shown in section on “timeframes”, the coordination of action matters. This is important in particular where a more complex stakeholder set-up is key to success. In the airport regions and metropolitan areas it has become most obvious, that e.g. in the field transportation a well-integrated approach, often reflected in regional transport associations is key not only to smooth operation convenient to the passenger, but also to future development of settlement area, which under a sustainability perspective is reciprocally linked to the structural accessibility patterns in the region.
Coupling an existing energy or transportation network with another one is not only a technically challenging task, but also tricky when it comes to organization of operation of systems. As shown in the MUC Solar Power case this might submit to an economical reasoning or might have capacity reasons like in the FRA surface water handling strategy (FRA 005 WH WA EN Process Water System and FRA 005 WA EN Wastewater Management). However another major risk and challenge is the reliability of the system. The complex set-up of the Danish regional heating grid (CPH 001 EN EL WA District Heating System) might only be understood if e.g. risks in the system are evaluated. In an integrated system like the one mentioned redundancy gets an all-new meaning. Here, network integration might be only possible if (on a larger scale) a new concept for peak load handling, buffer and systems redundancy solutions is integrated into national planning on infrastructure. As an illustration (not reviewed in the BAR-Module 2b) the freshwater infrastructure in the canton of Zurich might be mentioned, which completely redundant in its layout, allows for e.g. lowering standards on fire protection of buildings.
Potentials of qualification for redundancy of networks in energy (heat, power) which lie in the basic conception of the system, have to be evaluated in a more comprehensive study but might lead to substantial systemic gains on essential flows (Module 1ab).

2.3.5 Conclusion 5: Communication matters – Who knows what?

“System integration” as proposed in the previous section however does only work out, if there is access to a common knowledge base. Until now reporting standards differ substantially and (publically) available material often is limited to aggregated information, reflecting the reporters´ perspective rather than allowing for a systematic reflection of processes. The initiatives in Vienna and New York (see Research Phase 1) as well as the Umwelthaus in Frankfurt (FRA 014 ME CP Mediation Center (Umwelthaus)) are valuable attempts to create this base of knowledge. EU-wide Open Data projects are only recently supported aim at capacity building in the field. However, some airport operators as well as infrastructure companies still show a certain reservation in providing access to this strategic information, very often identifying a critical reception of their plans in societal debate. This observation has to be confirmed by the study. However, as a positive side effect of the above mentioned initiatives it could be observed, that an open policy towards information raises acceptance towards airport activities in the public debate and by that has a positive effect on the progression of e.g. planning and approval procedures, which allows for swifter and smoother implementation of projects along a sustainability path of the airport and the airport region.

3. Essential flows – closing cycles

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Table of Content

3.1 Introduction

From a systems approach, the performance of large international airports – as *sub*systems of the metropolitan areas they are located in – can be considered unsustainable with regard to the essential resources that drive those airports; their metabolism[1]. Firstly, because airports in general depend greatly on external supply and disposal. Secondly, these resources flow predominantly *linear*, as opposed to *circular*, whilst externalising both the negative and positive impacts associated with them. Moreover, qualitative and quantitative understanding regarding the throughput of these flows is often incomplete and the related data fragmented i.e. distributed over multiple actors within the system that comprises the airport. These conditions are indicative for the relationship of the airport with the larger system it is inherently part of. Anticipation of the interdependence between individual entities in a region or system seems hindered by vested interests. According to Rotmans [2006], an emphasis on sectorial concerns within individual policies prevails, whereas a multi-dimensional, integrated approach is required for sustainable and mutually beneficial systems. There is as strong a segregation between the various participants, as there is between the various disciplines, concerning solutions for matters including generation of renewable energy, 'sustainable water management' and the development of the necessary waste/material management. In the first few years after the energy crisis, the energy policy was also strongly characterized by institutional fragmentation. Until now, most research projects on environment related flows of energy, water, waste, nutrients and materials do not make any attempt to rise above the compartmentalized policy domains. Many well-meant initiatives stick in thematic and effect-oriented solutions without reaching a certain degree of integration or added value of environmental measures. The corresponding infrastructure is often restricted to transport infrastructure with its own status, dominant parties involved and path-dependent policy [Timmeren, 2006]. It is therefore necessary to take an *Urban Metabolism* perspective as a guiding principle in the interaction between integrated ecosystems on the one hand and ecosystems in which the created technical system performs on the other. Such an integrated approach means cutting across boundaries and disciplines in order to gain new insight and skills.

One of the prerequisites of the Better Airport Regions (BAR) project is a better understanding of the performance and dynamic relations regarding essential resource flows and their infrastructures in airport regions, whilst touching upon technical, spatial, organisational and institutional aspects. This chapter presents and reflects on the results from predominantly technical studies, which form the input for other BAR modules that focus on spatial development on the one hand and organisational and institutional frameworks on the other. The main research question that forms the rationale behind this chapter is formulated as follows:

Taking into account contextual characteristics, such as climate, human and physical geograhy, production/consumption systems and development plans, which potentials can be identified that facilitate the shift to renewable, circular resource flow systems on the one hand, and enhanced reciprocity between the airport and its surroundings on the other?

3.2 Methodology for essential flows in airport regions

Figure 3.1 visualises the methodical steps for analysing and mapping the resource flows relevant to the performed case study of Amsterdam Airport Schiphol. We applied an iterative method, in line with the dynamics around acquiring knowledge necessary for advancing in the research. In the first stage the context of the study was laid out, area boundaries were set and resource flows determined. The inventory stage subsequently comprised: i) system analysis, ii) initial flow charts, and iii) data collection. In a parallel track the quality of data was assessed and monitored to check whether the findings were in line with the goal and scope or adjustments were required. An interpretation and evaluation stage, in turn, induced a reiteration of specific process steps. The data generated were input for flow maps and potential maps. Furthermore, these data contributed to an indication of ways in which the various flows are – or could be – interconnected. Several geographic and thematic areas were detected with specific opportunities. These '*hotspot zones'* dictated a

[1] The concept of metabolism is expanded by Tansley [1935] from living cells to the inclusion of material and energetic flows for inorganic construction of settlements [Newman, 1999]. This so-called 'Urban metabolism' (UM) is a framework for modelling complex urban systems' and energy flows as if the city were an ecosystem.

tailor-made analysis, of which the results are precursors for generic lessons, potentially applicable in other regions as well.

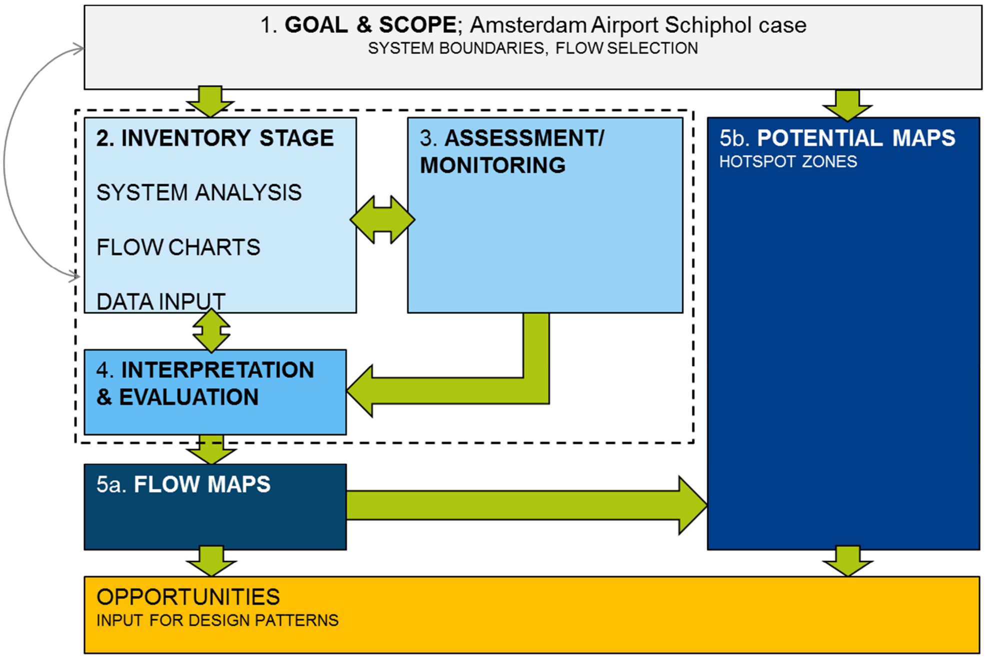


Figure 3.1: Research methodology

3.2.1 Goal and Scope

Flow selection

A preliminary selection focused on the following critical flows: energy, materials, water, food, and waste.[2] The energy flow has been divided in electricity, thermal energy and transport energy, leading to a focus on the energy carriers of electricity, gas, and combustion fuels. Associated indicators are related to the annual use. To measure and compare the energy involved in the different carriers this use was indicated in Joules (J). The term 'materials' is actually an overarching label for a large, heterogeneous array of categories and subcategories. Context and time restrictions considered, the selection was narrowed down to the packaging materials that constantly flow through the airport. Primary packaging materials are paper/cardboard, glass, and plastics. Recycling rates for paper/cardboard and glass packaging – in Europe – are currently around 70% [FEVE, 2013; ERPC, 2013], whereas the European Association of Plastics Recycling and Recovery Organisations indicated the following breakdown for packaging plastics: 33% recycling, 33% energy recovery, 33% landfill [EPRO 2013]. Various studies show that significant improvements can be made regarding the recycling of plastics [e.g. Morris, 1996; CE, 2011]. Moreover, 'plastic packaging materials' is a high-potential group for bio-based economy endeavours. For these reasons we focused primarily on plastic packaging materials. The unit used was kg/year. With regard to water, the emphasis was on wastewater, as this flow indicates to an important extent the consumption of water in the given system.[3] This was measured in m^3, litres and annual pollution units. Food consumption was measured in kg per year, and divided in six food groups: carbohydrates, vegetables, fruits & nuts, meat products, fish products, and dairy products. Regarding the waste flow, the following main categories were discerned: packaging material fractions in solid waste, organic waste and mixed waste. The unit used was kg/year.

2 The flow of people, obviously a key flow in the airport region, is further elaborated in other sections
3 Moreover, wastewater is a medium that carries a myriad of substances, whilst bearing multiple cross references with other flows

Soft spaces and area boundaries

Given Schiphol's action radius and the many interactions with its surroundings, on multiple levels, the airport region cannot be a well-defined area with clear borders. As one of Europe's most important air travel hubs the flows in and out of Schiphol do have a global span. The different essential resource flows we investigated also vary in their area boundaries; solid waste from Schiphol, for example, is processed all over the Netherlands, whereas waste water, on the other hand, is dealt with either on the airport itself or in its direct surroundings. The same variance was found when looking at the actors and administrative levels involved.

As the emphasis lies on an integrated approach towards area development rather than detailed mass balances of flows, we followed an approach that Haughton, Allmendinger & Counsell [2009] described for the new spatial planning, namely to work with 'soft spaces' and 'fuzzy boundaries'. Haughton et al understand soft spaces as policy spaces, which are not bound to statutory boundaries and therefore 'encourage more creative thinking, unconstrained by regulation and national guidance, and providing greater opportunities for a range of non-planning actors to engage productively with planning processes' [ibid, 240]. Following this argument, two aspects guided our definition of the area: i) current flows of essential resources from and to Schiphol and ii) the strategic decision that areas which are in particular affected negatively by the airport – noise, limits to (urban) development, etc. – should benefit from potential positive effects of circular resource flow solutions.

Thus, central to this study was Schiphol and its direct region, in particular the municipality of Haarlemmermeer but also the other surrounding municipalities, see Figure 3.2. Schiphol was defined as the 1st level 'nucleus' system, subject to a detailed flow analysis. The 2nd level area follows the borders of the municipalities that directly surround Schiphol. This area was subject to a general analysis of the flows. Next, by means of designated hotspot zones, the required levels of detail for the analyses were further defined.

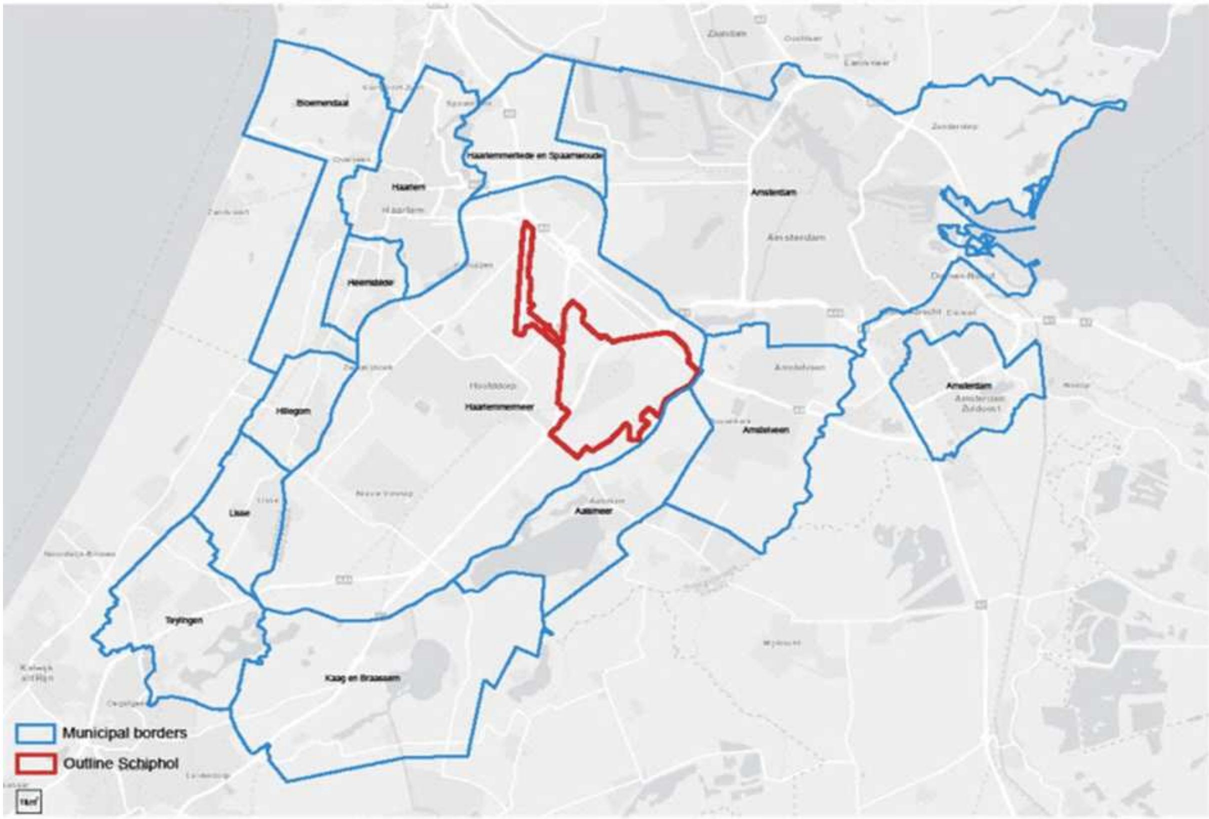


Figure 3.2: System boundaries of the Schiphol region

3.2.3 Inventory of the essential resource flows

During this stage, an extensive analysis was made concerning the current supply and demand patterns of the studied resource flows. Important data sources were, among many others, Schiphol Group, local authorities, regional administration offices, waste contractors, water boards, energy companies, branch organisations, GIS based software and map material, and statistical bureaus. Via interviews, desk research, expert judgment, best estimates and hands-on knowledge critical data were collected that helped gain insight in qualitative and quantitative aspects of the various flow patterns.

This stage also included an analysis of the local characteristics. Basic information has been collected of matters such as climate, topography, landscape, land use, infrastructure, and governance. For example, the local climate was essential for the determination of solar and wind energy potentials, land use gave a clue to the possibilities of harvesting this solar and wind energy, and information on governance provided a grasp of the dynamics regarding policy and decision makers that play a key role in resource flow management and sustainable development transitions. Furthermore, a survey of regional functions was required to get a picture of potential exchange of flows. In order to keep the inventory manageable, generic values of demand and supply were used where possible. However, for some functions specific processes and characteristics were studied in greater detail, using the most recent data available.

Mapping
Mapping evolved through the process of data sourcing, deduction and association. The generated GIS maps visualise areas with specific flows or buffers, for example, and evoke measures to be taken for closing cycles or connecting chains. Via these maps data of quantity, quality and location of demand and supply, as well related routes and infrastructure, has been made accessible and visible. This gave more insight in the spatial characteristics of the current flows and their infrastructures, and of potential interventions. Mapping the different supply and demand patterns generated a catalogue of the area to help anticipating or designing more healthy, robust and integrated regions with. The maps were made at the different scales, depending on their primary focus. Special attention is given to the designated hotspot zones, where specific opportunities or characteristics were detected.

3.3 Flows-analysis results – Case study Schiphol

The people ‘inhabiting’ Schiphol can be divided in three categories: passengers, workforce and visitors. Approximately 50 million passengers passed through Schiphol in 2011 [Schiphol Group, 2012]. The workforce at Schiphol contains around 60,000 employees, working for 500 companies. The category of visitors adds up to 13 million visitors in total. Furthermore, about 1.5 million tonnes of freight passed through the airport in 2011 [Schiphol Media, 2011]. All these people and processes make use of resources.

3.3.1 Energy

The energy flows through the airport are divided into electricity, thermal energy and transport energy, leading to a focus on the following energy carriers: electricity, gas, and combustion fuels. Virtually all of the required energy is directly or indirectly (i.e. combustion fuels for local generation of electricity and/or heat and cooling) imported into the airport system. 1.25% of electricity is generated renewably at the airport itself. Figure 3.3 shows the main current and planned energy infrastructure as well as energy network components in the airport region. Figure 3.4 shows a breakdown of the energy use at Schiphol – incorporating *Control*, *Guide*, and *Influence* levels – in terajoule (TJ) and percentages. It becomes apparent that most of the energy demand is related to fuels for air traffic, even if this only includes the landing and take-off cycle. Furthermore, Table 3.1 displays the energy use of the 12 municipalities in the airport region.

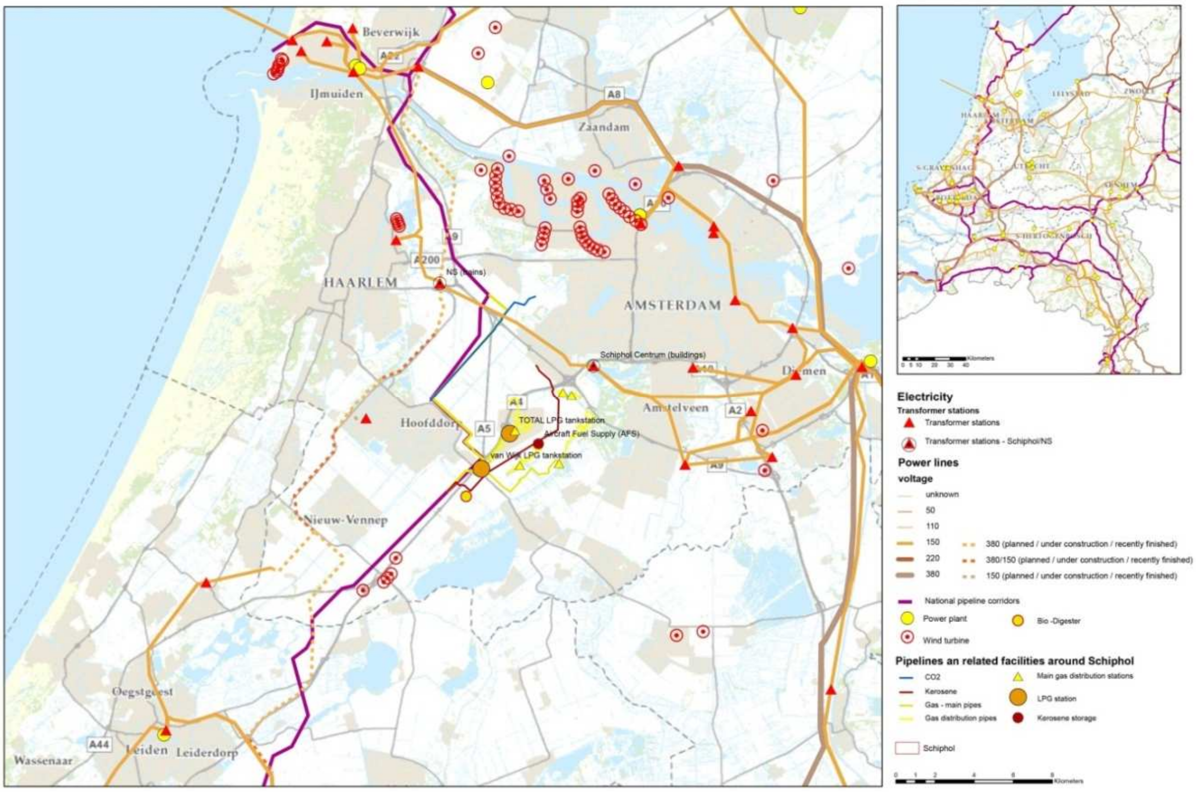


Figure 3.3: Main energy network and components in the Schiphol region

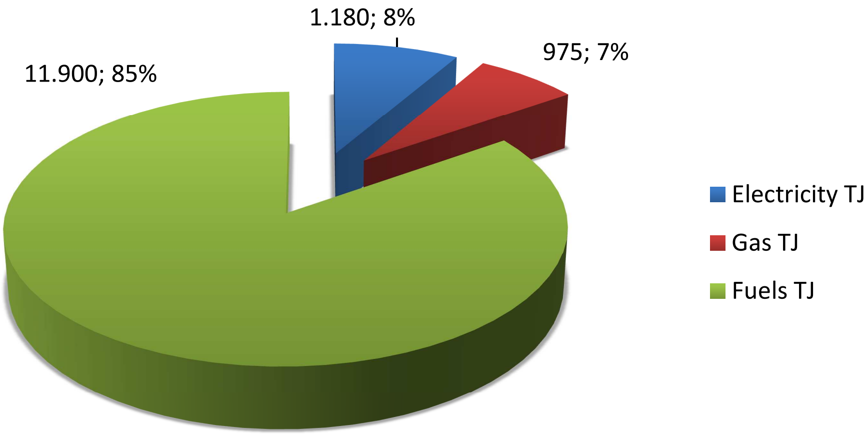


Figure 3.4: Energy use at Amsterdam Airport Schiphol, in terajoule (TJ) and percentages

Table 3.1: Energy use of the 12 municipalities surrounding Amsterdam Airport Schiphol

	el. (TJ)	gas (TJ)	fuels (TJ)
Aalsmeer	962	3,207	745
Amstelveen	1,505	3,845	1,557
Amsterdam	15,748	34,703	10,671
Bloemendaal	191	741	509
Haarlem	1,926	4,975	2,970
Haarlemmerliede	43	128	138
Haarlemmermeer	6,693	14,168	4,756
Heemstede	252	881	566
Hillegom	594	2,120	507
Kaag & Braassem	930	3,561	655
Lisse	516	1,619	515
Teylingen	568	1,759	778
Total	*29,927*	*71,708*	*24,366*

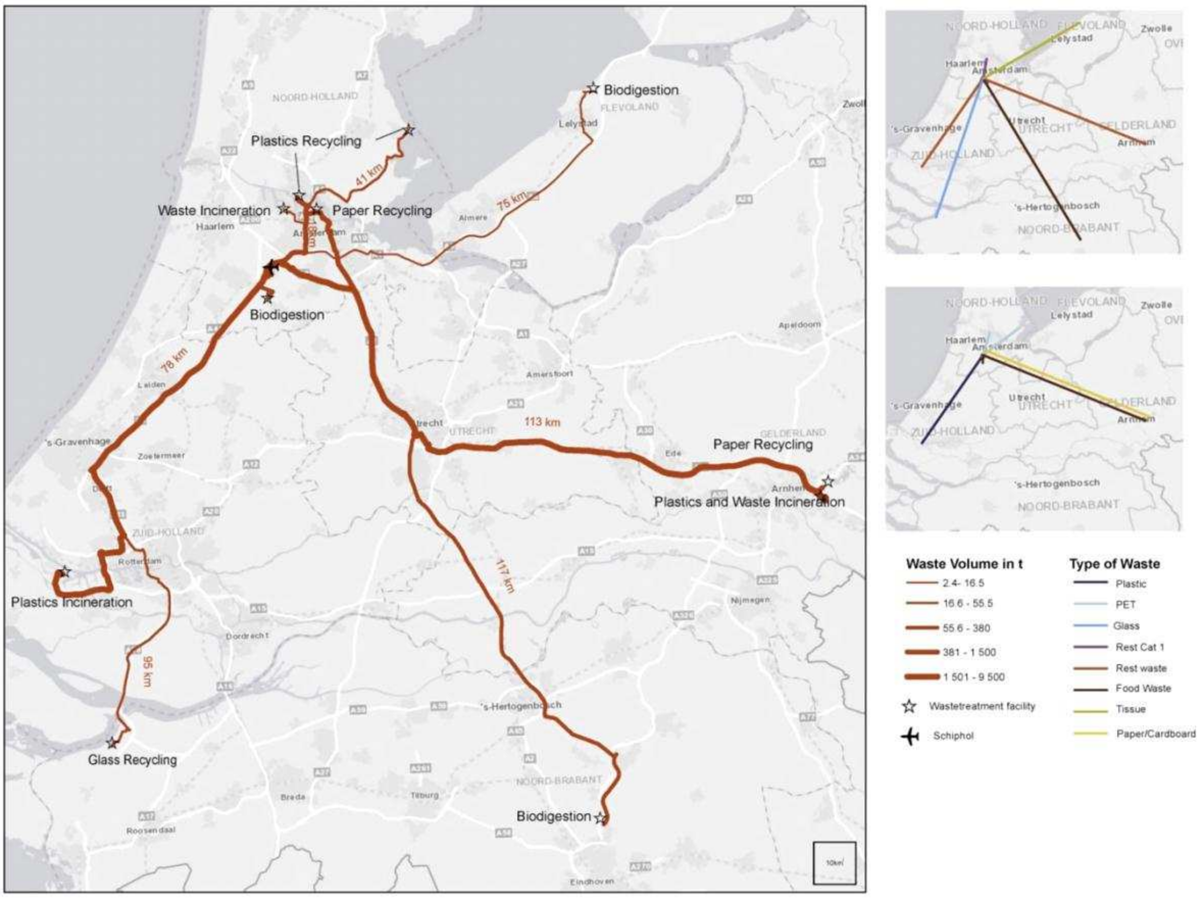


Figure 3.5: Waste flows and routes associated with Amsterdam Airport Schiphol

3.3.2 Waste

The current throughput of specific flows can to a significant extent be unravelled by an analysis of the waste associated with Schiphol. Figure 3.5 visualises selected waste flows and their destinations for treatment: food waste to bio digesters, packaging materials – glass, paper/cardboard, plastics, and separated PET – to recycling facilities, Category 1 airplane waste and rest – mixed – waste to incinerators with energy recovery facilities. Furthermore, the waste flow 'tissues' is included because of its specific significance and relation with both packaging materials and food. This flow is separately collected and distributed to a bio digester. The larger map shows the volumes in tonne (t) and transport routes by truck, following the shortest distances over road (in km). The smaller maps show the directions per waste flow in straight lines.

3.3.3 Plastic packaging materials

Due to the lack of transparency on the input side, we looked at the output side for an analysis of the plastic packaging materials throughput. More specifically: the solid waste handled under the control of Schiphol Group[4]. Based on information from the main waste contractor at Schiphol (Van Gansewinkel), plastic fractions in waste at the airport are divided in PET and other mixed plastics. PET (100 t) is separately handled, whereas the other mix of plastics (2 t) is not separated yet; 50% of these plastics is recycled and 50% ends up in incinerators for production of electricity and heat.

Waste from airplanes consists to a large extent of waste that has to be incinerated within 24 hours, in accordance with safety regulations. In total, this waste flow adds up to 2,400 t/year, which is incinerated at the waste energy company (AEB, Afval Energie Bedrijf) in Amsterdam. Random samples by waste-research agency Eureco indicate that this waste comprises 288 t of PET and 432 t of other, unspecified, plastics; a mixture of polymer types, such as polyethylene, polypropylene, polyvinyl chloride and polystyrene.

Based on generic data from Nedvang [2010] and Jetten et al. [2011], the municipal solid waste flow in the surrounding municipalities can be used to estimate the throughput associated with various packaging plastics in households.[5] This concerns approximately 25 kg annually per capita, of which the lion's share is currently incinerated. In Figure 3.6 the estimated annual plastic packaging waste per type of polymer is displayed for each municipality. Schiphol is included in the figure, discerning only the categories PET and Other/Unspecified.

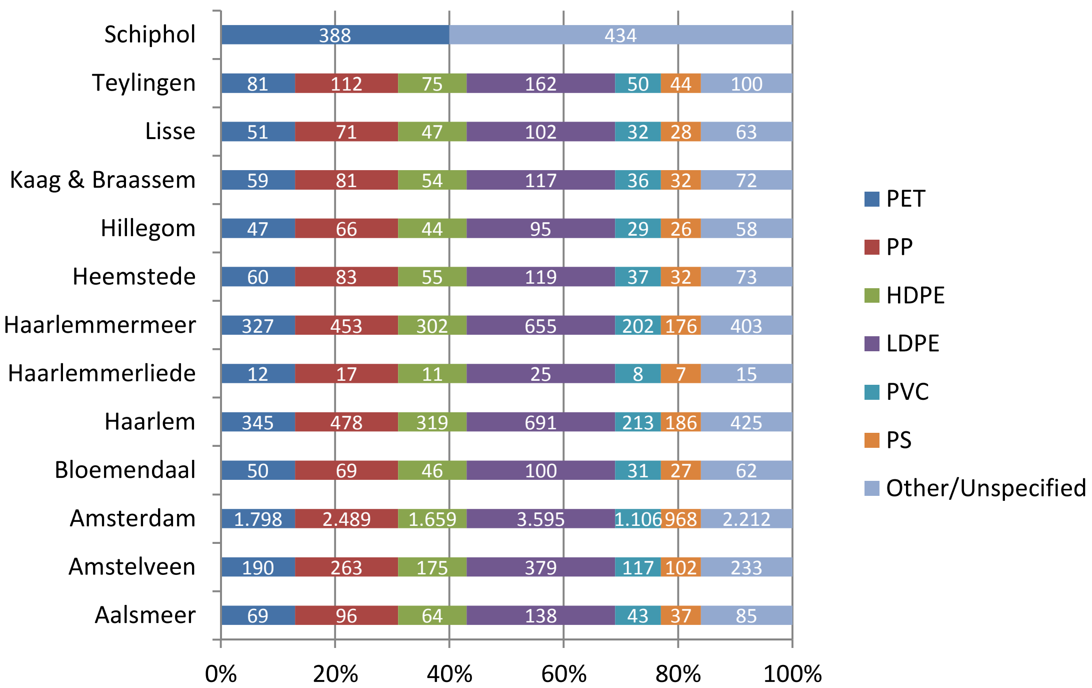


Figure 3.6: Plastics throughput in the Schiphol region in 2011, per polymer in tonnes and percentages

[4] Although this comprises most of the waste at the airport, a significant part falls outside of the direct control of Schiphol Group, for instance specific waste flows of the main airline company at Schiphol: KLM

5 Industrial use is not included

3.3.4 Food

At Schiphol, the various food & beverages companies have their own logistical scheme to get the food products in place, at the airport or in the airplanes. A small selection of large organisations is at the top of these chains. Data regarding consumption patterns and food waste flows associated with Schiphol is gathered from the two most prominent companies in the food & beverages segment at the airport: KLM Catering Services and HMS Host.[6] We also received data from Van Gansewinkel and the company responsible for the wastewater treatment at Schiphol (Evides).

Supplementary aspects, such as travel patterns, dwell times and nutrition were studied in order to paint a more complete picture of the air traffic related food chain. Statistics were used as much as possible; where these were not available data were sourced from literature and interviews. Figure 3.7 gives an overview of the results for passengers, workforce and visitors, both in weight and energy content, in total and per selected food group.

Concerning food waste, approximately 380 t was collected at the airport in 2011. This food waste is distributed to a bio digester near Eindhoven. Furthermore, food waste from airplanes adds up to an estimated minimum of 600 t annually. 25% of which ends up in a local bio digester; the rest is incinerated. Moreover, organic waste fractions end up in the black water flow.

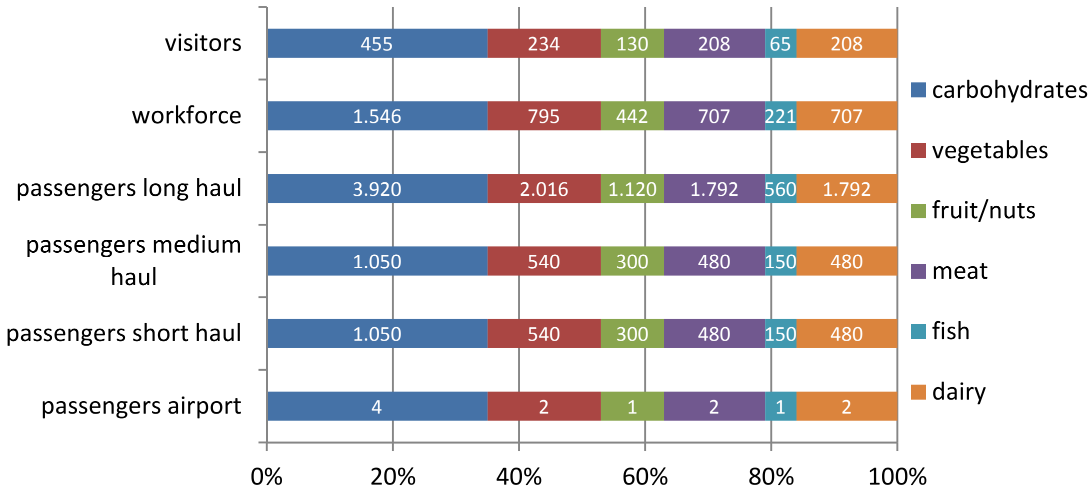


Figure 3.7: Food consumption at Schiphol in 2011, per food group in tonnes and percentages

3.3.5 Water

Drinking water is centrally supplied by – predominantly – water company Waternet, who use water from the river Rhine that is transported to and purified in the dunes. In the year 2011, the water use at the airport was 14 l per passenger, excluding bottled water. Furthermore, Schiphol has a wastewater treatment plant within its borders that is exclusively allocated to processing wastewater flows from the airport. The water treated here therefore is an appropriate indicator for the water throughput. This wastewater is associated with a variety of functions, predominantly fed by the drinking water supply network. Water Company Evides owns and operates the wastewater treatment plant. Approximately 4 million l (4,000 m^3) is processed per day, corresponding to 45,000 pollution units. The treated water is fed back onto the surface water, whilst sludge is reused as fuel in factories of Dutch cement producer ENCI.

De-icing of aircraft – a specific airport related water flow – leads to a significant wastewater flow, but volumes depend on winter conditions. This de-icing water is collected separately. Pilots with algae to metabolize this

6 HMS Host operates more than 70 food and beverage venues at Schiphol, holding about 65% of the total share at the airport before customs and 90% beyond customs, and KCS is the largest airline caterer at Schiphol

glycol containing water were as yet unsuccessful, due to the mismatch between supply timing (winter) and algae growth optimum (summer) on the one hand, and heavy metal content in the algal product on the other. Currently this wastewater stream is divided in a high and a low concentrate; the former is recycled, the latter landfilled. Figure 3.8 displays the water and wastewater network of the Schiphol area.

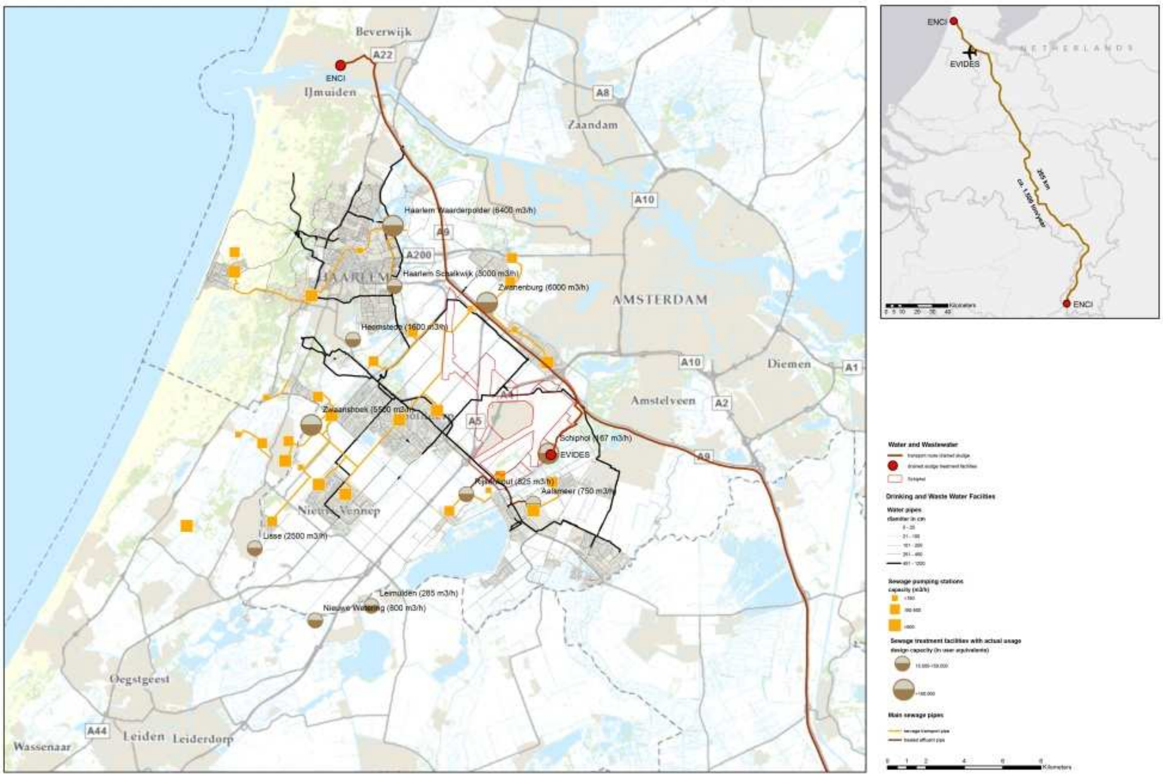


Figure 3.8: Water and wastewater network of the Schiphol region

Table 3.2: Schiphol throughput overview of selected flows, including People, in 2011

PEOPLE	Passengers	Workforce	Visitors			
	50,000,000	**60,000**	**13,000,000**			
ENERGY	Electricity *TJ*	Gas *TJ*	Fuels *TJ*			
	1,180	**975**	**11,900**			
WATER	Drinking Water *m^3*					
	1.220.000					
MATERIALS	Plastics: PET *tonne*	Plastics: Unspecified *tonne*				
	388	**434**				
FOOD	Carbohydrates *tonne*	Vegetables *tonne*	Fruits/nuts *tonne*	Meat products *tonne*	Fish products *tonne*	Dairy products *tonne*
	11.500	**5.930**	**3.290**	**5.270**	**1.650**	**5.270**
WASTE	Total waste *tonne*					
	13.900					

Table 3.2 is an overview of the volumes through Schiphol in 2011 concerning the flows people (passengers, workforce, visitors), energy (electricity, gas, fuels), drinking water, plastic packaging materials (divided in PET and unspecified), food (divided in six food-groups) and total waste.

3.3.6 People: Schiphol workforce and centrality

500 million passengers per year pass as passengers through Schiphol Airport. Additionally, 13 million people visit Schiphol Airport and related facilities per year. Moreover, Schiphol is a working place for 60,000 employees. The latter aspect seems specifically interesting with regard to the integration of Schiphol with its surrounding metropolitan region. We focus on the land-side related aspect instead of the air traveller because Schiphol as airport has a worldwide catchment area for its passengers, but with the high concentration of workplaces and its specific 24 hour economy it plays a unique role for the metropolitan region. The relation between the location of Schiphol and the workforce at Schiphol, which lives predominantly in the Randstad, leads to specific travel behaviour, and thus to a specific transport infrastructure. Figure 3.9 investigates this in a more detailed way and presents how many residents of a specific *postal code-4 area* work at Schiphol, and how much these are in relation to the total population.

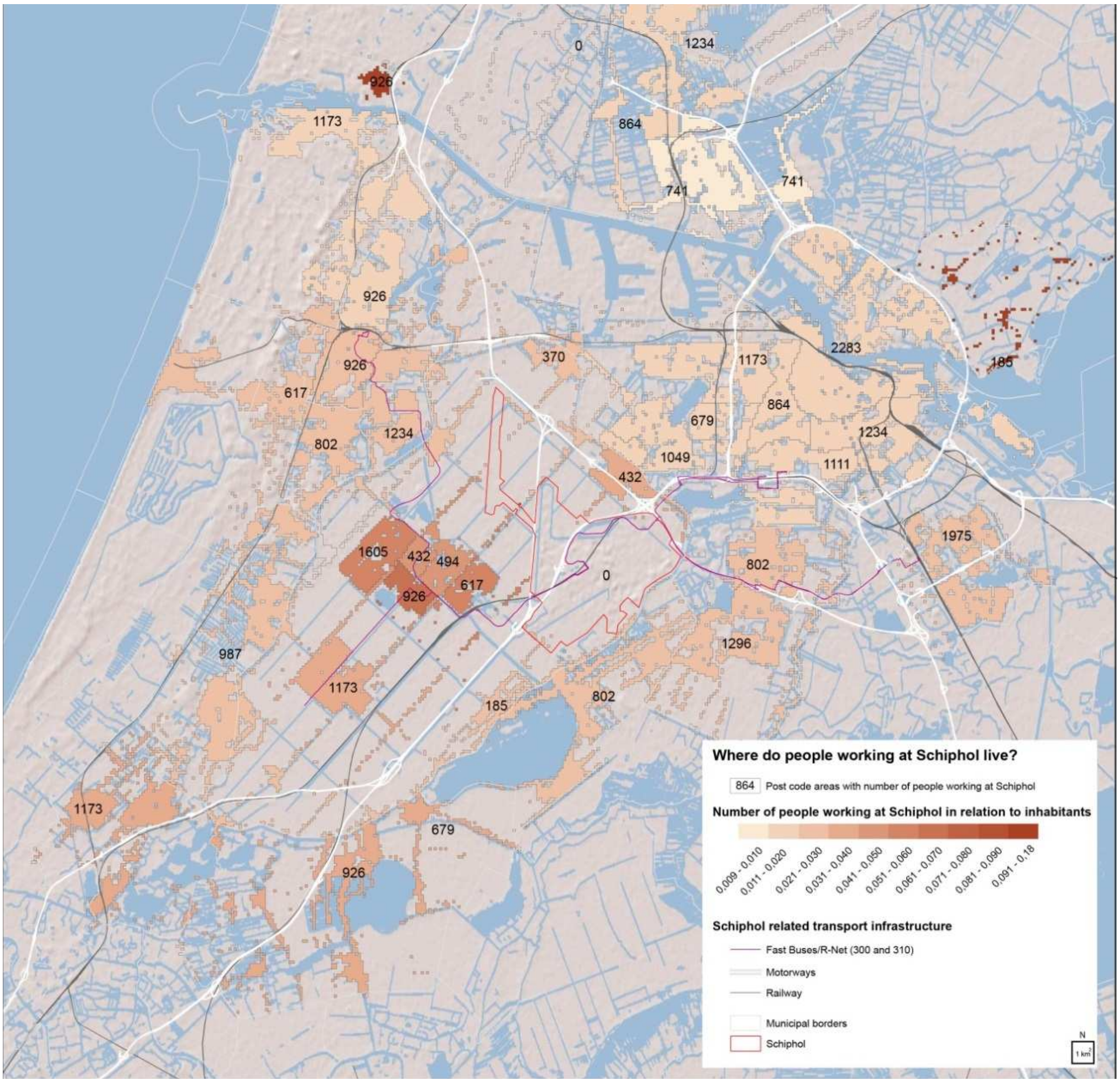


Figure 3.9: Living location of persons working at Schiphol. (Data Source: Regioplan 2011; BAG)

Schiphol as work place has a dominant role for the towns in the municipality of Haarlemmermeer specifically for Toolenburg, Hoofddorp, Overbos and Badhoevedorp, where up to one tenth of the living population works at Schiphol. Because of the location of Schiphol International Airport, specific transport infrastructure was developed, such as the high speed rail connection between Amsterdam and Rotterdam, as well as the fast bus lines of the so called Zuidtangent (lines 300 and 310) that connects Schiphol with exactly those municipalities where most of the workforce in Schiphol lives. Furthermore, the density of the motorways is also significantly higher around Schiphol. This has a large influence on the spatial quality in the region, among others on *centrality*.

Two different aspects of centrality showed to be of crucial importance during the BAR project, first how central Schiphol is within the national and local streets network and second, how the specific local street network, that is highly influenced by Schiphol, affect local centralities in the surrounding municipalities. Behind the first aspect lies the idea of Schiphol as airport city, therefore we compared the *betweenness* of Schiphol with the city centres of the five biggest Dutch cities. The results show that, considering a radius of 40 km, Schiphol has a higher regional betweenness centrality than the city centres, see Figure 3.10. On the local scale (radius 3km) Schiphol shows a much lower betweenness centrality than the city centres. This means that if the goal is to integrate Schiphol better with is surrounding metropolitan region, the major urban design tasks lies on the local scale.

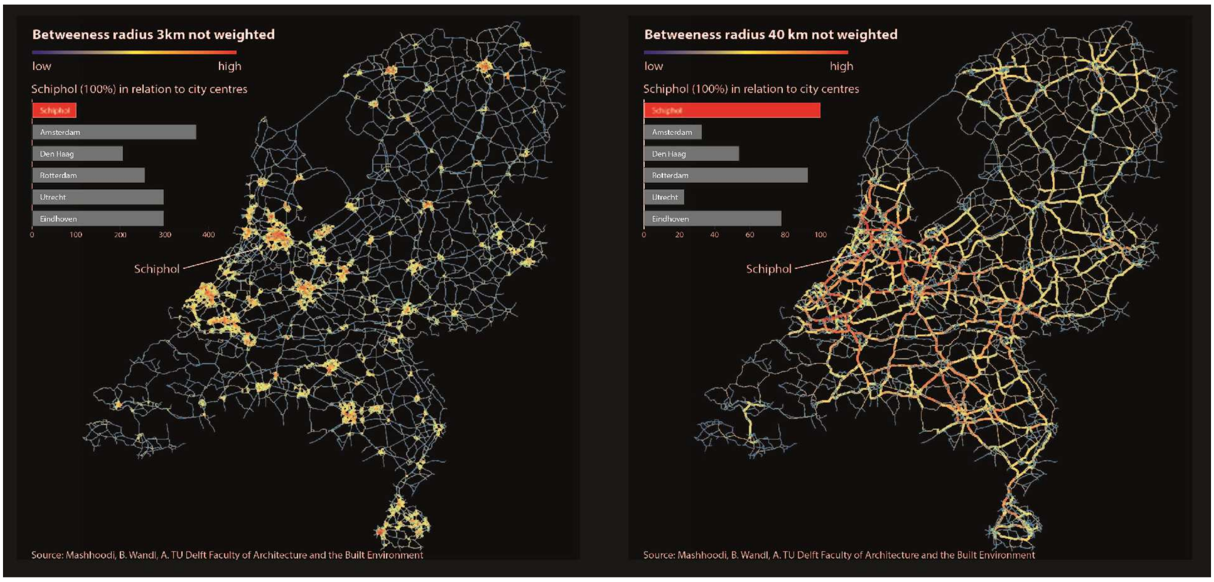


Figure 3.10: The comparison of the local and national betweenness centrality of Schiphol international airport with the city centres of the five biggest Dutch cities

The local scale was where the centrality measure came into play for the second time. Two urban design studios were organised by the chair of Architecture and Urban Design at the ETH Zurich during the BAR project. Among other design goals, the students identified the lack of integration between different parts of the area as one problem they wanted to address. In Figure 3.11 is presented how centrality measures were used to inform the students about the centrality of different areas within the Schiphol Airport region. The figure clearly shows the low local centrality value for Schiphol and the edges of the surrounding towns. Figure 3.12 presents how a student proposal changed the local centrality values of the area indicated as design area. We chose to show the *straightness centrality*, as it was the one showing the biggest change between situation and design. The reason was that the students changed the street layout from a structure, which was characterised by one main street connecting the different parts of the city and dead ends within the different neighbourhoods to a grid like street network with more direct connections between the different neighbourhoods. This reduced the difference between *Euclidian distance* and *network distance*, which is what the straightness centrality measures.

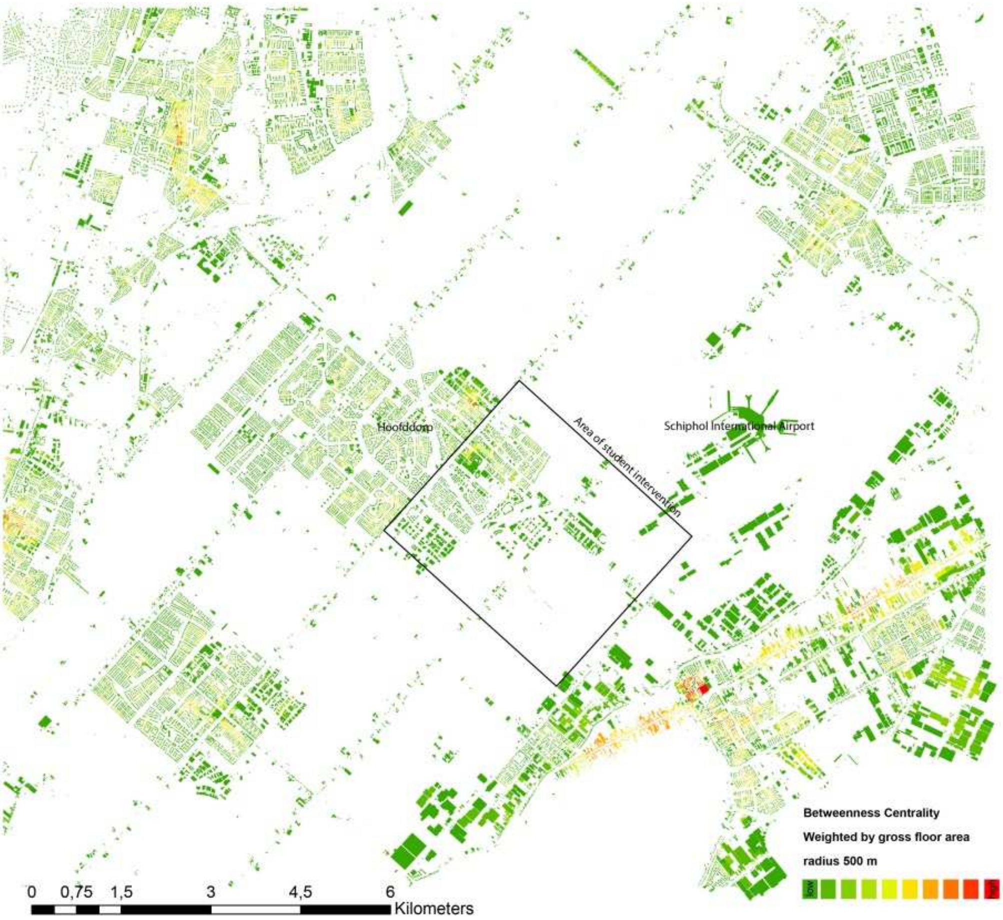


Figure 3.11: Buildings coloured according to their betweenness centrality value, from red/high to green/low in the surrounding of Schiphol international airport, based on a radius of 500 meter.

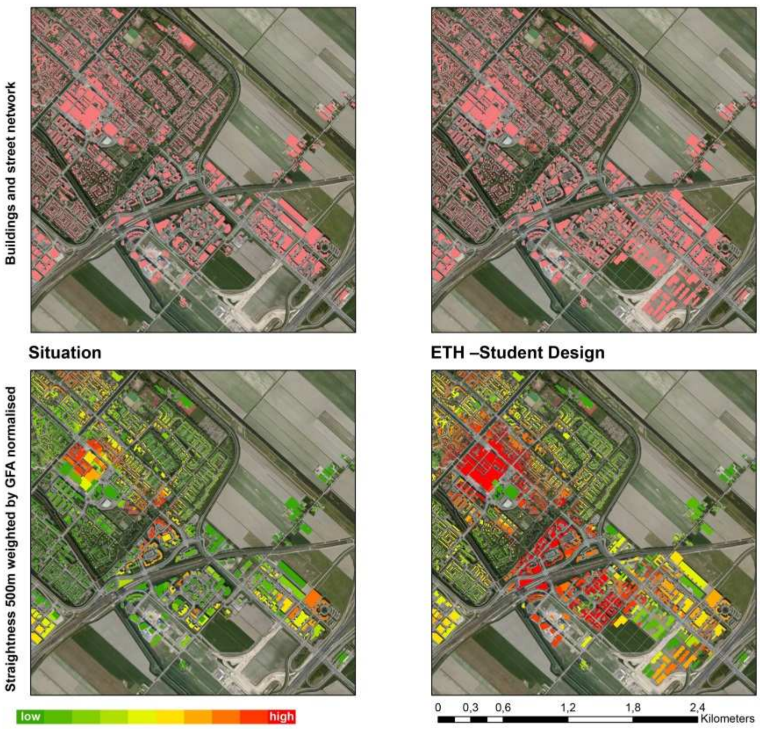


Figure 3.12. The comparison of the straightness centrality between the situation on the left, and a student proposal on the right.

3.4 Potential-analysis results: Hotspot zones

In this section, the identified hotspot zones in the area of Schiphol and the surrounding municipalities are described and discussed. Each hotspot zone revolves around one or more coinciding main themes with above average potential and rooted in – but not exclusive to – that specific context. Generic lessons can be drawn through these specific examples. The map of Figure 3.9 displays the hotspot zones.

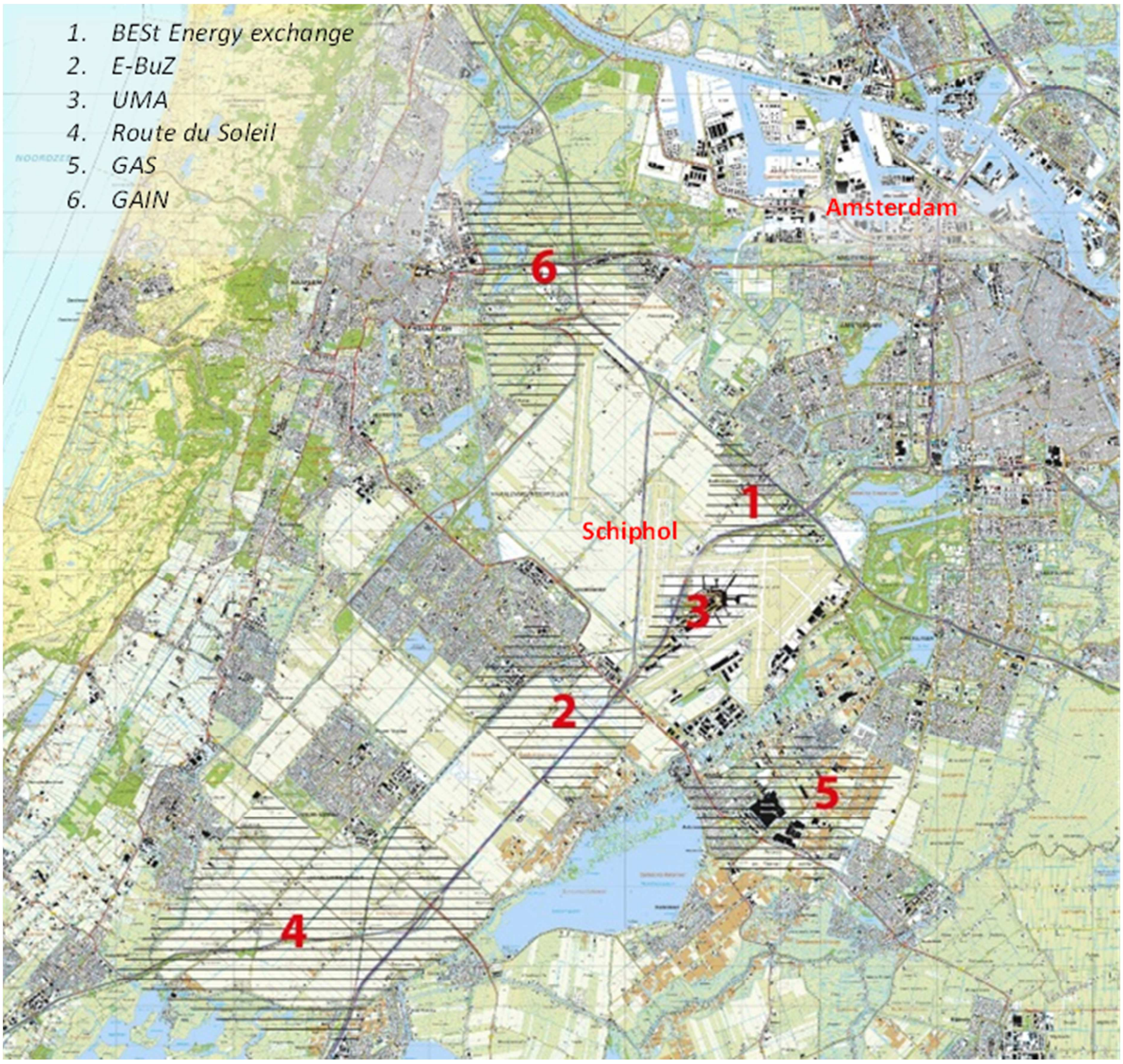


Figure 3.13: Six hotspot zones in the Schiphol region

3.4.1 Badhoevedorp/Elzenhof/Schiphol triangle (BESt) Energy exchange

In Badhoevedorp, just North of Schiphol ('Hotspot zone 1' in Figure 3.13), a variety of real estate and restructuring plans is under development or foreseen for the near future. Each plan comes with a particular energy demand, which could in theory be covered by collective thermal energy systems centred around a low temperature heating (LTH) /high temperature cooling (HTC) grid. Excess heat from Schiphol could be part of such a thermal energy net. At the same time Schiphol has an extensive cooling demand, for example equalizing the heat production related to daily fluxes of passengers in terminals. Main water grid transport pipes that run under the northern area of Schiphol could provide a significant and constant source of cooling, albeit with

temperatures that vary over a year.[7] Furthermore, within this hotspot, business zone ‘Elzenhof’ – connecting Schiphol and Badhoevedorp – accommodates a large datacentre. This datacentre produces a constant flow of waste heat and explores options to render this waste heat useful. Lastly, in Amsterdam, a city-cooling grid is currently under development, using deep lakes – that emerged through sand extraction for the building of the new residential areas in the 1960s – as point sources. One of these lakes, named ‘Nieuwe Meer’, borders the Badhoevedorp/Elzenhof/Schiphol triangle in the northeast.
Built on the aforementioned facts, a local distribution and storage network for heat and cold results to be an opportunity to serve mutual interests of suppliers and customers. The related technologies and infrastructures are relatively straightforward and both supply and demand capacities are significant and spatially near to each other. Though distances aren’t that short, the thermal quality of the transport medium can be sustained over reasonably long distances, in that respect bridging the distances in the BES triangle is not expected to be an obstacle. Figure 3.14 displays heat and cold sources and demands and indicated capacities (in TJ/year) and potential synergies in the BES triangle. Planned new real estate of Schiphol Area Development Company (SADC) just outside of the airport boundaries (bottom left in Figure 3.13) is also indicated with estimated heat and cold demands. Furthermore, the underground drinking water transport pipes are shown in light blue on the map.

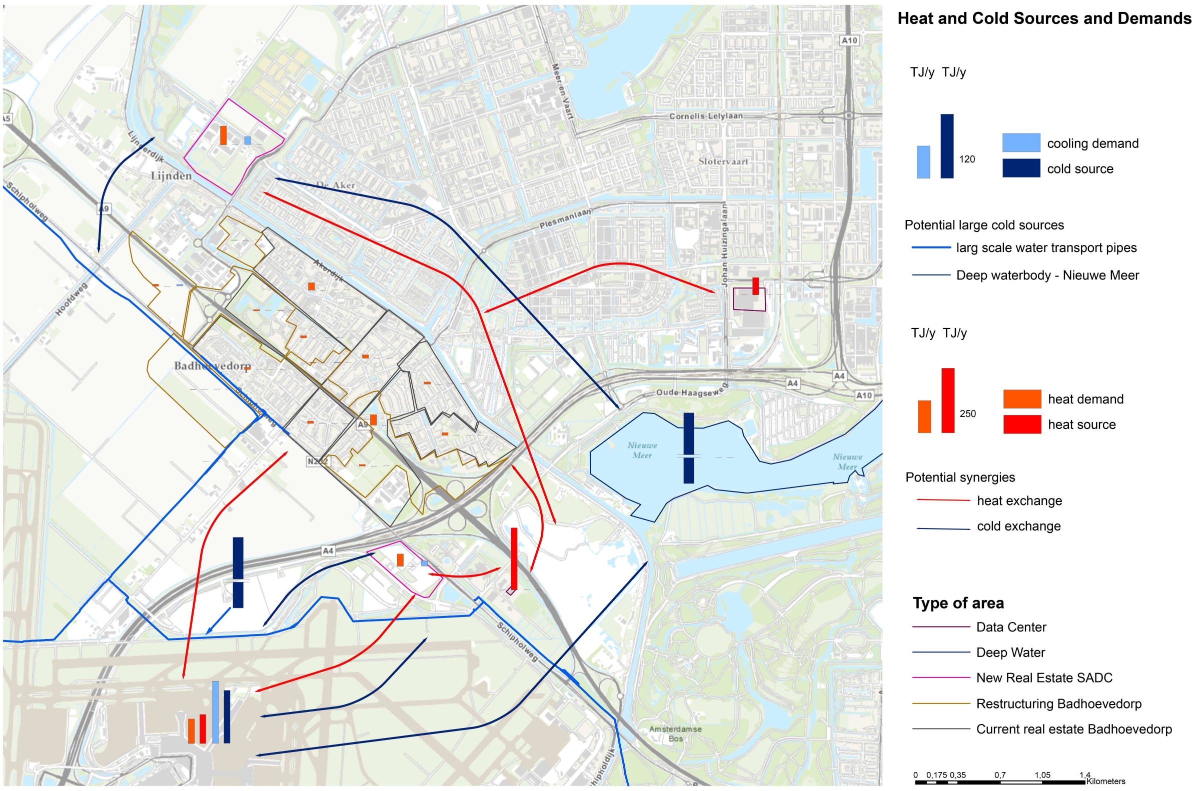


Figure 3.13: Hotspot zone BESt – Energy exchange

The BESt energy-exchange concept brings heat/cold supply and demand patterns of specific local assets together. Some characteristics are predominantly generic, such as the presence of water-bodies and occurrence of heat losses (excess heat) from industrial processes. Other characteristics are more specific, in particular with regard to the subterranean water supply pipes. There is a variety of temperatures associated with the supply and the demand side; roughly from 5°C – e.g. lake water in winter – to 40°C – e.g. datacentre. A smart distribution grid is envisioned, in which the required thermal qualities are available at the right place at the right time, following a *cascade* of functional applications, including storage capacity for load balancing. Thermal energy can be stored in a variety of ways, and one of them is storage in aquifers. Figures 3.15 and 3.16 display the regional potential for shallow and deep thermal energy storage in aquifers. The triangle Badhoevedorp, Elzenhof, Schiphol is indicated on the maps.

7 The ‘Rivier- Duinwaterleiding’ (River-Dune water supply)

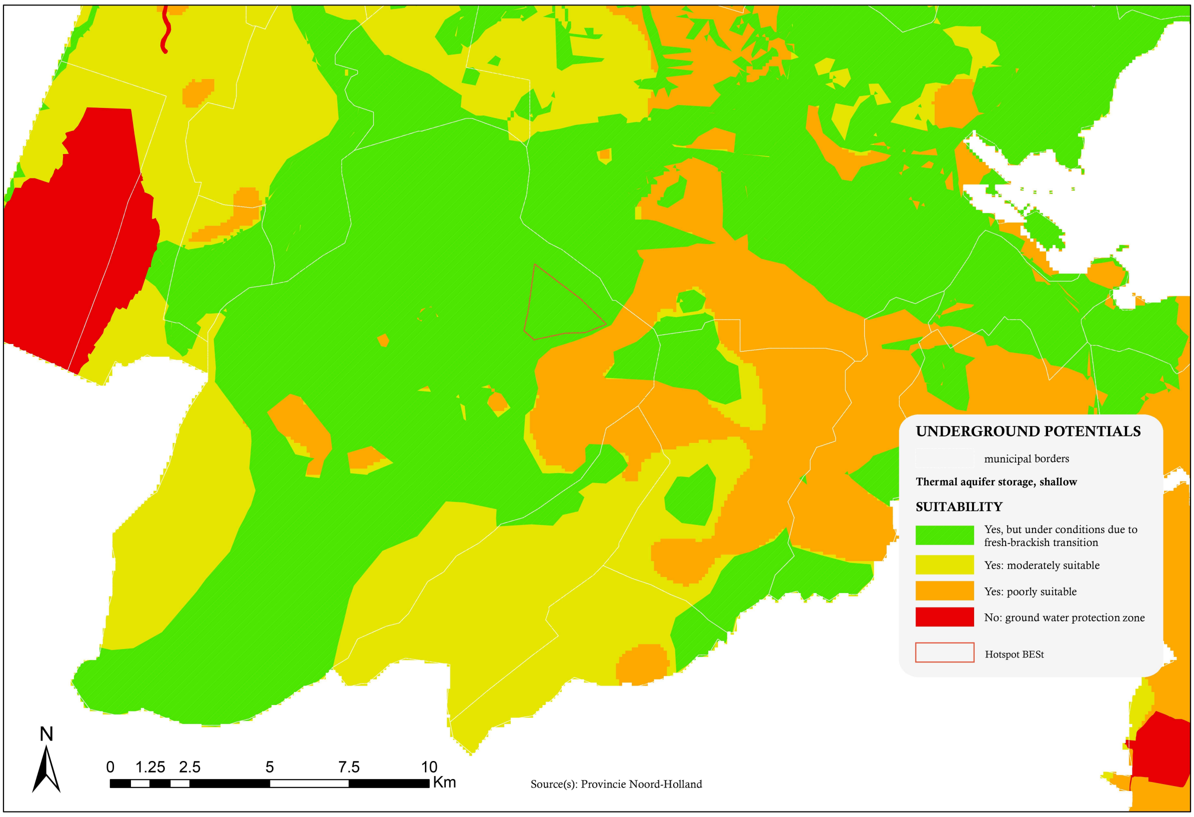


Figure 15: Thermal aquifer storage potential in the region, shallow underground

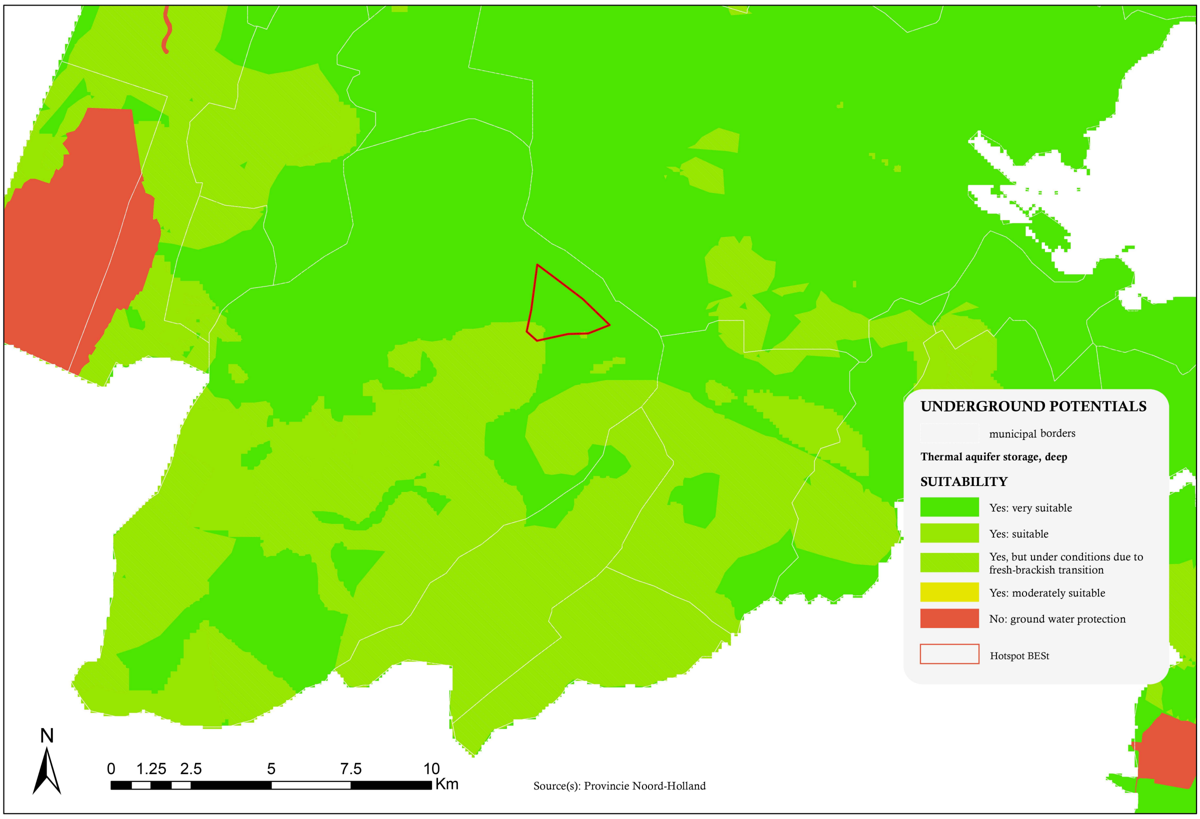
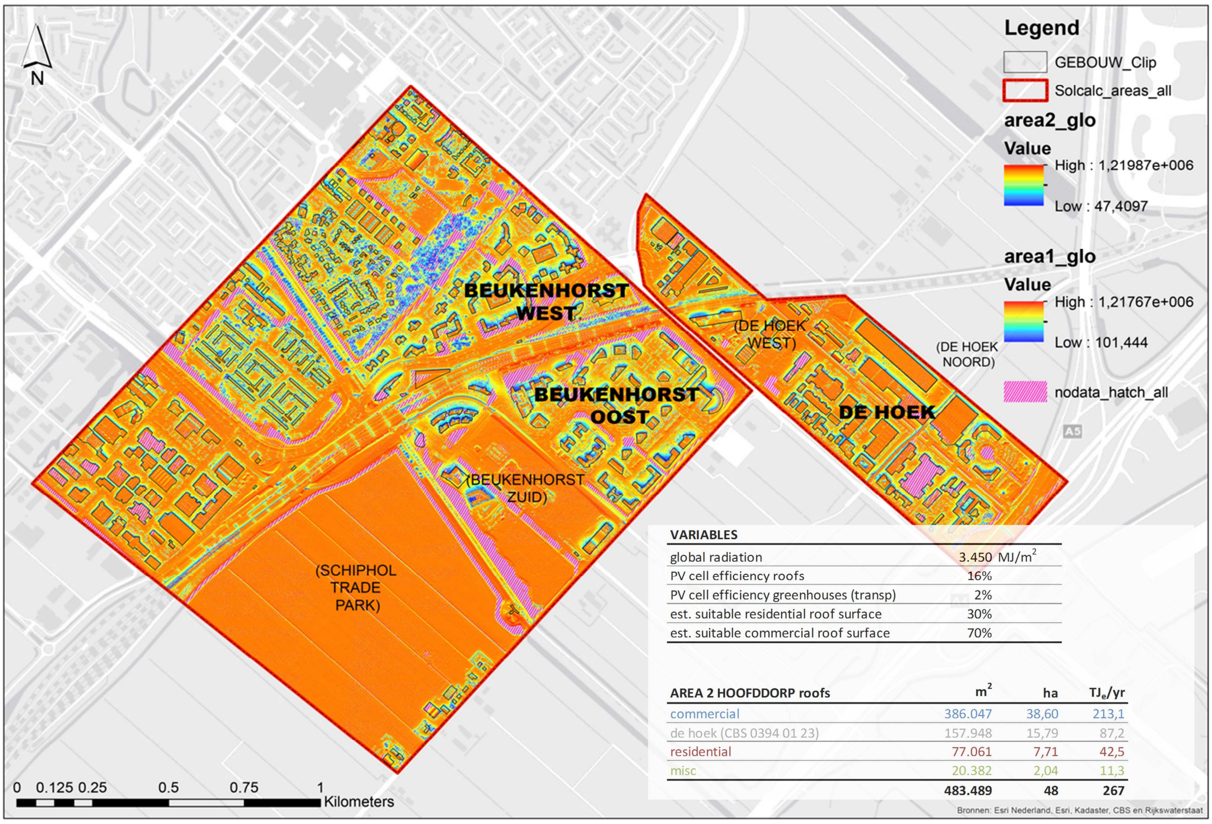


Figure 3.16: Thermal aquifer storage potential in the region, deep underground

Finally, supplementing the envisioned thermal energy grid with functions that utilize leftover energy at the end of the cascade would enhance its efficiency and effectiveness. An opportunity in this respect is making a link with algae cultivation at Schiphol. This relates to an earlier experiment at the airport to purify glycol-containing de-icing water with algae. One of the main reasons this experiment failed was that glycol containing feedstock is primarily available in winter, when temperatures are far from optimal for algae growth; this discrepancy could be compensated by utilizing low temperature waste heat as part of the proposed heat/cold exchange and storage network. After application as purification agents, algae could subsequently function as biomass feedstock for fermentation or other conversion processes.[8]

3.4.2 Energetic business zones (E-BuZ) in Hoofddorp/Beukenhorst/De Hoek area

In the surrounding area of train station Hoofddorp (Hotspot zone 2 in Figure 3.13), so-called 'last-stop' before the airport from southern directions, important existing and strikingly fast growing new sustainable business areas are situated. This results in a vast amount of existing grey roof surface, making this zone particularly suitable for quick wins associated with energy production and green roofs. Moreover, the areas are closely related to international branding of sustainable real estate. This touches upon energy production – and exchange – but also a great deal on (perception of) spatial quality and ecosystem services, such as biodiversity, rainwater retention and air purification. Roof surfaces can be used more optimally, through integrated solutions regarding 'green', 'red' and 'blue' functions, or combinations of those, depending on the specific characteristics on location. Given typology and function, specifically energy production is estimated to be suitable for quick wins relating to these commercial buildings. In this study, the focus is primarily on electricity production.



VARIABLES	
global radiation	3.450 MJ/m^2
PV cell efficiency roofs	16%
PV cell efficiency greenhouses (transp)	2%
est. suitable residential roof surface	30%
est. suitable commercial roof surface	70%

AREA 2 HOOFDDORP roofs	m^2	ha	TJ$_e$/yr
commercial	386.047	38,60	213,1
de hoek (CBS 0394 01 23)	157.948	15,79	87,2
residential	77.061	7,71	42,5
misc	20.382	2,04	11,3
	483.489	**48**	**267**

Figure 3.17: Roof contours and global radiation in the East of Hoofddorp

8 This principle is also applicable to hotspot zone Route du Soleil, where the saline agriculture connotation would be compatible with year-round algae cultivation

In order to gauge the potential solar yields of these roof areas, a GIS study was performed. By calculating solar radiation using a high detail (0.25 x 0.25m) elevation map of the area, a GIS solar model and pyranometer[9] measurements from the Schiphol weather station, a global radiation map was generated. This resulting map was subsequently filtered on roof contours (TOP10NL) and reduced by a percentage in order to account for unsuitable roof areas, excluding uneconomic roof placements. Even when taking into account lower results due to data inaccuracies[10], potential yield turns out to be significant; De Hoek alone could technically yield 87 TJ_e/y[11]. Figure 3.17 displays roof contours and global radiation characteristics in the East of Hoofddorp, including Beukenhorst and De Hoek. De Hoek is separately demarcated as a CBS neighbourhood.[12] Furthermore, planned commercial developments are indicated (in brackets).

In the E-BuZ scenario, local solar potentials were explored in greater detail, whilst avoiding long distance energy transportation. Although the calculation steps took a significant amount of time to perform, potential yields were also significant and visualized in high detail. This level of detail increases the precision with which technical solar potential can be anticipated for specific contexts, including assessments regarding roof structure suitability and potential partnerships. Furthermore, the required data to calculate the potentials should be readily available for most airport regions. Concerning the applicability to other zones in the study area, particular interest is directed at different existing and planned commercial zones, e.g. Schiphol Trade Park, De Hoek Noord. Furthermore, the (temporary) use of idle space is interesting in this respect. As far as potential glare issues, caused by sunlight reflecting off the panels, can be overcome, extending PV fields around the airport may be an opportunity.
Increasing the instantaneous use of the available electricity is currently preferable over storage or feeding back to the grid, due to economic and technical – load – characteristics. However, when the share of renewable and intermittent energy sources, such as wind and sun, grows and smart storage and exchange technologies mature, instantaneous use is less of a priority.[13] Finally, distribution of solar-based electricity in new, decentralized networks has implications for the infrastructure. The applicability of existing infrastructures should be assessed with regard to e.g. capacity, lifespan and ownership.

3.4.3 Urban Mining in Airport regions (UMA)

The third Hotspot zone (see Figure 3.13) concerns the potential of plastic waste recycling. On-going efforts at Schiphol to valorise valuable waste fractions lead to increasing recycling rates associated with solid waste. Plastics, mainly from packaging, are to some extent separately collected and transported to recycling facilities. With 100 t per year, PET is currently the primary polymer in this context, but there is good recycling potential for other polymers as well. With regard to waste from aircraft, recycling is virtually absent; in accordance with safety regulations, most aircraft waste is incinerated within 24 hours. The plastic fraction of this waste flow – 720 t annually of which 40% PET (288 t) and 60% unspecified (432 t) – could easily be brought into common practice recycle routes. Recycling generally leads to a better environmental score and conserves more energy than is generated by incineration [e.g. Morris 1996 and Bergsma et al. 2011].[14]
Given the specific conditions of the waste collection in aircraft, i.e. hardly accommodating for waste separation at the source, post separation seems the most appropriate step towards recycling – and the next best option after reducing that waste flow. With regard to plastics in municipal solid waste (MSW), on average 25 kg capita per year is produced per capita [Jetten et al. 2011], the majority of which disappears in incinerators (15-20 kg). In the municipalities surrounding Schiphol this implies a production of 20-27 kilotonne of plastics in domestic waste streams for incineration annually. However, the lion's share, consisting of the polymers PET, PP, PE (HDPE and LDPE), PVC, and PS can be recycled. Figure 3.18 displays the division in percentages per polymer type in the solid waste flows of Schiphol and its surrounding municipalities.

9 A pyranometer measures solar irradiance on a planar surface and the radiation flux density
10 A few highly reflective roof surfaces weren't measured by the laser altimeter
11 Equivalent to the electricity demand of > 10% of the electricity use of Schiphol Group
12 Statistics Netherlands' division in neighbourhoods: number 0394 01 23
13 A promising technology in this respect, for example, is Power to Gas (P2G), converting surplus electrical power to a liquid gas fuel.
14 Incineration with energy recovery – electricity and heat – leads to approx. 500 GJ of electricity and 1,900 GJ of heat + losses. Caloric value of this waste is approximately 10 GJ/t and the recovery efficiency is 21%.

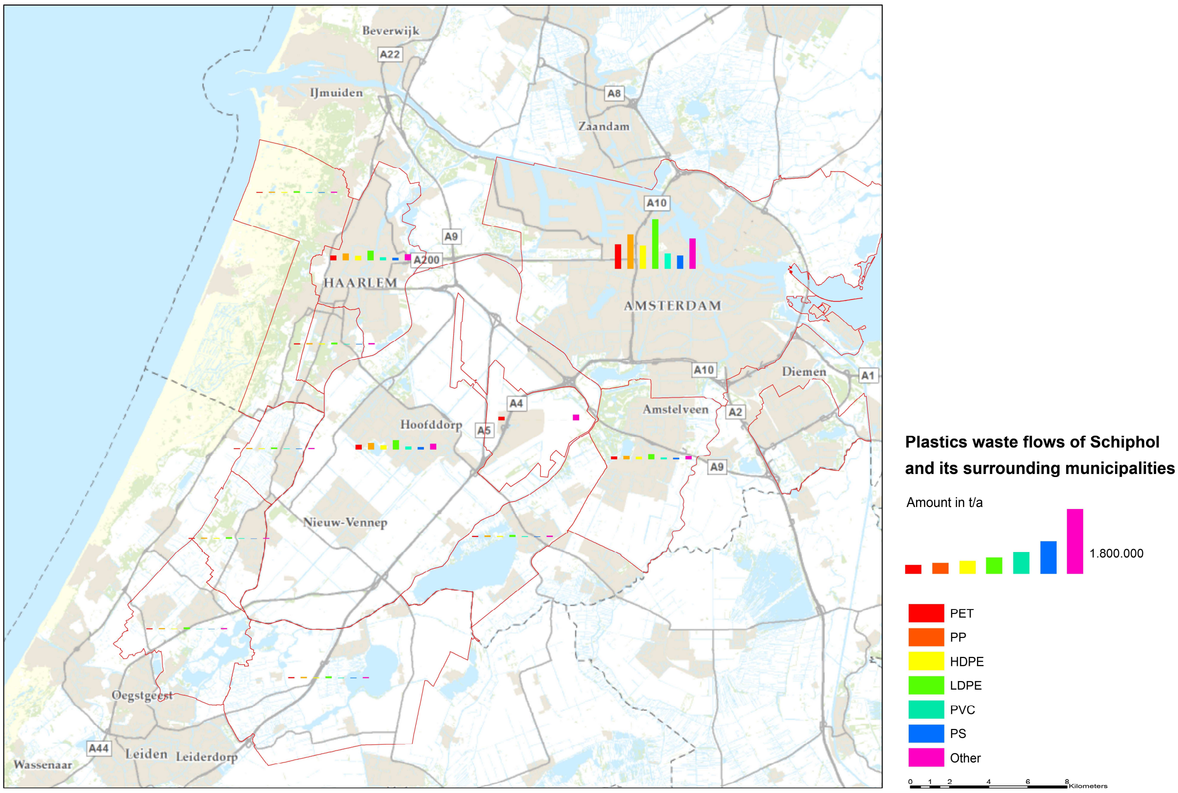


Figure 3.18: Division in percentages per polymer type in solid waste flows of Schiphol and its surrounding municipalities

Expanding the plastic recycling efforts in the airport region centres on potential economies of scale and the shift from waste related costs to added value through recycling. Table 3.3 lists the main polymers used for packaging, whilst also being indicative for the main products or product categories that enter the airport. Furthermore, the table lists the packaging applications, identification code for recycling purposes, and common recycling routes. Because of the close relation with essential resource flow Food, other – food related – plastic products associated with airports, such as cutlery and trays, are also included in the table.

Table 3.3: Polymers for packaging + common recycling routes

Polymer	Examples of (packaging) application	Identification code	Examples of recycled content applications
Polyethylene terephthalate (PET, PETE)	Plastic bottles for soft drinks, water, juice, sports drinks, beer, mouthwash, catsup and salad dressing; food jars; food trays	01 PET	Fiber for carpet; fleece jackets; comforter fill; carrier bags; containers for food, beverages (bottles), and non-food items; film and sheet; strapping.
High-density polyethylene (HDPE)	Bottles for milk, water, juice, cosmetics, shampoo, dish and laundry detergents, and household cleaners; grocery bags, cereal box liners; reusable shipping containers.	02 PE-HD	Bottles for non-food items; plastic lumber for outdoor decking, fencing and picnic tables; piping; floor tiles; buckets; crates; flower pots; garden edging; film and sheet; recycling bins.
Polyvinyl chloride (PVC)	Rigid packaging applications, such as blister packaging for non-food items; flexible packaging, such as bags for bedding; cling films for non-food use.	03 PVC	Piping; decking; fencing; paneling; gutters; carpet backing; floor tiles and mats; resilient flooring, mud flaps; trays; electrical boxes; cables; traffic cones; garden hose; packaging; film and sheet; binders
Low-density polyethylene (LDPE)	Bags; squeezable bottles; cling films; flexible container lids; coatings for paper milk cartons and hot and cold beverage cups.	04 PE-LD	Shipping envelopes; garbage can liners; floor tile; paneling; furniture; film and sheet; compost bins; trash cans; landscape timber; outdoor lumber.
Polypropylene (PP)	Reusable microwaveable ware; kitchenware; yogurt containers; margarine tubs; microwaveable disposable take-away containers; disposable cups; plates.	05 PP	Automobile applications, such as battery cases; signal lights; battery cables; brooms and brushes; ice scrapers; oil funnels; bicycle racks; garden rakes; storage bins; shipping pallets; sheeting; trays.
Polystyrene (PS)	Egg cartons; protective and insulating packiging; disposable cups, plates, trays and cutlery; disposable take-away containers;	06 PS	Thermal insulation; thermometers; light switch plates; vents; trays; rulers; license plate frames; cameras or video cassette casings; foamed foodservice applications; plastic mouldings; expandable polystyrene (EPS) foam protective packaging.
Other (often polycarbonate: PC or Acrylonitril-butadieen-styreen: ABS)	Beverage bottles; baby milk bottles; custom packaging; housing for electronics and compact discs	07 O	Bottles and plastic lumber applications.

main source: American Chemistry Council

The polymers could either be recycled into the same type of product; closed loop recycling, or into another product; open loop recycling. Separation of – post consumer/post industry – plastic waste into mono-flows of polymers is one of the steps to help facilitating high quality recycling. Smart collaborations regarding collection, separation and recycling will reduce processing costs associated with the various steps, while increasing the volumes of valuable flows of plastics. Recovery of the plastic waste could take place in a facility that processes all regional plastic flows.

Associated with mining of plastics in aircraft waste, the step to – first and foremost – *reduce* waste should be further addressed. In relation to this, several aspects came up during the research. First, most airlines currently make use of plastic packaging, which hampers optimization of certain recycling processes. The catering department of Schiphol's home carrier, KLM Royal Dutch Airlines, has implemented advanced recycling tactics in this respect. KLM made steps to separate leftover bread rolls from their plastic packaging. The bread is fermented at a nearby fermentation plant, whereas the plastic fractions end up in plastic recycling routes. However, by replacing those plastics with bespoke biodegradable types, that separation step may eventually be eliminated. [15] Biodegradable plastics can be made from locally harvested chemical building blocks. Second, the shift from *push* to *pull supply* regarding the meals in airplanes, i.e. giving customers upfront choices, may reduce leftovers, as the required quantities could be more finely tailored per flight. Third, increasing the share of locally grown food could reduce the food transport related secondary packaging.

Apart from solid waste materials, the application of urban mining efforts at Schiphol related to wastewater products is not only imaginable but currently also explored by Schiphol and Evides; the company responsible for wastewater treatment at the airport. The ambition is to further exploit the opportunities in wastewater treatment processes, whilst producing cleaner effluent water, reducing direct discharge onto the Ringvaart, and recovering nutrients. A pilot case that currently runs at Schiphol revolves around harvesting phosphates from urine. Phosphates are becoming increasingly scarce and, apart from reclaiming them, there are no alternatives in the Netherlands.[16] The pilot is aimed at production of *struvite*, a mineral that can be used as fertilizer for local agricultural land.[17] Furthermore, semi-solid organic fractions in wastewater are potential raw materials for biogas and soil improvers through anaerobic digestion.[18] Forming collaborations or so-called 'smart coalitions' regarding existing or planned initiatives and developments in the region could bring economies of scale, supply and demand optimization, and possibly knowledge sharing; for example regarding separated sanitation facilities in new building developments.[19] Furthermore, multiple initiatives in the region aim at valorising by-products of wastewater treatment, such as sludge, effluent water, nutrients and low temperature heat. The Rijnland District Water Control Board, operating several wastewater treatment plants in the region, is an important player in this respect; currently extending their activities with regards to, among others, sludge-fermentation. Moreover, strong links are possible with the horticultural and agricultural sector, regarding the use of tailored effluent water for various irrigation purposes for instance.

3.4.4 Route du Soleil; Integrated road energy landscapes

The South-East of Haarlemmermeer (nr. 4 in Figure 3.13), where two main access highways join, has specific potential to become an energy landscape, whilst integrating e.g. wind turbines, photovoltaic (PV), thermal buffering, biomass, and LED lighting. This is not only due to absence of hinder zones related to lower flight paths of airplanes, but also due to larger availability of land, optimal orientations, lower building densities and higher wind speeds at lower and higher altitudes. As such, this zone could contribute significantly to renewable energy goals set by the municipal, provincial and federal governments. In Figure 3.7 various options are mapped: wind energy, PV (on existing noise barriers) and (roadside) biomass. Regarding wind potential, we followed the 'Variant Max' scenario (40 MW capacities) of Windpark Haarlemmermeer-Zuid.[20] If these capacities are distributed over 20 turbines of 2 MW on 80-100 meter axis-height, then approximately 80 GWh of electricity will be generated per year. This corresponds with roughly 300 TJ/y (≈ 1.2 TJ/ha); an estimated

15 Provided that the biodegradation times for bread and packaging are within a compatible range
16 Phosphates are currently imported, notably from Morocco and China
17 Schiphol currently buys 30 tonnes of fertilizer per year for its land [Vewin 2012]. Schiphol is equivalent to 45.000 pollution units. Roughly 500 L of urine is produced per pollution unit per year. 1 m3 of urine could yield between 1,5 and 3 kg of struvite ($NH_4MgPO_4 \cdot 6H_2O$)
18 Regarding co-digestion and reclaimed nutrients, links are discernible with hotspot zones GAIN and GAS
19 Separated-sanitation leads to more concentrated – liquid or solid – waste flows
20 Windpark Haarlemmermeer-Zuid initiates and develops a wind park in Haarlemmermeer's South-East zone

supply for 24,000 households. For PV potential on noise barriers along the highways, we calculated the following: 19.2 km of provincial noise barriers receive 2m of PV coverage, using the roadside of the best-oriented half. This includes a 16% PV efficiency rate and an estimated 10% reduction due to lack of cleaning, leading to a potential of in total 16 TJ of electricity per year for this area. With regard to biomass, the main focus was on roadside grass; this potential can be estimated from a) the length of (federal, provincial and – to a certain extent – local) roads, b) an approximate average roadside width of 3 meters, and c) an average of 3,5 t of roadside grass per hectare [e.g. Warmerdam et al. 2011 and Tolkamp et al. 2006]. A potential of 75-150 t per year is considered a conservative estimate. Roadside grass is suitable for fermentation; 1 t of roadside grass can yield 120 m^3 of biogas. For the total area this represents 200-400 GJ per year (2.6 GJ/ha). Figure 3.19 visualises current land use in this hotspot zone, as well as noise barrier heights and potential wind turbine locations based on the abovementioned Variant Max scenario.

Route du Soleil brings together a variety of potentials with different levels of implementation feasibility. PV on existing noise barriers, for example, is an intervention with relatively low spatial and societal impact, whereas plans for the implementation of wind turbines, such as the proposals of Windpark Haarlemmermeer-Zuid, stumble into organisational obstacles. Furthermore, engaging local petrol stations along the A4 and A44 in local renewable energy strategies (based on green power and green gas) could stimulate the implementation of sustainable mobility: an ambition that connects to the environmental vision of Schiphol. On the one hand biofuels from regional biomass are of interest here, on the other hand these stations could function as recharge points for electric vehicles, using locally generated solar and wind electricity. Another potential with regard to hotspot zone 4, Route du Soleil, is the use of LED and thermal collectors in the road; LED for lighting systems results in lower energy use and lower light-pollution characteristics than traditional lighting, while thermal collectors help extend the lifetime of road surfaces and create frost-resistant roads (or landing strips). Using this thermal energy for low temperature heat supply in other functions is less relevant at this location, given the limited efficiencies. However, it may be a relevant application at other locations, for example with regard to mitigation of urban heat island effect.

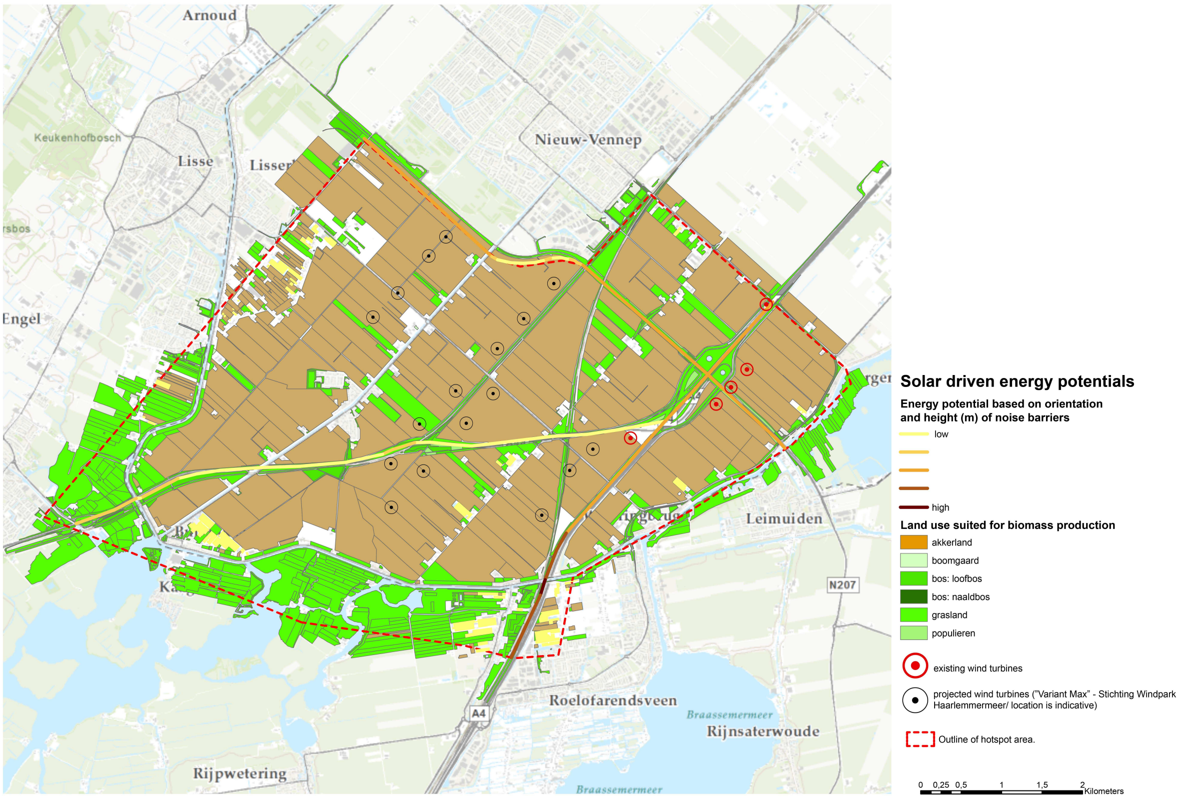


Figure 3.19: Hotspot zone Route du Soleil

Agricultural activities could be allocated to e.g. food, materials and energy production. The latter focused on agricultural waste flows rather than specific energy crops (e.g. Elephants grass, as temporary the case in the

Schiphol Trade Park area within Hotspot zone 2). Concerning crop cultivation on agricultural plots, the many variables make it difficult to render reliable statements on yields – of food, materials and biofuels; potential yields per hectare differ significantly, depending on the crop and the conversion route. [21] Nevertheless, an indication can be made via the following comparison regarding bioethanol, with an energy content of 26.7 GJ per tonne:

- Winter-wheat yields 2.3 t/ha ≈ 61 GJ/ha
- Potatoes yields 4.6 t/ha ≈ 122 GJ/ha
- Sugar beet yields 4.8 t/ha ≈ 128 GJ/ha.

In this context, the food versus fuel discussion cannot be avoided. Apart from general questions of priority, one could debate the rationale behind fuel production for transportation in one sector on agricultural land that could contribute to avoiding transport distances in another. For example, Geldermans et al [2014] estimated that 4% – roughly 300 hectares – of the available agricultural land in Haarlemmermeer would suffice to produce the amount of carbohydrates (captured in potatoes) consumed at the airport.[22] Figure 3.20 displays the total amount of agricultural land in Haarlemmermeer and the part required to fulfil the annual carbohydrate needs at Schiphol in potato equivalents.

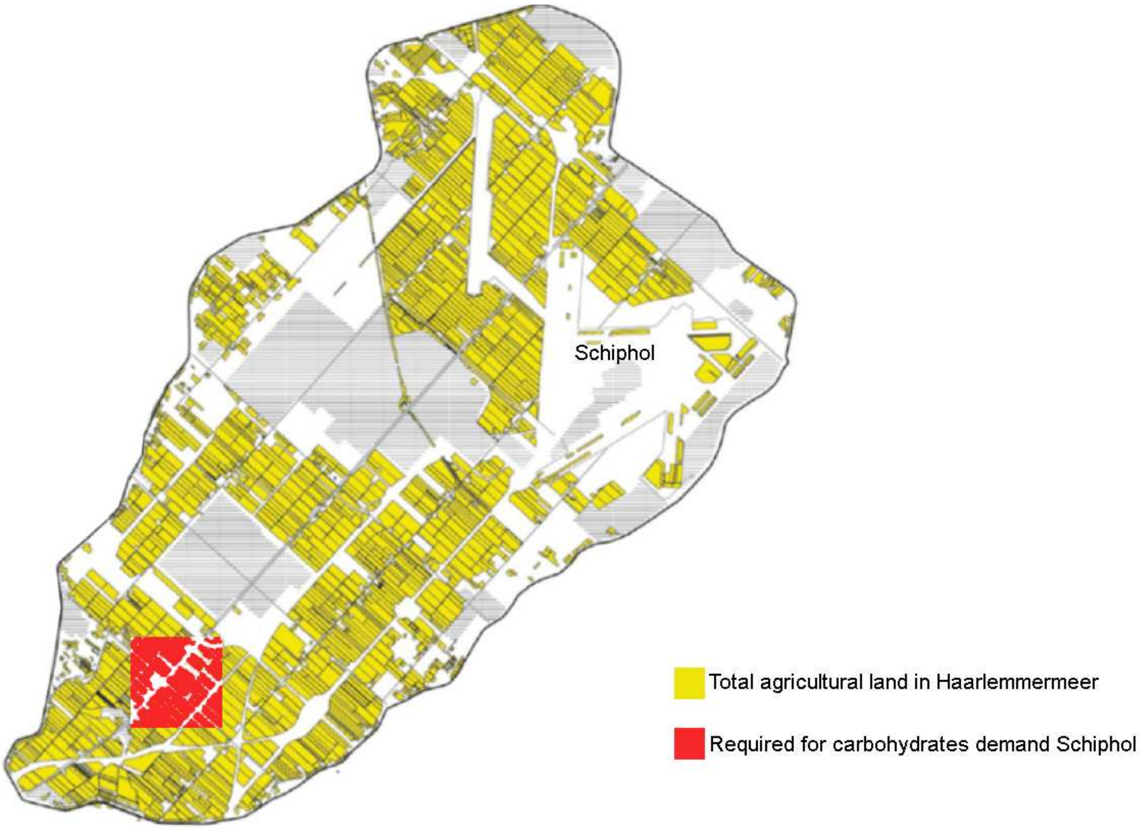


Figure 3.20: 300 ha in 7,600 ha agricultural land Haarlemmermeer [adapted image from Mijnders et al. 2011]

Finally, this part of the municipality is allocated in legal documents for innovative agriculture (e.g. Structuurvisie Haarlemmermeer 2030). Because the municipality of Haarlemmermeer as a whole is fighting the increasing problems resulting from salination, this hotspot zone can be considered an essential test-bed to start applying innovative saline agriculture, whilst anticipating the inevitably increasing salinity level of the groundwater in this area. Another option considered in this research project was algae, which – similar to several other crops – is capable of utilizing saline water.

[21] Conversion routes e.g.: fermentation to biogas, fermentation to bioethanol, gasification and combustion

22 Agricultural land in Haarlemmermeer is roughly 7,600 ha – 40% of the total area – about 5,900 ha is allocated to crop cultivation; mainly potatoes, sugar beet, wheat and onions. Furthermore, 1,200 hectares are meadowland, and 500 ha allocated to horticulture.

3.4.5 Greenport Aalsmeer Symbiosis (GAS)

Greenport Aalsmeer is one of the five greenports in the Netherlands, with horticultural trading gateway FloraHolland as the epicentre, and therefore a logical hotspot zone (hotspot zone nr. 5 in Figure 3.13). The related greenhouses are mostly scattered over multiple municipalities in the surrounding region. In 2011, an inventory study was made regarding locally available biomass near to Greenport Aalsmeer [Innoforte 2011]. This study, commissioned by the Amsterdam Meerlanden+ municipalities (Aalsmeer, Amstelveen, Diemen, Ouder Amstel, Uithoorn and Haarlemmermeer), is aimed at the development of a heat grid, coupled with bio-digesters and combined heat power (CHP) plants – at least partly – fuelled by local biomass waste flows. The concepts resulting from the study combine heat, electricity, gas and CO_2 supply, with a central role for co-digestion of manure with other biomass flows. Links with the electricity grid, natural gas net and OCAP CO_2 pipeline[23] are anticipated. Multiple stakeholders are involved in this initiative, such as municipalities, branch organisations, horticulturists and farmers.
Figure 3.20 displays the biomass flows in the Amsterdam Meerlanden+ municipalities per category. This excludes the share that is already part of running contracts. Furthermore, the map indicates regional greenhouse clusters and the OCAP pipeline, transporting CO_2 from the Rotterdam Harbour to customers (greenhouses) or underground storage.
This hotspot zone, based on industrial ecology related to horticulture, could function as a flywheel for comparable concepts elsewhere in the region, whilst potentially benefitting economies of scale. Taking into account other applications, flows and spatial factors will improve the envisioned system's resilience, as well as its economic viability and long-term sustainability. Furthermore, expertise dispersed over the region, can be clustered around the hotspot zone.

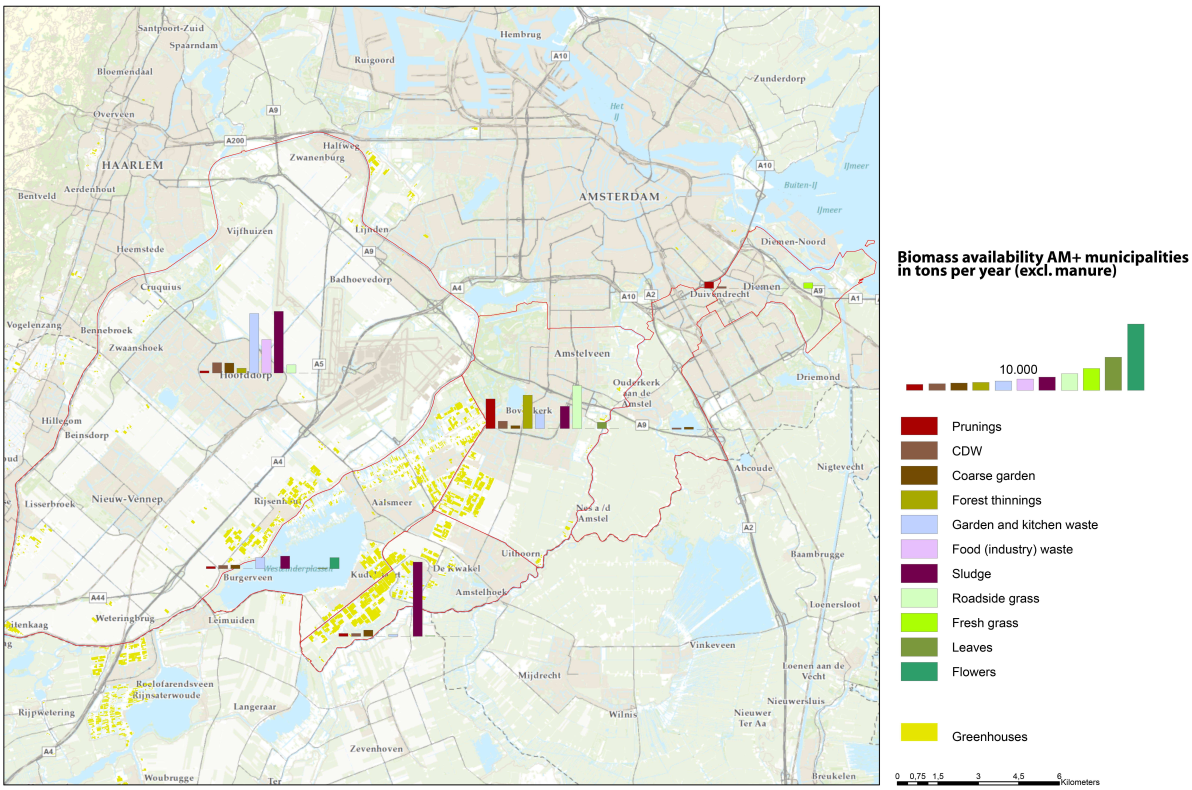


Figure 3.20: biomass availability AM+ municipalities

The local heat grid envisioned by the AM+ municipalities, as referred to in hotspot zone GAS, is currently still in its conceptual stage. However, valuable work is done concerning inventorying biomass flows, supply and demand patterns, stakeholder participation, technical requirements, returns on investment, and other factors

23 OCAP: Organic Carbon dioxide for Assimilation by Plants, a CO2 distribution pipeline running from Rotterdam to Amsterdam

that define the feasibility of such an initiative. Within the concept, the infrastructure is not dependent on one heat source or generating process, but can be fuelled by multiple sources, which is crucial for the flexibility and resilience of the system. Concerning the temperatures, there is less flexibility anticipated: these are limited to 90°C in and 40°C out. Even though this may not be the most effective choice (due to its disregard of potential energy cascades), it does anticipate future connections to the city-heat grid of Amstelveen – and possibly other ones.

An analysis of the various stakeholders' perspectives indicates that the biggest threats of this biomass initiative revolve around increased interdependency, touching upon technical, organisational and legal aspects. Another disadvantage is the fact that peak-load systems are still required in this concept. This means that the horticulturists will probably keep their – natural gas driven – CHP installations running. Despite the claim that the envisioned heat grid offers an economically stable energy supply, horticulturists are likely to let energy purchasing follow market mechanisms (best price). It depends on the agreements between partners to what extent flexibility in this context is allowed or desirable. Moreover, overruling individual CHP systems also implies that CO_2 supply has to be secured in other, economically attractive ways. Integrating multiple resources and supply chains upfront seems necessary to prevent a lock-in effect.

3.4.6 Green Agro Industrial Nexus (GAIN)

Hotspot zone 6 (see Figure 3.13) focuses on an agro - industrial connection. Manure is a valuable biomass flow because of its relatively high nutrient and energy content. Manure is also associated with problems of ecological degradation, such as eutrophication. Those problems differ a lot per region in the Netherlands, and lately are diminishing significantly as a result of legislation. Naturally, manure has always been an indispensable product for soil improving purposes for the agricultural sector. In that respect, the surplus of manure that one agricultural entrepreneur deals with may be welcomed by another. Manure is increasingly a focus in bio based economy strategies, with regards to nutrient cycles and energy potential. Nitrogen (N), phosphorous (P) and potassium (K) balances in the Netherlands are unstable; on the output side nutrients end up – and cause problems – in the environment, whereas a worldwide shortage of notably phosphorous, due to depletion of resources, on the input side is imminent.[24] Synthetic fertilizers, which are introduced lately to address this, are based on short term, quantity driven benefits, and may hinder long-term soil and water quality even more. Moreover, these synthetic fertilizers depend largely on high quantities of non-renewable resources and are sensitive to price fluctuations by implication.[25] Before manure could function as a competitive, high-grade soil product, certain process steps are required. Fermentation fits well into these processes; it conserves soil improving qualities, whilst potentially contributing to green gas production, low temperature heat and reduction of methane emissions during storage. Creating a green agro-industrial nexus in the region would accelerate the efforts in this respect; apart from optimized logistics and supply & demand alignment, knowledge and experience can be shared.
Table 3.4 lists the manure production per municipality, with its dry weight and biogas potential.[26] A co-digestion scenario is included as an example.[27] Furthermore, the nutrients contained in the manure are listed [CBS Statline 2013].[28] Figure 3.21 shows land use, with two industrial zones Polanenpark and De Liede, the Ringvaart waterway, and nearby wastewater treatment plants. Moreover, the manure production with its energy content is indicated per municipality.

24 According to the Dutch Nutrient Platform, the Netherlands has a phosphate overload of 50 kilotonne per year, of which 40% accumulates in agricultural land, 10% ends up in surface water and 50% ends up in purification and incineration facilities
25 Yara Sluiskil is – with ca. 1,8 billion m3 per year – one of the largest industrial users of natural gas in the Netherlands: approximately 4% of the total Dutch gas use [Food & Energy Impuls Zeeland 2010]
26 1 tonne of (wet) cattle manure contains on average 5,2 kg N (nitrogen), 1,7 kg P2O5 (phosphorus pentoxide) and 7 kg K2O (potassium oxide)
27 Co-digestion is a common practice to increase biogas yields
28 Manure-nutrient use in agriculture is in all 12 municipalities higher than what is produced by their livestock

Table 3.4: Manure production, biogas potential and nutrient content

	Manure from cattle				Co-digestion example manure/roadside-grass 50/50*			Nutrient excretion in cattle manure (*1.000 kg)		
	Manure from cattle/year (*1000 kg)	**m3 biogas/year from manure**	**GJ/year**	**Dry weight of digestate (*1000 kg)**	**m3 biogas/year from co-digestion manure/roadside grass (50/50)**	**GJ/year 50/50 example**	**Dry weight of digestate 50/50 example (kg)**	**N**	**P**	**K**
AALSMEER	1.000	20.000	440	45	140.000	3.080	245	5	2	7
AMSTELVEEN	35.000	700.000	15.400	1.575	4.900.000	107.800	8.575	182	60	245
AMSTERDAM	43.000	860.000	18.920	1.935	6.020.000	132.440	10.535	224	73	301
BLOEMENDAAL	5.000	100.000	2.200	225	700.000	15.400	1.225	26	9	35
HAARLEM	5.000	100.000	2.200	225	700.000	15.400	1.225	26	9	35
HAARLEMMERLIEDE	21.000	420.000	9.240	945	2.940.000	64.680	5.145	109	36	147
HAARLEMMERMEER	24.000	480.000	10.560	1.080	3.360.000	73.920	5.880	125	41	168
HEEMSTEDE	3.000	60.000	1.320	135	420.000	9.240	735	16	5	21
HILLEGOM	1.000	20.000	440	45	140.000	3.080	245	5	2	7
KAAG & BRAASSEM	194.000	3.880.000	85.360	8.730	27.160.000	597.520	47.530	1.009	330	1.358
LISSE	15.000	300.000	6.600	675	2.100.000	46.200	3.675	78	26	105
TEYLINGEN	30.000	600.000	13.200	1.350	4.200.000	92.400	7.350	156	51	210
	377.000	***7.540.000***	***165.880***	***16.965***	***52.780.000***	***1.161.160***	***92.365***	***1.960***	***641***	***2.639***

For manure, a dry weight content of 9% and a biogas yield of 20 m3/ton is assumed

For roadside-grass, a dry weight content of 40% and a biogas yield of 120 m3/ton is assumed

*This example does not make any statements about the availability of roadside-grass in the municipalities

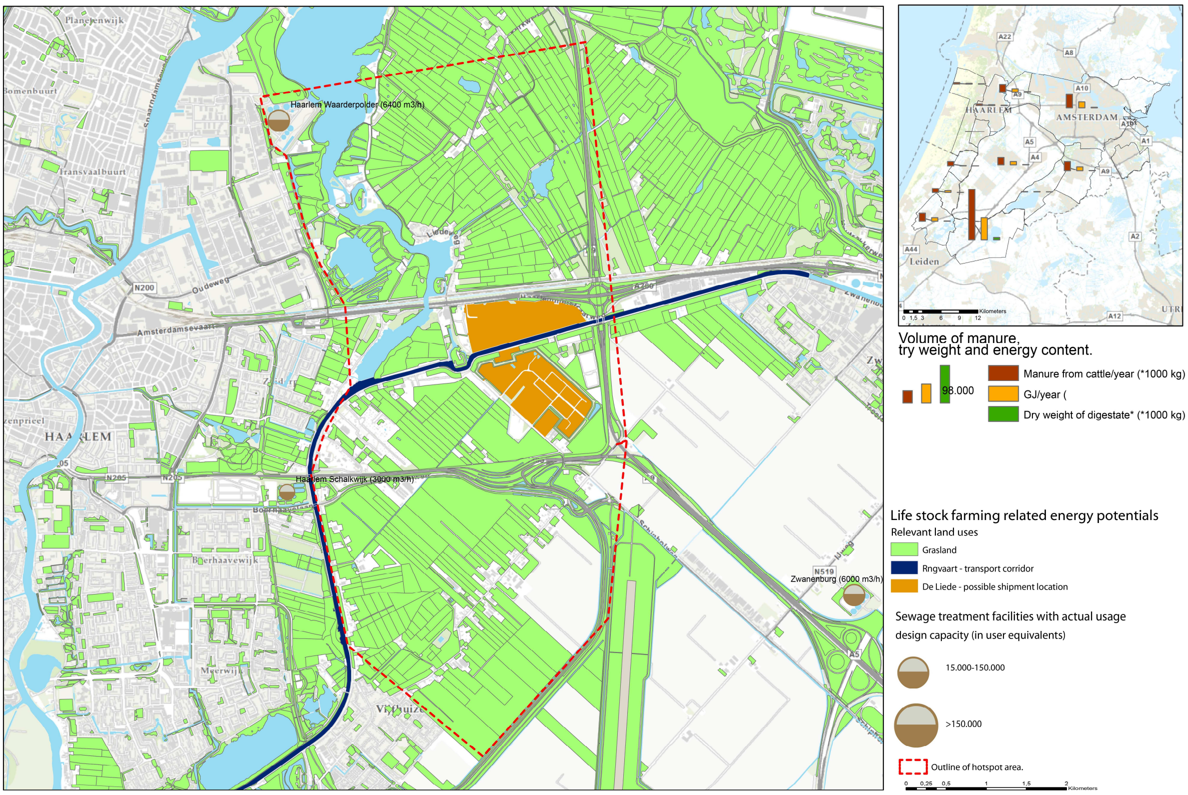


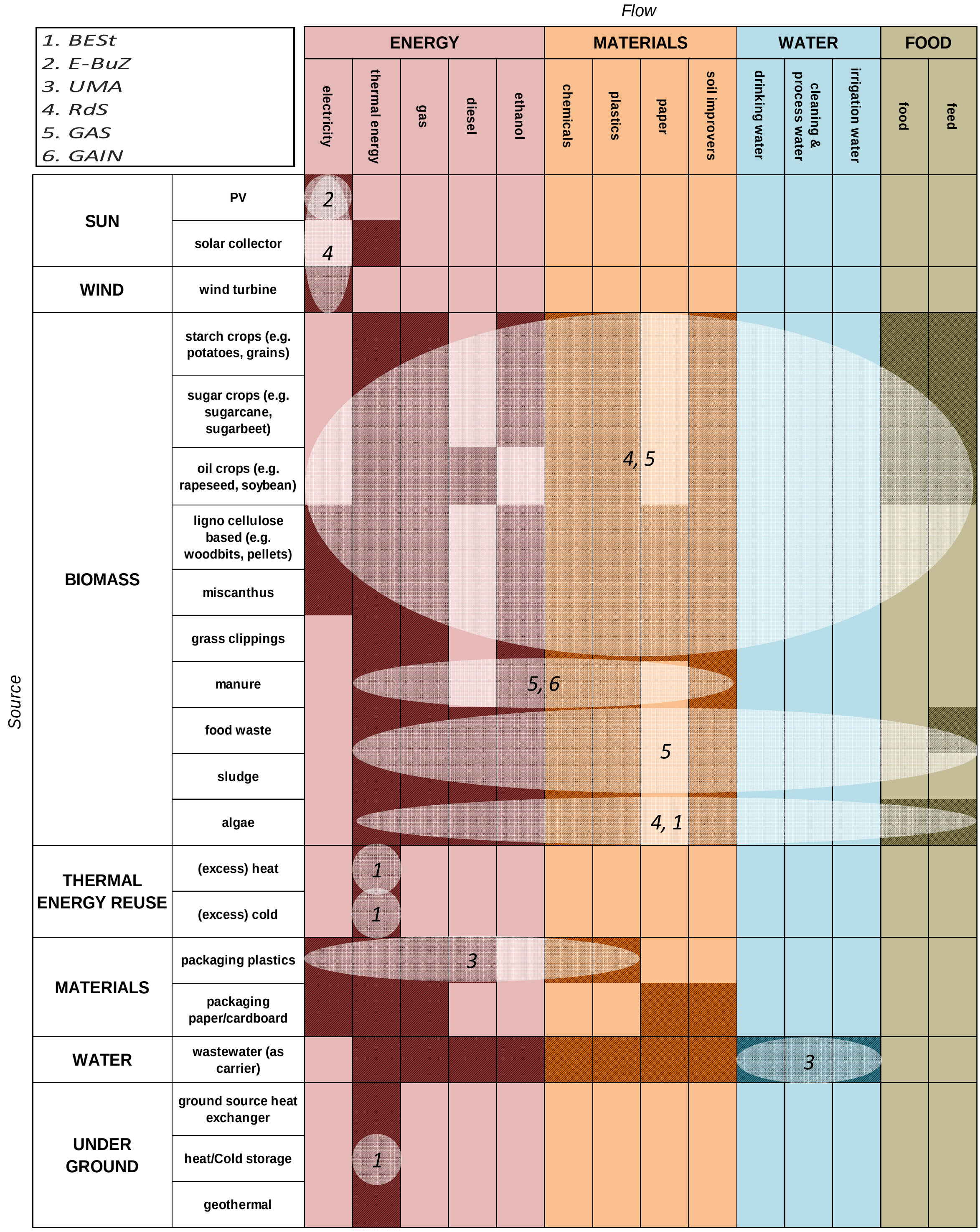
Figure 3.18: Hotspot zone GAIN, with regional volumes of manure, dry weight and energy content

When addressing manure from cattle, with regard to hotspot zone 6, the cattle's diet is an aspect that cannot be omitted. Cows' preferred feed is grass. Alongside they are fed concentrated feed and coarse fodder. Coarse fodder is made from common crops, such as grass, corn, beet and potatoes. Feed is made from e.g. wheat or soy based (by-) products. At this moment a large part of the feed is produced abroad. Although they can be found closer by: for instance waste flows from breweries or waste flows from vegetable oils and biofuel production are very suitable. A quick estimation based on averages suggests that roughly 3,000 tonnes of feed per year would be required for the cattle in Haarlemmermeer.[29]

29 Based on the average of 1,600 cows eating approximately 30-60 kg of feed per day (and producing 30,000 t of manure per year)

The municipalities Haarlemmermeer and Haarlemmerliede have good potential with regard to their livestock farming and agro-industrial activities. Fixed between these two municipalities are industrial zones *De Liede* and *Polanenpark*, which may accommodate storage and transhipment activities or possibly a production or bio-digestion facility. In terms of space, expertise, permits and capacity, nearby wastewater treatment plants (WWTPs) may also be suitable production locations. Potential WWTP locations are, for instance, Zwaanshoek and Haarlem Waarderpolder. Finally, given the existing water infrastructure, cost effective and sustainable (bulk) transport of biomass over water in this area can be considered.

Table 3.5: Productive interrelations matrix, including hotspot zone positioning



3.5 Integrated and circular flows

System based considerations are conditional to accurately weigh the pros and cons of identified potentials associated with circular resource flows and regional integration. This touches upon the interrelatedness of resource flows and the link between applications and stakeholders that were hardly, or not at all, related in traditional linear resource systems. Apart from embedded – or *production* – interrelations (material production requires energy and water, energy production requires materials and water etc.), one can distinguish *productive* interrelations (biomass for food and materials, wind for electricity and clean air, sun for electricity and heat, etc.).
The integrated flows matrix of Table 3.5 is an overview resulting from the inventory of selected resource flows in the airport region and, more particularly, the potential analyses of the hotspot zones. On the horizontal axis essential resource flows are divided into sub categories and on the vertical axis renewable sources and types are listed that facilitate these flows. The shaded cells indicate the primary productive opportunities; those represented in one or more of the hotspot zones are highlighted and numbered accordingly.

3.6 Discussion

The matrix (Table 3.5) indicates, amongst others, that biomass offers a myriad of – technical – opportunities within the study area. Each type of biomass has a different composition relating sugar content, calorific value, moisture content etc., and hence divergent intrinsic qualities. By choosing different conversion methods (mechanical, chemical, biochemical or thermochemical), biomass can be refined into a variety of products. To what extent the intrinsic value is optimally recovered depends not only on resource availability and conversion technologies, but also greatly on the interaction between sectors and stakeholders; an interaction that will radically change in an economy striving for optimal valorisation of biomass resources, whilst integrating a growing number of supply chains.[30] Biomass potential may be regarded negligible when conversion into mono-functional biofuels – replacing current fossil fuels – is the aim. However, the potential of biomass increases significantly when the perspective shifts to a systems scope based on diversified supply chains. A meaningful question in this respect is, for example, to what extent a configuration based on thermal energy reuse (for thermal comfort) and solar or wind energy (for electricity) could reduce the demand for combustion fuels. In particularly meaningful when considering an all-electric mobility scenario (excluding air traffic). Within such configurations, the use of space is a critical factor, making spatial layout – and quality – an even more acute local issue. A related question is to what extent legal frameworks should be adjusted in order to enable overarching coordinating bodies to influence and manage this impact, beyond individual interests. Such questions, more elaborately addressed in other modules of the BAR project, are examples of leads to further research.
Furthermore, two interrelated aspects in particular have come to the surface as critical factors that determine the value of the proposed approach and its results: complex system dynamics and data quality. Below, those aspects are further discussed.

3.6.1 Complex system dynamics

Airports, being complex systems in their own right, interact with their direct surroundings in complex and multifaceted ways. Enabling reciprocal relationships with those surroundings implies adding value rather than nuisance in the form of noise, pollution and traffic congestion; associations that currently seem to prevail. This reciprocal relationship relates to new paradigms in dealing with essential resources. Reciprocity not only implies a symbiotic relationship but also a degree of mutual obligation that comes with it. These are properties of systems thinking and underline the non-linearity in complex systems. The proposed methodology results in identified potentials that are largely of a technical nature. But technology is often not the limiting factor with

[30] Following a value pyramid for biomass applications (WUR 2012), pharmacy, fine chemicals and food come first, followed by feed purposes, after which residual biomass is used for bulk chemicals and other functional materials, and subsequently for energy applications.

regard to breakthroughs of sustainable innovations. In that respect, the methodology contains a paradox: a *reductionist* approach to ultimately understand a *holistic* system. However, this methodology is part of an integrated effort to understand complex systems, whilst yielding *sub*-results as input for design patterns. Those patterns are subsequently coupled with spatial design, planning and governance. In this way the opportunities detected in the case study area of the Schiphol airport region obtain systems based value.

3.6.2 Data quality

During the research, we have strived for the highest data quality possible within the restrictions dealt with. However, due to the complexity and size of the study area, as well as the amount of data owners and stakeholders, a certain asymmetry in data has to be taken into account. In those cases the emphasis is more on qualitative than on quantitative results. Despite the cooperation of several key players, data – if existent at all – are in many cases not readily available. Lack of transparency is an issue here in two ways: firstly, actors may not want to – or be allowed to – share certain information. Secondly, actors may not share the piece of information that is valuable for us, and/or they may not be aware what the significance of specific information is. In the first case it is clear that confidentiality renders data out of reach. The latter case, however, is more ambiguous and seems closely connected with individual sectorial concerns. During the research we have explicitly operated from a systems approach towards sustainability; data are assembled to anticipate non-sectorial solutions. It is not self-evident that this approach coincides with the interests of individual actors. However, outlines of specific projects become discernible in the hotspot zones, which may appeal to individual actors as much as the society. This appeal is thought to create the required incentives for individual actors to take next steps in generating and sharing data. This aspect is further addressed in other modules of the BAR project, in particular the module dealing with governance.

3.7 Conclusions

3.7.1 General conclusions

Through theoretic and empirical research, as well as interviews and workshops, multiple potentials and challenges were identified with regard to closing cycles, energy potential mapping, nutrients recovery and regional integration, whilst drawing generic lessons through specific examples. The potentials and challenges addressed in this paper have a predominantly technical focus and are input for other modules within the overarching BAR project aimed at the related organisational, legal, spatial, and financial issues. The main general conclusions are listed below:

- Relating essential resource flows in the Amsterdam airport region, circularity and regional integration are currently largely unanticipated, leading to squander of valuable resources and disregard of potential mutual benefits.
- Unravelling resource flows and their infrastructures on the one hand, and local conditions on the other, brings a variety of potential enhancements to the surface with regard to circular flow management and regional synergies.
- The potential enhancements regarding circular flow management and regional synergies have inherent spatial implications.
- The hotspot zones studies underline the necessity of trans-disciplinary, systemic approaches.
- Identified potentials comprise both specific characteristics relating local projects and generic lessons applicable to other (airport) regions.
- The main criteria to determine the hotspot zones – presence of specific flow potential, spatial relevance, strategic relevance, current or planned regional developments, and spatial and thematic dispersion – will arguably lead to a better integrated, area-specific selection procedure. This is valid provided that an optimal blend of disciplines and stakeholders takes part in the selection process.
- Outlines of specific projects become discernible in the hotspot zones that address both societal benefits as those of individual stakeholders. This appeal is thought to create incentives for individual actors to take next steps in generating and sharing data, know-how and values.

- From a view of essential resource flows there is not one airport region, neither a system nor an area with boundaries; it is a soft space with fuzzy boundaries.
- Schiphol has a dominant role as a work place for the towns in the municipality of Haarlemmermeer. Specifically for Toolenburg, Hoofddorp, Overbos and Badhoevedorp, where up to one tenth of the living population works at Schiphol.

3.7.2 Key findings for the Schiphol airport region

- Relating essential resource flows in the Amsterdam airport region, circularity and regional integration are currently largely unanticipated, leading to squander of valuable resources and disregard of potential mutual benefits.
- Unravelling resource flows and their infrastructures on the one hand, and local conditions on the other, brings a variety of potential enhancements to the surface with regard to circular flow management and regional synergies.
- The potential enhancements regarding circular flow management and regional synergies have inherent spatial implications.
- The hotspot zones studies underline the necessity of trans-disciplinary, systemic approaches.
- Identified potentials comprise both specific characteristics relating local projects and generic lessons applicable to other (airport) regions.
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- From a view of essential resource flows there is not one airport region, neither a system nor an area with boundaries; it is a soft space with fuzzy boundaries.
- Schiphol has a dominant role as a work place for the towns in the municipality of Haarlemmermeer; specifically for Toolenburg, Hoofddorp, Overbos and Badhoevedorp, where up to one tenth of the living population works at Schiphol.
- The airport and the mobility infrastructure, which it is connected to, results in a specific commuting pattern: more public transport less bike.
- The airport is situated along one of the most central highway segments of the Netherlands. This provides potentials for other economic sectors.
- The inhabitants of Haarlemmermeer have only limited access to a sufficient variety of green spaces.
- The urban development along the Kruisweg and the A 200 block the regional permeability of the landscape.
- The green areas under the noise contours have a cooling effect during heat waves.
- Most of the neighbourhoods in Haarlemmermeer have a high internal connectivity but are not permeable.
- The densification potential in the housing areas is significant.

3.7.3 Selected recommendations for Schiphol airport region stakeholders

- Reduce the dependency on green certificates based on far away sources. The identified potential for renewable energy production and exchange in the region justifies a diminished use of those certificates.
- Scale up the execution of audits on the use of idle spaces and roof surfaces regarding ‘red’ (energy), ‘green’ (vegetation, biodiversity) and/or ‘blue’ (water) functions. Commercial zones have good potential in this respect.
- Strive for cascaded thermal energy systems, including storage capacity for load balancing, in order to maximize the work potential contained in the energy flow.

- When smart storage technologies mature (such as Power to Gas), intermittency of solar and wind energy – and the preference for instantaneous use – becomes less of an issue. Efforts in this direction are thus a priority.
- Determine to what extent existing infrastructure (gas, heat, CO2...) may support – or possibly hinder – smart, decentralized networks. And invest in infrastructures that are resilient i.e. that anticipate different types of gas, temperatures etc.
- Team up with the right partners in innovative business models around resource management. For example, there is good potential for scaling up the efforts to recover plastics in waste, while avoiding the less favourable incineration option, but this implies a regional, trans-sectorial approach to plastic waste handling. Regarding a recovery facility: the region offers multiple potential locations to accommodate this.
- Packaging hampers optimization of aircraft waste recycling. Explore ways to reduce the use of packaging, simplify separation steps and/or allow product and packaging to follow the same processing route.
- Enable locally grown food to have a bigger share at the airports and in aircraft. Make better use of the region's assets in this respect, whilst reducing food transport and secondary packaging.
- Further analyse the effects of a shift from push to pull supply regarding meals in airplanes. Upfront choices for customers may reduce leftovers.
- Use the opportunity of test-beds to start applying innovative saline agriculture, whilst anticipating the inevitably increasing salinity level of the groundwater in this region.
- Livestock feed is made from e.g. wheat or soy based (by-) products. At this moment a large part of the feed is produced abroad. Although they can be found closer by: for instance waste flows from breweries or waste flows from vegetable oils and biofuel production are very suitable.
- Use energy carriers wisely, according to optimal application within the given context and time. Local biomass, for example, has limited potential to comply with the current demand for combustion fuels (especially not for aircraft!), but its potential increases when other biomass value chains are included.
- Apply a stepped approach, based on implementation-feasibilities, to increasingly facilitate circular resources and renewable energy systems. For example, PV on noise barriers is an intervention with relatively low spatial and societal impact compared to the implementation of wind turbines.
- Consider a mediating organisation that aligns initiatives, from an integrated sustainability viewpoint, and that checks potential double-counting.

3.7.4 Zero Energy Terminal Building

On July 2nd 2014 MSc student of Building Technology Mira Conci graduated on a zero-energy terminal building, for which she approached the design of a terminal building next to the Polderbaan in a very structured way, resulting in an energy-neutral, water neutral building. Mira's report is added to the collection of Annexes.

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4. Patterns and complexity
Integrated patterns for essential streams & spatial qualities for Better Airport Regions

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Table of Content

4.1 Theoretical framework: a complexity-cognitive approach

In order to deal with the complexity of the Airport Region it is proposed to use patterns to describe the relations between essential streams and spatial qualities. The basic idea is that patterns are useful tools to mediate in multi-actor design processes in complex urban environments. This section gives an overview of the theoretical framework[31], the proposed method and the integrated patterns for essential streams and spatial qualities.

In order to understand the Airport Region on a systems level, a theoretical framework is developed based on *'Complexity Theories of Cities'* (J. Portugali, Meyer, Stolk, & Tan, 2012)[32]. According to the later, urban environments, like an Airport Region, can be considered as a Complex System (CS).

The Airport Region as a complex adaptive system

Complex systems: (1) are open systems, as they continuously interact with their environment; (2) have emerging properties, that is, they have global properties which cannot be explained by the interactions of local parts; (3) are nested systems, in which parts of the complex systems are complex systems in themselves; (4) are unpredictable systems because of the nature of the system, not because of the lack of data; (5) are difficult to control in a top-down manner; (6) in some specific cases, can adapt itself to the changing environment. In these cases, the complex system is called a Complex Adaptive System (CAS).

In the case of the Airport Region: (1) there is a continuous flow of energy, information and people in and out of the Airport Region; (2) the sum of all the elements of the Airport Region is more than it's parts, which is one of the driving forces of the BAR project; (3) the Airport region consists of a multitude of interacting subsystems, for example the different networks of streams of energy, information and people; (4) it is impossible to predict the future of the Airport Region; (5) the Airport region is difficult to control in a top-down manner;(6) the Airport Region adapts itself to changes in the environment, either it be the political or cultural environment or, for example, climate change.

Differences between 'natural' and 'artificial' complex adaptive systems

Compared to 'non-human' complex adaptive systems, complex systems including human beings have some distinct characteristic, because of humans' specific cognitive capabilities. This is one of the main drivers to relate the science of complex systems to human cognition, as previously elaborated in '*Complexity, Cognition and the City'* (Juval Portugali, 2011). One distinct characteristic of such a system is the following: humans collectively produce artifacts on an unprecedented scale, shaping their environment by creating buildings, infrastructures, cities, and Airport Regions.

In shaping their environment humans make use of their capability to *plan* and *design*. Besides being professional activities, as is the case in urban planning and design, these capabilities are basic cognitive capabilities of humans in general (J. Portugali & Stolk, 2014) [33]. Whereas cognitive planning is a subdomain of cognitive science, cognitive design is an emerging field originating within the domain of design thinking and psychology. Besides, *urban* planning and design are studied in the domain of urbanism. This domain is related to the domain of geo-design, which studies design process on large-scale urban territories.

The Airport Region as a Complex Adaptive Prospective System (CAPS)

Besides the capacity to produce artefacts, including human agents into a complex systems view on the urban environment adds three other important properties: (1) human beings have a limited capacity to process information, and use heuristics to deal with complex issues; (2) in doing so, humans move between concrete and abstract information, which enables them to analytical and synthetic modes of thinking – which are the building blocks for our capacity to plan and design; (3) in this processes humans are capable to mentally simulate the future, and act based on these mental simulations: humans are *prospective agents*.

31 Partly, the theoretical framework is developed in the context of and with support from the Province of North-Holland. It is elaborated within the BAR project. A more elaborate description of the framework can be found in Stolk (2014).

32 See also part C of the thesis of Martijn Lugten (2014) for a summary of (Batty & Marshall, 2012) as can be found in (J. Portugali et al., 2012)32.

33 Whereas Portugali (2011) includes the notion of (cognitive) planning, he overlooks the notion of (cognitive) design.

In sum, instead of considering planning and design as external interventions in a complex adaptive system, we propose them to be part of the system itself, giving a proper place to *planning* and *design* in our systems view. As people are *prospective* agents, who not only act on changes in the environment, but also *cause* changes by their future orientated planning and design capabilities. Because of this prospective nature of humans, we propose to consider the Airport Region to be a Complex Adaptive *Prospective* System (Stolk, 2014).

The Airport Region as a dually complex system

When it comes to the planning and design on the level of scale of Airport Regions, the development of ideas can be described as a complex system in itself, resulting in a dually complex system. The first complex system is the environment itself; the second is the complex system of the collective planning and design process.

Some of the plans and design are realized 'in the real world'; some of them only exist 'on paper', while ideas 'on paper' can emerge out of the (re)combination of sensory inputs from the 'real world'. The understanding of the dynamics of the environment by the planning and design actors plays a crucial role in the type of interventions they will propose and the efficiency and effectiveness of these interventions 'in the real world'.

To conceptualize these two complex systems an existing model (SIRN) to describe the production of artefacts (Haken & Portugali, 1996; J. Portugali, 1996) is extended into a 'multilevel design-model', as shown in Figure 4.14.

This multilevel-design describes design and the production of artefacts as occurring in two different worlds ('on paper' and 'in the real world') and in four different cognitive contexts. These different cognitive contexts refer the size of the social group involved in the production of artefacts. This can differ from individual (intrapersonal process), to person-to-person interaction (interpersonal), interactions within a group of agents, and the interactions between different groups of agents. The collective planning and design process can be conceptualized as the simultaneous interaction of these cognitive contexts.

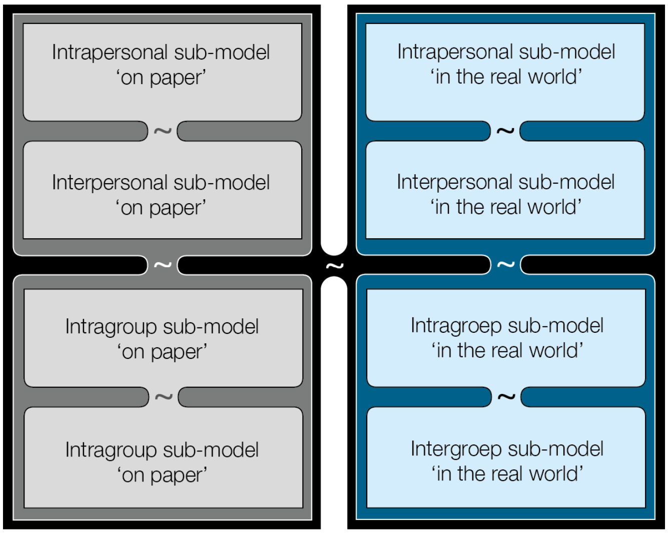

Figure 4.14: Multilevel SIRN-design-model (Stolk, 2014)

The need for a design methodology to deal with complexity

On the one hand, complex systems are fundamentally unpredictable, on the other, humans have the innate need to generate predictions of the future in order to act in the here and now. Similarly, a complex system consists of an extremely large number of dynamically interrelated parts, while humans have a limited capacity to process information. This seemingly paradoxical situation should be taken into account when developing a design methodology to deal with complexity.

Where design in general is considered to be a effective strategy to deal with complexity (Johnson, 2009), there's a need for 'boundary representations', or a 'common language', that can travel between the different worlds and that can be understood similarly in different cognitive contexts. Especially in the case of large-scale urban territories, like Airport Regions, there's a need for an explicit methodology to enable different stakeholder/groups to communicate efficiently and effectively in their collective planning and design process. Besides, This methodology should facilitate the process of moving between concrete and abstract information, stimulating a (creative) planning and design strategy.

4.2 Method: using patterns for essential streams & spatial qualities

A design methodology for 'boundary representations' or a common language, in the domain of urbanism is the Pattern Language as introduced by Christopher Alexander.

Pattern languages in architectural and urban design

> *"Each pattern is a three- part rule, which expresses a relation between a certain context, a problem, and a solution. As an element in the world, each pattern is a relationship between a certain context, a certain system of forces which occurs repeatedly in that context, and a certain spatial configuration which allows these forces to resolve themselves. As an element of language, a pattern is an instruction, which shows how this spatial configuration can be used, over and over again, to resolve the given system of forces, wherever the context makes it relevant."*
> Christopher Alexander

The theory of pattern languages is developed by a group of researchers in Berkeley led by architect and mathematician Christopher Alexander (Alexander, 1979). The methodology aimed to organize and structure architectural and urban design processes, and resulted in a pattern language (Alexander, Ishikawa, & Silverstein, 1977) describing a lexicon of patterns, starting with very large patterns of regions and metropolitan areas, through patterns of cities and neighbourhoods, ending with patterns of very small details of alcoves, windows and door-handles. The book also shows the interrelations of the patterns, forming a whole language, structurally not very different from spoken or written languages. They can be compared to schemata in cognition: "a kind of generative thing, which is flexible but which can produce highly structured interpretations of events and situations" (Rummelhart et al. 1986 in Portugali 1996).

These schemata/patterns form the building blocks for the design and construction of space. The patterns of doors, windows, buildings, squares, neighbourhoods and cities, are interrelated in a way similar to words, concepts, sentences, paragraphs, chapters and stories. The patterns are natural entities in the sense that they exist not only in physical structures in the environment, but also in people's minds. The languages which hold together the many patterns are "very complex sets of interacting rules [which] ... are actually there, in peoples' heads and are responsible for the way the environment gets its structure" (Alexander, 1979, 49-50).

Like schemata, Alexander's patterns are:

> *"something in the world" - a unitary pattern of activity and space, which repeats itself over and over again ... each time in a slightly different manifestation.... these patterns are created by us ... in our minds ... [as] mental images of the patterns in the world: they are abstract representations of the very morphological rules which define the patterns in the world. However, unlike the patterns in the world ... the same patterns in our minds are ... generative. They tell us what to do ... (Alexander, 1979, 181-2)*

Recent additions: pattern couplings and clustered patterns.
Although pattern languages have become important means in computer sciences, the principles are scarcely used and highly criticized in the source domain. Salingaros (2000) suggests the criticism arose because of the structure of the individual patterns and a lack of extensive explanation and reflection on the connectivity of the individual patterns. For example, how to relate large-scale (more abstract) patterns can be related with small-scale (more concrete) patterns is unclear.

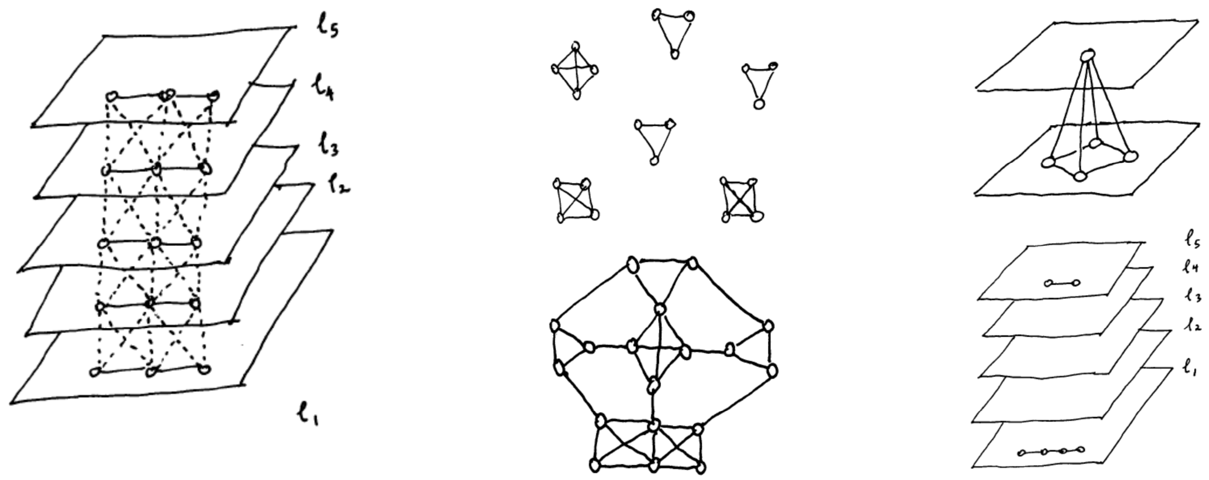

Figure 4.15: Clarifications on the couplings between patterns as suggested by Salingaros (2000)

Salingaros (2000) proposed two essential additions. First, a series of couplings that could be made between the patterns that can clarify the hierarchical orders between the patterns:
1. One pattern contains or generalizes another smaller-scale pattern
2. Two patterns are complementary and one needs the other for completeness
3. Two patterns solve different problems that overlap and coexist on the same level
4. Two patterns solve the same problem in alternative, equally valid ways
5. Distinct patterns share a similar structure, thus implying a higher-level connection

The second addition is providing clustered patterns for designers, which makes the pattern methodology more suitable for application in design-processes. Sets of connected patterns provide insights in the method itself, and at the same time are open to add or replace individual patterns.

It is interesting to note that the Pattern Language of Alexander can be considered as a forerunner of strategy to deal with complex systems – before complexity theories were explicitly related to architecture and urban design. The more recent work of Salingaros shows more explicit relations to notions taken from complexity theories. Nevertheless, the relations to the domain of Design Thinking are rather limited so far.

Patterns: combining the pattern methodology with conceptual models of the design process

> *"How artefacts are made out, how they work, what they do in respect to what has to be done, how they fit in the environment, and how all these aspects relate to each other" (Tzonis 1990)*

In order to add to the clarity of pattern descriptions, we suggest describing the patterns in line with descriptions of conceptual models of the design processes. In several of these models are given, originating in different domains, varying from Activity Theory, Design Thinking, Architecture, Urbanism, and Geo-design. It is interesting to note the similarities between different domains in describing *how and artefact is made, how it works and how it performs*.

Here, we propose to use the classification of Tzonis (1992) and Guney (2007) – which is, according to the authors, both prescribing and describing the design process. Their model links the performative qualities (Performance) to the actual working of the artefact (Operation) and the form (Morphology) of the artefact under consideration using the concept of affordances, and is a such the richest and most general conceptual model of the design process from the ones listed in

Table 4.2: Ways to describe design processes originating in different domains (Stolk, 2014)

Domain	Activity Theory	Design thinking	Architecture	Urbanism	Network Urbanism	Geo-design
Source	Nosulenko et al	Gero et al	Tzonis & Guney	Lynch	Oswald & Baccini	Steinitz
Morphology	Conceptual model	Structure	Form	City form	Morphology	Representation model
Operation	Operative image	Behavior	Operation	Flows and interactions	Physiology	Process model
Performance	Goal image	Function	Performance	Dimensions of performance	Criteria for evaluat-ing urban quality	Evaluation model
Relations			Causal Affordance	Legibility		

Analysis, M-O-P, can be considered as deriving how a form affords some operations, and how these operations afford some performances. Synthesis follows the opposite direction, P-O-M (Stolk, 2007), see Figure 4.16 for an illustration.

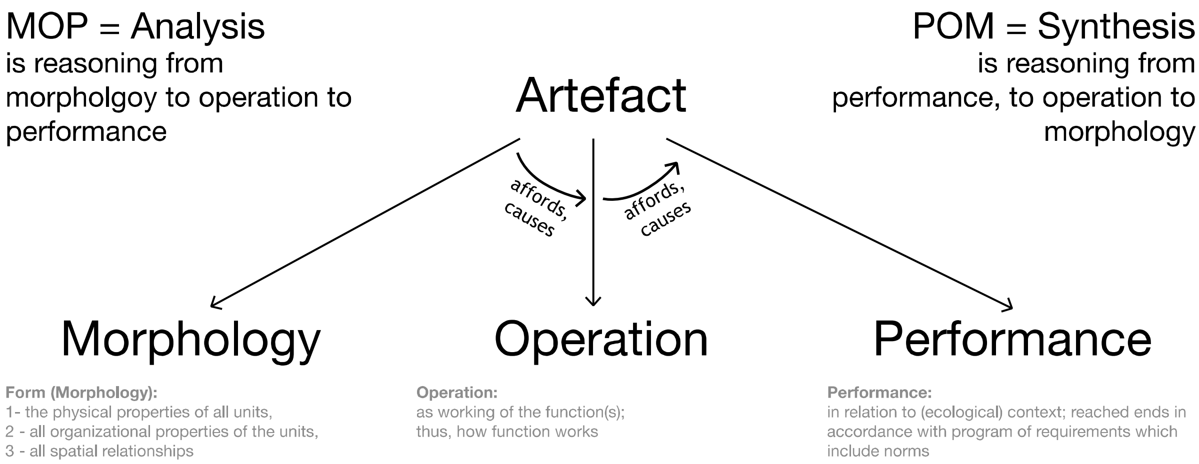

Figure 4.16: Design as the oscillation between analysis and synthesis. Based on Guney (2007)

In the case of the development of integrated patterns Better Airport Regions the M-O-P scheme can be applied for both the essential streams and the spatial qualities. In the case of spatial qualities the relations between the morphology, operation and performance can be best described as 'affordance relations', indicating the non-causal relation between human beings and their environment. In the case of the essential flows, these relations can be described as being causal, as non-human flows, like water, have no choice in flowing one way or the other.

A second addition originating in the domain of design thinking is the CLT-scheme of design and planning as developed by Stolk (2014). In this scheme design and planning are considered as moving between concrete and abstract information on seven dimensions. In order to stimulate creative thinking, it is suggested patterns should contain both concrete and abstract information, including different types of representation (like words and images[34]), and familiar and unfamiliar information.

34 As for the different types of representations used to describe patterns: this does not have to be limited to words or images, but can include calculations, simulations or combinations thereof.

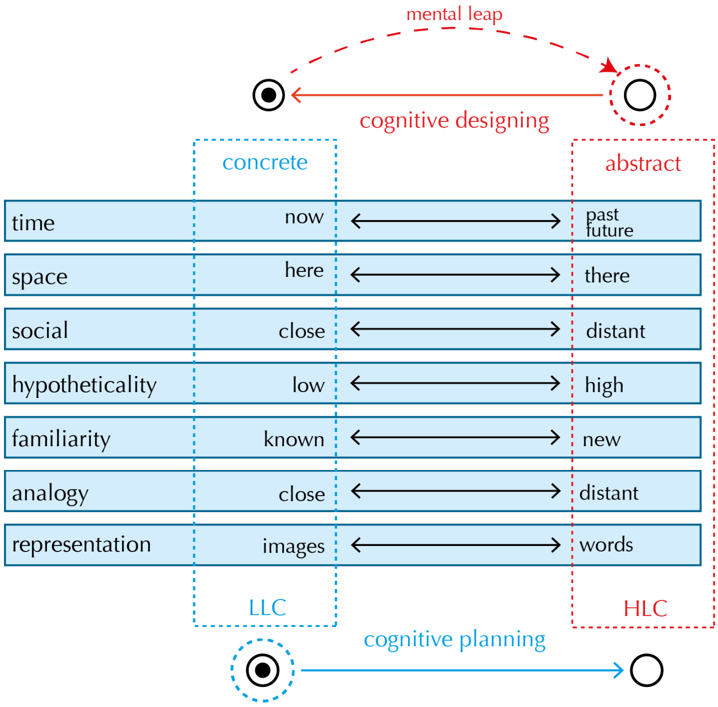

Figure 4.17: A CLT–scheme of cognitive designing and planning as moving between concrete and abstract information on seven dimensions (Stolk 2004)

Empirical research into design aids: analogies, scenario's and patterns
In the case of essential streams and spatial qualities, designers are confronted with both familiar and unfamiliar information. To reflect on the chosen methodology several design-experiments are carried out to empirically test the usefulness of three different design aids: analogies, scenario's and patterns - in both individual and team contexts (Casakin, Timmeren, & Badke-Schaub, 2013).

- By reasoning by *analogy* we can transfer known relations from a familiar situation (source) to potential relations to an unknown situation (target). Analogies might be made within a domain (close) or between domains (distant) (See the dimension 'analogy' in Figure 4.17).
- *Scenarios* are a technique that enables the development of imaginative thinking about new spatial and temporal architectural and urban design realities, enhancing the possibility to envision a variety of futures from unorthodox viewpoints (See the dimension 'hypotheticality' in Figure 4.17).
- A *pattern* describes the essence of a problem that occurs repeatedly in the environment and offers a solution to that problem in a general way. Patterns are described in both words and images, and can be related to other patterns (See the dimension 'representation' in Figure 4.17).

From the experiments can be concluded that patterns are specifically fit to define design problems, analyse idea solutions, and evaluate proposals on their functionality. They help to gain basic understanding from a technical/functional perspective. Analogies & design scenarios are fundamental for thinking out-of-the-box, generating large number of innovative ideas, and thus enhancing design creativity. Whereas analogies/scenarios are between-domain and can be considered as unstructured knowledge sources, they can stimulate divergent thinking at the outset of a design task. In contrast, patterns are within-domain and can be considered as coherent knowledge structures, they can be applied in a later stage to encourage convergent thinking and test different design conjectures.

Integrated patterns for essential streams & spatial qualities
In the context of the BAR project it is proposed to develop integrated patterns for essential streams and spatial qualities they serve as a way to integrate information from several domains (engineering and design), and making this information available to experts from both domains, or to stakeholders in general. This

transdisciplinary nature of the BAR project, aiming to integrate flows and spatial qualities, requires this design methodology by which familiar and unfamiliar information can be combined.

In Figure 4.18 the basic underlying structure of the integrated patterns for essential streams and spatial qualities is given. In this semantic network, the left-hand side represents the essential streams – which can are described using the M-O-P schema for design. On the right-hand side the spatial qualities are described in a similar way.

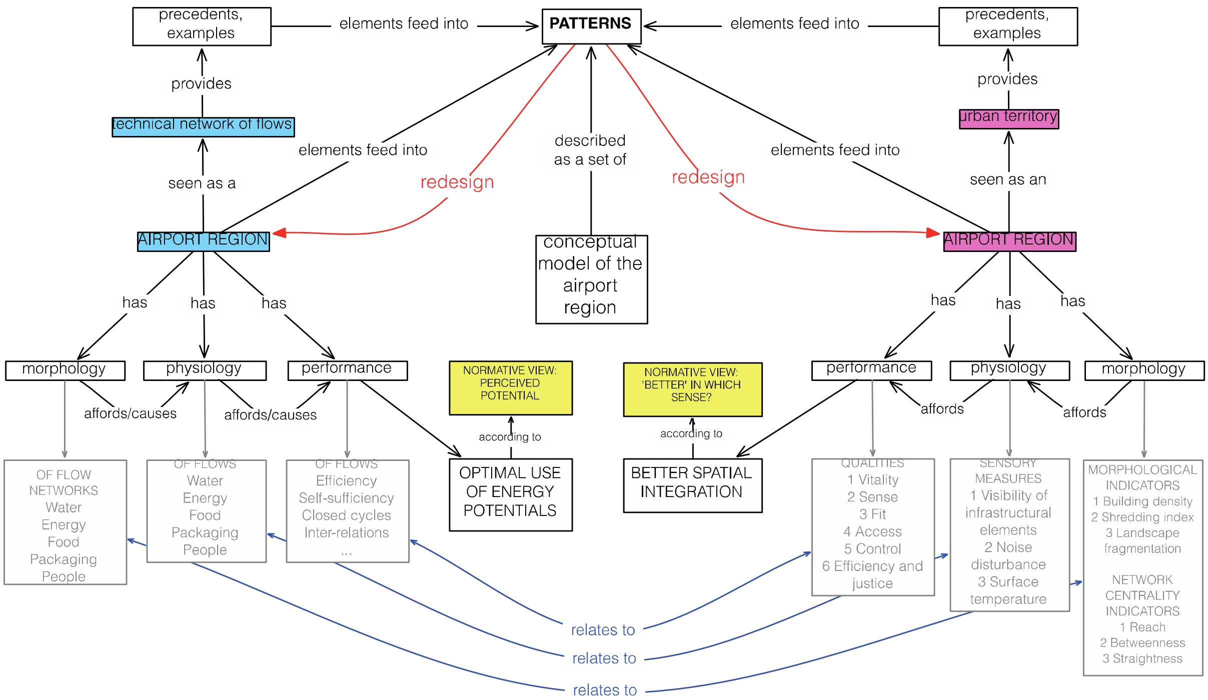

Figure 4.18: The basic underlying structure for integrated patterns for essential streams and spatial quality

The patterns will have the basic outline almost any pattern language has (introduction, solution provided by the pattern, scientific or empirical explanation, introductory illustration and schematic diagram). Besides, the patterns can consists of basic calculations, GIS data from *flows* and *qualities*, basic simulations models and/or precedents (as close or distant analogies), references and crosslinks to other patterns.

4.3 Result: an overview of Better Airport Regions patterns

In ANNEX 4 the different sets of integrated patterns for essential streams and spatial qualities developed in the context of the BAR project are presented. In this paragraph these sets are described in brief, including their specific stream/quality and methodological characteristics. In general, it is strived to base these patterns on scientific insights and empirical data, leaving less room for discussion in comparison to Alexander's patterns.

Starting point: BAR patterns

Figure 4.19: An example pattern as used in the serious game with stakeholders

The project originated with a set of BAR patterns, which formed the basis for several elaborations in subsequent sets of patterns. The original patterns were described in five clusters of three patterns each (called 'sentences'). These network of patterns are comparable to the clusters of patterns as suggested by Salingaros (2000). In the course of the BAR project, it turned out that the preliminary pattern descriptions were quite complex to grasp for general stakeholders, as they included detailed theoretical and empirical support. For this purpose, simplified versions of the patterns were developed and used in the serious game with stakeholders, see Figure 4.19. In the annex, the redundant BAR patterns are left out, as some of them have been elaborated within other pattern sets.

The IPG1 BAR Patterns

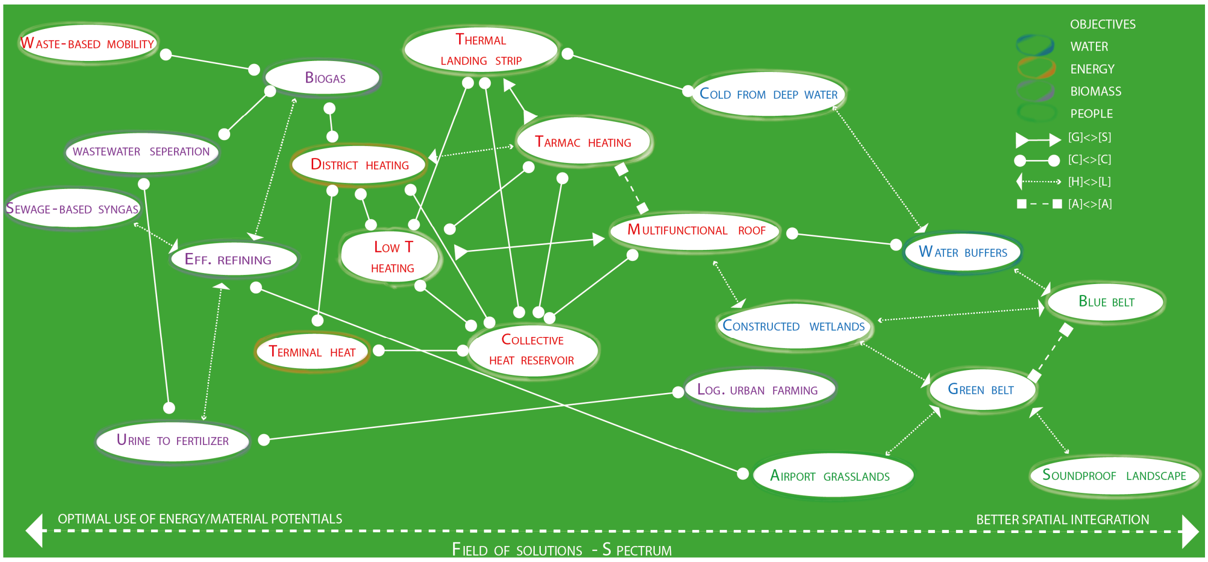

Figure 4.20: The IPG1 BAR network of patterns, including different themes and different relations between the patterns. Patterns on the left focus on energy/materials, patterns on the right focus on a better spatial integration.

In the IPG1 BAR project, 21 patterns are developed focusing on Urban Airport Symbiosis around physical flows by a group of Industrial Ecology students (Mentink, Henriquez, NIekerk, & Verheul, 2013a). Besides, the project included an updated pattern methodology(Mentink, Henriquez, NIekerk, & Verheul, 2013c), a manual to make a pattern library(Mentink, Henriquez, NIekerk, & Verheul, 2013b), and a background paper on patterns (Henriquez, Mentink, NIekerk, & Verheul, 2013). Besides the patterns themselves special attention was given to the network of patterns and the different types of relations between the patterns. A diagram of the network of patterns can be seen in Figure 4.20. Each of the patterns consists of generic and Schiphol specific information.

The IPG2 BAR Patterns

The second IPG group focused on the development of one of the sentences of the original BAR patterns, and focused on Hotspot 2 as a location. The research goal was '*to design a renewable energy mobility hub for innovative transport'*. This led to the development of patterns for four types of transferia. In the development of these patterns, special attention was given to the stakeholders related to the patterns. First, the patterns were part of the serious game with 'real' stakeholders and second; they were subject to several workshop formats. One of the interesting suggestions was to include 'morphological charts' to capture the preferences of several stakeholders and experts.

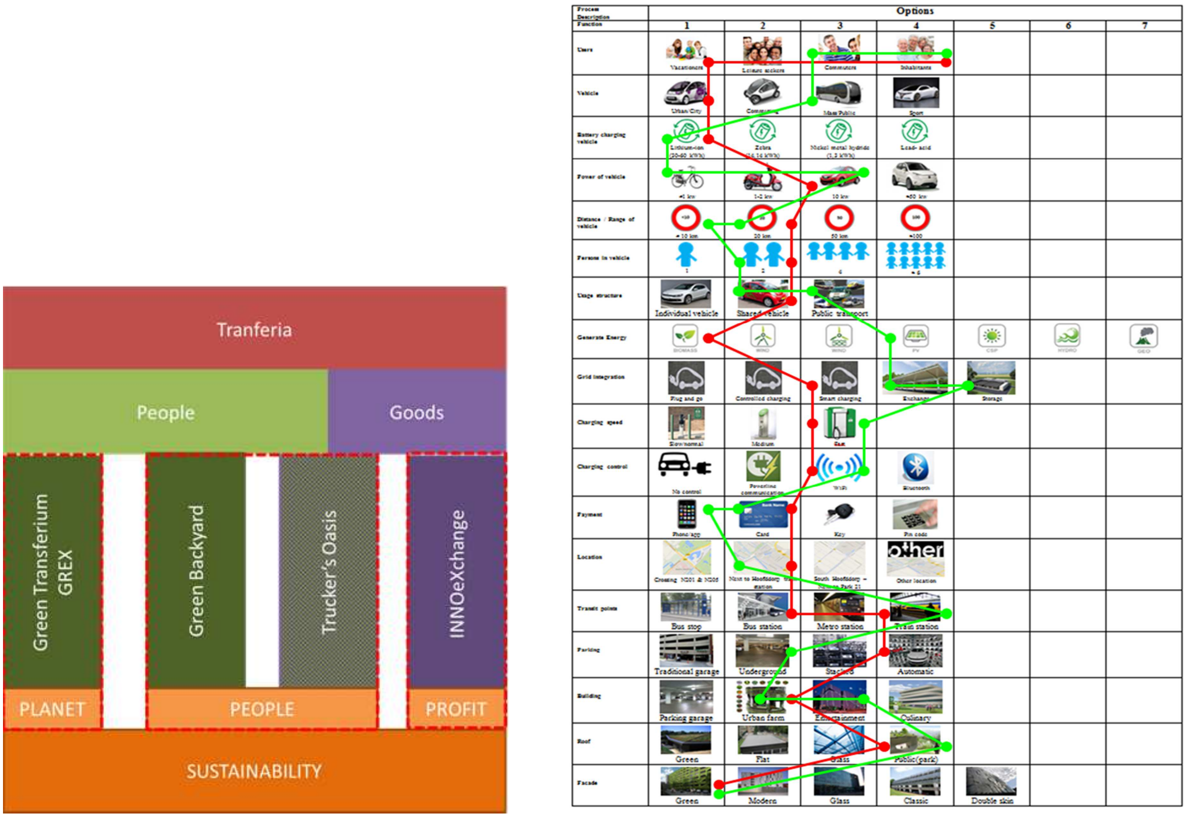

Figure 4.21, Left: the 'sentence' consisting of four patterns. Right: the morphological chart used to capture stakeholders' preferences for the case of the G-REX.

RE SIL(I)ENCE patterns

The resil(i)ence patterns are developed by Martijn Lugten and focus on noise attenuating measures, this theme was one of the sentences of the original BAR patterns. Starting with the observations that there is a knowledge gap between the built environment and airplane noise. The project filled this gap by developing 24 patterns on three levels: building engineering, materialization and urban morphology. The pattern descriptions consist of a generic part and an Schiphol specific part, indicating the areas in the Schiphol region in which the patterns can be applied. Within the patterns distinctions are made between: noise from stationary, starting and taxiing airplanes (SST) and crossing airplanes (CA); direct and indirect noise; and measures focusing on absorption, shielding and dispersion. On a methodological level, the couplings of patterns, as suggested by Salingaros (2000), complements the previously mentioned 'sentences', by suggesting example designs, see Figure 4.22. Besides, the patterns are tested within a context of the municipality of the Haarlemmermeer and in an individual design project. On top of this the individual design proposal is tested on its noise abating effect using a simulation model from TNO.

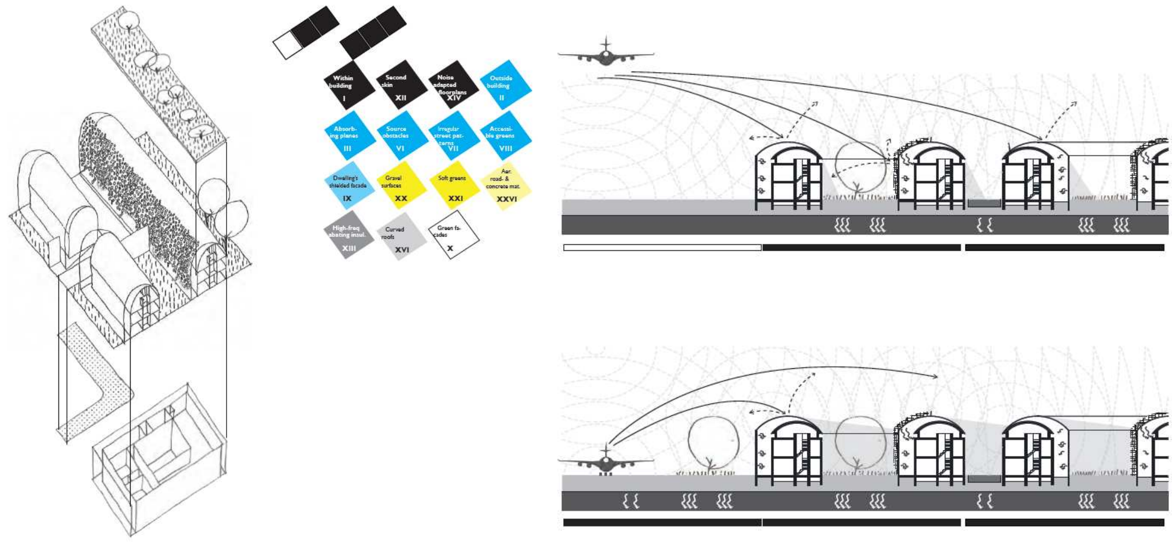

Figure 4.22: An example of pattern-couplings within an integrated design solution. On the right: the effects of the typology on SST and CA noise.

4.4 General findings

As explained in section 4.0, the Airport region can be considered as a *Complex Adaptive Prospective System*: both the Airport Region and the planning and design processes are complex systems. The generative nature of patterns makes them suitable to be utilized in such a system. Both the theoretical and empirical study, as conducted by Casakin, supports the use of patterns in the case of the Airport Region. On the one hand patterns are means to generate creative solutions for changing environment, on the other, they form appropriate 'boundary representations' required to move forward in complex multi-actor multi-level settings. As such, the methodology provides the possibility for flexible adaptive planning and design. Besides, they act as a way to deal with our cognitive limitations: patterns compress information, by chunking the information into useable parts.

By providing multiple and interchangeable links between patterns in the pattern network, pattern languages can provide input for new couplings between patterns and therefor anticipate on constant changings decisions being made between stakeholders interacting alongside a spatial plan or design. This feature of pattern languages is especially interesting for the linkage between decision-making processes between stakeholders and the spatial translation of decisions being made. End users can refine, add and subtract elements to create a context-based-design. From this perspective, pattern languages provided packages of information, which have to be merged by a creative mind (e.g. designer, planner, local resident), which can form endless combinations. As such, a pattern language can co-evolve with both the planning and design processes as well as with the Airport Region itself.

The patterns provide a multi-dimensional understanding of the relation between spatial qualities and essential recourse flows – and allows combining multi-dimensional geographical properties (human capital, accessibility, property-value) of the Airport Region. The pattern-sets as developed by the IPG groups and Martijn Lugten provide very good illustrations and support the further development of the pattern methodology, especially regarding the pattern couplings. The noise abating patterns of Lugten are promising, as several organizations have shown their interest in these patterns, which fill in the knowledge gap between the built environment and airport noise.

4.5 Acknowledgements

We would like to thank the MSc students for their valuable contributions to the development of the BAR patterns and methodology.

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5. Urban regional development

Transformation analysis of Integrated Urban and Regional Development / Development of a Conceptual Model

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Table of content

5.1 Introduction

In the context of the BAR project, modules 2a and 2c provided desirable and plausible transformation scenarios, stakeholder recommendations as well as a description of the airport region through a model. The central format for this approach was the Urban Research Design Studio (UDRS), in which configurations of the urban structure were tested and projected. The knowledge gained from the UDRS was fed into the more traditional scientific research formats of the other research groups for proof, refinement, or falsification according to the respective disciplinary perspective. Their results, in turn, were fed back into another design round in order to produce new and richer knowledge about urban transformations in the airport region. On this basis, stakeholder recommendations, design tools also applicable for other airport regions, as well as a description of the airport through a model were deduced.

5.2 Approach and methodology

5.2.1 Approach

Original setup
In the initial research setup, the first Urban Design Research Studio (UDRS) was to start after a six-month evaluation phase in which basic data for determining areas holding high potentials for sustainable development was to be gathered. During the following months, possible development paths for these areas were to be projected in the UDRS and subsequently evaluated by the research groups from Module 1. The feedback from these groups would inform a second UDRS following in the next semester. This second UDRS would elaborate the findings of UDRS 1 and lead towards concrete projections and policy proposals, complementing the results of the other modules.

Changed setup
After the project had started, the participants agreed on a different procedure in view of the fact that such analyses would not be at hand at the start of UDRS 1. Instead, UDRS 1 was conducted in the fall of 2012 without a detailed prior analysis but leaving more room for analysis of the results by all research groups in between UDRS 1 and 2. A report was produced after that and distributed to the other research groups. UDRS 2 was conducted in the fall of 2013.

Timeframe
The first UDRS was conducted from September 17th, 2012 to December 19th, 2012. It was complemented by an integrated seminar week to Schiphol and Haarlemmermeer which took place from October 19th to October 28th, 2012. 20 students took part in UDRS 1 and an additional eight students took part in the Seminar week. The final results were presented on December 19th, 2012 to the BAR research team and stakeholders. UDRS 2 was conducted from September 16th, 2013 to December 18th, 2013. It was complemented by a trip to Schiphol and Haarlemmermeer from September 28th to October 2nd. 17 students took part in UDRS 2. The final results were presented on December 18th, 2013 to the BAR research team and stakeholders. Parallel to UDRS 2, a master thesis was conducted by two students.

Geographical focus
In the preparation of UDRS 1, the changed research setup brought up the question of how to identify the geographical areas on which UDRS 1 should focus without empirical data from the other BAR research modules to back the decision. To achieve this, continuous discussions starting in May 2012 were led both within research group 2, with research group 1 and with stakeholders. Secondary literature and analytical studies on the Schiphol Airport area were consulted. Also, a preparatory field trip from July 11th to 13th 2012 was conducted, during which stakeholders and researchers were interviewed and various sites around the airport visited. An intermediate scale between local and regional was quickly decided upon (which also was kept in UDRS 2 as a scale), as the regional scale is covered by the SMASH study, especially in terms of governance and urban structures. Also, to be able to verify the impact of urban developments in terms of sustainability, these have to be projected on a local scale to take building types, land uses and infrastructures into consideration.

Relevance of the Airport Backyard

To decide on which part of the airport area the UDRS should focus, a preliminary system of classification was chosen that—in relation to the main urban node, Amsterdam—differentiated these area into (a) Airport Frontside, (b) Airport Flanks and (c) Airport Backyard. This system was based on our observation of other reference cases, notably Zurich. Most airports have clearly identifiable back and front sides, caused by their size and impenetrability in combination with the proximity to an urban node. While the specific configuration is different for each airport area, the Airport Frontside towards the nearest large urban node is generally characterized by high connectivity, higher land prices and a development tendency towards knowledge-intensive uses. In research, the most important urban configuration in this area between airport and city has been identified as "Airport Corridor". While the area between city and airport is quite intensively discussed, the area between the airport and surrounding rural areas as well as secondary nodes have until now been more or less been neglected in the discussion on airports and cities. It was decided that the UDRS should thus mainly focus on these areas, while a master thesis was conducted on the "Airport Corridor".

Suitability of Amsterdam Schiphol Airport's Airport Back Yard for the BAR UDRS

Both discussions and field observations showed that in the case of Amsterdam-Schiphol, the Airport Back Yard (UDRS 1) would prove the most suitable for focusing the UDRS for four reasons:

1. The Airport Back Yard is a focus of future real estate development. Most available land resources in the airport region are located here. Accordingly, major infrastructural developments take place in this area right now. This means that in terms of sustainable development of the area there is a high potential influence of the research results during the next decades.
2. While in the case of Amsterdam the Airport Frontside is only slightly affected by airport noise, the Airport Back Yard is strongly affected by the planes landing from the south onto the Kaagbaan. As airport noise is an important factor in airport-related urban development, the area south of the Kaagbaan is especially interesting in terms of urban design in airport regions.
3. The airport as an urban actor is a central point of the research. The airport of Schiphol lies in its entirety on the municipality of Haarlemmermeer and thus has a very close relationship to the municipality. Most of the municipality lies to the southwest of the airport and thus in the Airport Back Yard with a potentially very influential role of the airport, while this role is much weaker in the area towards the city of Amsterdam.
4. In view of the goal of creating a new, holistic model of the airport region, there is a knowledge deficit as to the Airport Back Yard, while other parts have been more thoroughly described.

With the focus on the "Noise Landscape" in UDRS 2, this approach was continued and clarified. Basically, the Noise Landscape overlaps with the Airport Back Yard, yet as a conceptual model it is a more precise, and comparable, tool for better understanding the reciprocity of airports and their built environment.

Scales

No clear geographic limitation was imposed to delimit the site for both UDRS, but for each semester a certain area was highlighted as the increased focus of analysis and design. Several areas were chosen inside this zone because of their spatial and programmatic intensity and relevance as well as because of important developments taking place there. The main design focus was on these areas. On the larger scales of the Randstad and of the Haarlemmermeerpolder, students conducted analyses and proposed project-specific strategic interventions.

Relation to previous research

The spatial and programmatic effects that can be observed in the area around Schiphol are, in their general form and effects as urban periphery, not unknown to research. Such areas have been extensively described in urban literature, for example in Peter Rowe's "Middle Landscape", the PBL's "Tussenland", or Thomas Sievert's Zwischenstadt (his book "Zwischenstadt entdecken" focused on an area near Frankfurt airport). The specific properties of the Amsterdam-Schiphol/Haarlemmermeer area have been the object of a number of analyses and designs, such as TU Delft's recent series of urban design studios by Daan Zandbelt. Therefore, the focus of the UDRS was on the specific urban conditions created by the airport, not on a general description of urban periphery.

5.2.2 Methodology

Research and design
Design does not accord to traditional scientific principles such as strict empiricism, reproducability, or falsification. Nonetheless, design produces new knowledge about complex situations, and it produces knowledge that is not achievable by other methods in such circumstances. The basic characteristics of our design methodology has been described by Simon Kretz in his paper “Entwerfen, Erfahrungsprodukte und Erkenntnisgewinn” (2013) as a use/test entity. One of its main characteristics is that solutions and problems have to be found in parallel, not in a linear way from a problem definition to proposals of solutions. Another important aspect is its generally holistic approach.
While the design process itself is always “messy” in a scientific methodological sense, its results can be described in a clear and well-argued manner. This report is such a description that in its first version allowed the exchange of the knowledge gained through the urban design research studio with the other research groups of the Better Airport Regions project, while this final version should inform other projects and other disciplines.
General goals
Generally, a UDRS on a certain urban situation is mainly a platform for communication and collaboration that can foster discussions by local planning institutions, citizens and stakeholders. The design solutions of a UDRS are not geared towards immediate implementation or feasibility. They can be regarded as “educated guesses“. (Michaeli 2007) UDRS provide specific knowledge about the properties and potentials of the urban structure at hand that can, due to the complexity of urban situations, only be gathered through working on design interventions. The “educated guesses“ are then communicated and presented. They can be understood as “injections” of new ideas and new solutions into the discourse on the complex urban situations they deal with. As solutions, they will then possibly completely change their form and character in the ensuing process, but only after they have proved their agency in influencing the development of the discourse.

Formats of the results
As it is the main goal of a UDRS to serve as a communications and collaborations platform, its results take on three different formats (Kretz 2013):
1) Specific theses,
2) Commented design experiments,
3) Elements (analytical, methodological, operational).
Through these three formats, the future of the urban situation at hand can be discussed and channelled in several different ways. For example, the commented design experiment on the Beukenhorst office area illustrates the general possibility of changing this area from a currently stagnating and unsustainable status into a more resilient, liveable and sustainable neighbourhood; the specific theses can serve as the basis for a more general discussions, or more research, and the Elements can be used to discuss solutions for this situation in a way not specific to the site, making it comparable to similar situations. Discussions with the other research groups as well as with the stakeholders can be used to further elaborate all three result formats, while the situation at hand is already changed through the direct involvement of the stakeholders in the research project. For the BAR UDRS, students conducted the design experiments, while researchers commented and added the specific theses and a first set of preliminary Elements.

Specific formats of results requested by other research groups
Upon our general request to the BAR research team, some research groups specified formats for results of the UDRS:
- Research group 1cd (Ellen van Bueren, Michel van Wijk) requested a list of original statements from the studio work for their questionnaires. A list of 64 statements was sent on January 28th, 2013 with the preliminary version of this report. For the serious game workshop, a presentation with the results of the UDRS studios was handed over on February 20th, 2014.
- Research group 1ab (Arjan van Timmeren, Egbert Stolk) worked on a set of patterns to describe spatial qualities for airport regions. After discussing the format of the UDRS results, research group 1ab planned to elaborate patterns based on the first version of this report. Upon their request, we included a first list of preliminary Elements in the intermediate report. As mentioned above, these Elements are results of our design methodology and may not fully comply with the patterns of rg 1ab. An important difference is that

our Elements are not necessarily normative, but are often descriptive, while others are not spatial, but procedural or methodological.

- Research group 1ab (Alex Wandl) requested a set of dxf drawings of our design interventions in specific layer formats. A number of files was exchanged throughout the research project, after UDRS 1 as well as after UDRS 2. An analysis was also done for the “Airport Corridor” Master Thesis.

Working process

In complex urban situations, the knowledge that is to be gathered in an UDRS can neither be gained through a rigid methodological setup nor through a totally open process. Instead, we chose an approach in which the general direction is given by the design course leaders but which can be challenged, elaborated and made plausible by working with the students. For scientific as well as for educational purposes, this approach requires a balance between a purely instructional approach, where the course leaders define the whole process, and a laisser-faire of leaving the students “out in the open“. To ensure this balance, the UDRS was guided through a set of basic working hypotheses.

At the beginning of the UDRS, the students were given a number of sources to work with, such as maps, secondary sources and policy documents. The students worked with plans, models, sketches, diagrams and renderings, always depending on the task and the scale at hand. During the seminar week, small groups of students interviewed stakeholders from the region. The design studio was conducted in English. At three intermediary critiques, stakeholders, BAR research team members, and external experts were invited and commented the intermediary results directly to the students.

5.3 Outcomes

Urban Design Research Studio 1

In the first Urban Design Research Studio (UDRS 1), the question was how the ”Airport Backyard” could be transformed into a more sustainable urban structure. Airport Backyard is a term derived from the conceptual model studies. In the case of Amsterdam, we especially focused on one of its parts, the ”Airport Tangent”. It denotes the urban development corridor along Kruisweg, passing along the south-western edge of the airfield. The UDRS 1 yielded a number of specific theses, which were formulated as ”conflict statements” and ”intervention themes”. On the basis of these findings, transformation scenarios were elaborated in five commented design experiments: 'The Airport Tangent', 'Centralities Hoofddorp', 'Beukenhorst Oost', 'Beukenhorst West: Living at the Park', and 'Beukenhorst West: Courtyard Landscape'. Densifying Hoofddorp was equally tested. A first design for the landscape under the noise contour was elaborated as well, especially with regard to placing logistic uses in the polder landscape. From these design experiments, preliminary design elements were derived.

Urban Design Research Studio 2

The topic of the second Urban Design Research Studio (UDRS 2) continued with the transformation of the Airport Backyard, but with a more precise focus on the possible spatial implementation of closed cycles. To that aim, UDRS 2 was built on findings of UDRS 1 and of findings of Research Group 1, notably on the Hotspot Maps, the Pattern Book, and the results of the spatial quality analysis. Additionally, an ETH-internal cooperation with Dr. Reinhard König, Chair for Information Architecture, helped to integrate the Space Syntax method. During UDRS 2, attention focused on the ”Noise Landscape”, another term from the conceptual model group that denotes the specific urban and landscape structure in and around the noise contour, as well as on central points connected to the airport, and on the airport itself. Four commented design experiments were elaborated in UDRS 2: 'Transit-Oriented Development with Rapid Bus Transit around Schiphol', 'Node-Place-Development in Hoofddorp', 'The Green Airport / Airport as a Flows Machine', and 'The Noise Landscape as Regional Park'. During the semester, the preliminary design elements from UDRS 1 as well as the specific theses were refined and complemented.

Master Thesis

In a free Master thesis, students Karl Wruck and Eric Bloch developed a transformation scenario for the other side of the airport, the ”Airport Frontside”, by proposing a development strategy for the Airport Corridor between Schiphol-Noord and Amsterdam-Zuid.

The design research was complemented by two research field trip in which researchers, students, and a professional photographer analysed the urban situations around the airport. Stakeholders were present during the research field trips, intermediary critiques, and the final critique of both UDRS. In an elective thesis, the case of transforming Beukenhorst office area was further elaborated.

Transformation scenarios output and dissemination:
- Report ”Results of the First Design Round” (2013)
- Report ”Infrastructure Landscape Haarlemmermeer/Amsterdam-Schiphol” (2012)
- Karl Wruck, Eric Bloch, ”Amsterdam Airport Corridor”, master thesis, exhibited at ETH Zurich (2013)
- Mirjam Züger, Fabian Willi, ”Retrofitting Beukenhorst”, elective thesis (2014)
- Conference Paper, Sustainable Airport Areas Seminar, Paris (2013)
- Conference Paper, Logistiek, motor van de Amsterdamse economie, Amsterdam (2013)
- Conference Paper, ACI Airport Exchange Conference, Amsterdam (2013)
- Exhibition and catalogue, Haarlemmermeer: ”The Noise Landscape”, Hoofddorp (in preparation)
- Follow-up book project ”Designing a More sustainable Airport Area” (working title, in preparation)

Conceptual Model
The work on the conceptual model started with an analysis of the situation around Zurich Airport, our main reference case. Main findings were that there the formation of a corridor can be distinguished, but that it emerged accidentally, based more on the logic of local and regional development than on the direct influence of the airport (see S+RO article). However, a closer look suggested that the airport does yield remarkable indirect effects on urban development, which we analysed in depth for the case of the area Cher-Bäueler in Opfikon, a municipality between Zurich Airport and Zurich City, bordering the airfield (see DISP article). Based on these findings, we ventured further in proposing a new categorization of urban effects of large airports on cities. We found five principle effect types: Territorial effects, aviation effects, flows effects, allocation effects, and urbanization effects (see Routledge article). In close collaboration with the UDRS, we further developed a new taxonomy for urban development around large airports, including the above mentioned terms ”Airport Backyard”, ”Airport Tangent”, and ”Noise Landscape”, some of which we put forward in our publications. With the effect categories and the taxonomy, we have built a toolbox of conceptual elements which we can describe the interaction of airports and urban development. In an elective theses, the element ”Last stop before the airport” was further investigated in an international comparison.

Conceptual model output and dissemination:
- DISP article (accepted with revisions, in reworking)
- Routledge book chapter (to be published in August 2014)
- Regional Studies, Regional Science article (accepted under conditions, in reworking)
- Conference Paper, Sustainable Airport Areas Seminar, Paris (2013)
- Conference Sustainable Airport Areas Seminar, Atlanta (2013)
- Conference Future of Asian Airports Seminar, Singapore (2013)
- Conference Passenger Terminal Conference (2014)
- S+RO Article (published 2012)
- Arpad Hetey, ”The Last Stop Before the Airport”, elective thesis (to be finished in 2014)

5.4 Policy recommendations

5.4.1 General policy recommendations

The international research project ”Better Airport Regions” intended to clarify the workings of the reciprocity of large hub airports with their urban and natural environment. The goal was to get a deeper understanding of the transformation mechanisms, the problems and the potentials in order to frame pathways towards more sustainable airport regions, a goal that is important and achievable even if aviation itself is still far from becoming sustainable through advanced technical solutions—biofuels or improved engines are only a beginning. This project looked not on the so-called ”airside”, but on the ”landside” of airports.

The urban airport area and the airport as urban node

The majority of large airports in Europe is at 15km or less from the centre of the next large city. Their environment can be described as ”urban airport area”, where reciprocity of urban and airport development is strong and often disputed. Yet urban airport areas mostly fulfil a major success factor for the economic development of urban regions by providing fast access to aviation. In most cases, these areas are the result of historical developments in which urban expansion reached or, in some cases, enclosed the present airfield which for a number of reasons—political, environmental, economical—could not move out further. The ensuing situation is usually one of spatial and political conflict about resources, notably traffic infrastructure, land, and the distribution of adverse effects of and on aviation. This awkward neighbourship is made more complicated by different administrative settings for urban, airport, and transport administration. But above all, it is a problem of perception and self-perception: airports and cities are seen as two rather exclusive and certainly very different conditions. Our research resulted in a different view: the airport is not outside, at, or in the city—it is a part of the city, a city that stretches beyond administrative borders and can only be understood on the scale of the metropolitan region. Such a city is poly-centric, and the airport is one of its important urban nodes, and the region around it is not just a backyard without significance.

Reciprocal development and effects

The airport as an urban node has, as any infrastructural element in the city, both push- and pull-effects: it attracts certain uses and developments and repels others. Nature and extent of these effects are disputed between interest groups. We propose a clarification by introducing five effect categories that describe the reciprocal development mechanisms of airports and cities:

1. Territorial effects describe how the large, fenced-off airfield distorts the physical structure by interrupting and rerouting infrastructure lines, creating areas of poor accessibility and increasing compartmentalization.
2. Aviation effects describe how emissions and security restrictions impede certain land uses which have to be located elsewhere, while other uses flourish just because of the same reasons.
3. Flows effects describe how the airport generates, reroutes, and concentrates essential flows of people, goods, water, waste, energy, food, and goods.
4. Allocation effects describe how certain land uses locate at or close by the airport because of specific advantages that it causes.
5. Urbanization effects describe the larger impact of allocation effects in increasing demand for housing, infrastructure, and urban services.

These five effect categories can be observed in all cases, notably in urban airport areas. Further research is needed to detail criteria, measurements, and critical factors for each category. In the future, these five categories should be the objective base for any further discussion and policy making on airports and cities and will help to foster a productive dialogue between different interest groups.

Problem sharing: Reframing airports and cities

Airport and urban development, which on this scale includes landscape development, are inherently reciprocal. By their very nature, airports and cities are mutually dependent. In comparison to cities, airports have a quite different nature as internationally connected transport hubs, very large-scale regional employers, and specific territorial units with own administrative and legal organization. However, the seeming dichotomy of airports and cities began to soften when we observed the daily interaction of the two spatial entities, of their decision makers, and of daily users.

As stated above, airports and cities have interdependent, often intertwined problems. Only if they regard them as shared problems, it will become possible to negotiate solutions in a democratically legitimized manner. The first step, so it seems, is to reframe how decision makers, users, and academics frame the socio-spatial situation of airports and cities. As other infrastructures before, airports have become integrated parts of the city-region. The above stated understanding that the airport is an urban node must become the point of departure for future policy. This includes not only the terminal and the runways, but the entire area of the airport and the area of its major territorial and aviation effects on urban development.

This perspective forces a certain scale of observation on the observer, which is—as stated before—the scale of the metropolitan region. It is the right scale for a first approximation on airports and cities if the smaller and the larger scales are also regarded. The stated effects become physical notably on the smaller effects where they directly shape urban form, architectural expression, agricultural uses, road and railway connections, and more generally, the quality of life.

Reframing engrained perceptions is a challenging task. It can only be successful if it emerges from implementing shared solutions—in other words, realizing prototypes for new coalitions, spatial configurations, technological implementations, discourses, and research. Reframing grows from small experiences rooted in real problems on the ground, not from an imposed, overarching, single new administrative entity, model, or—let alone—plan.

Each step towards a new perception and a new reciprocity of airports and cities has to enhance the overall sustainability of the urban system. Every single project will need the communication, support and commitment of a large number of diverse decision-makers and stakeholders. If they are successful, they will lead the way to other projects in similar or further developed coalitions and approaches. In our research, we hope to have found some of the urgent shared problems that may rally for action. In our design experiments, we have proposed images of how solutions might look like: this is a start for developing a real implementation, which will eventually look quite different. A better airport region will slowly emerge.

5.4.2 Policy recommendations for Amsterdam Airport Schiphol urban airport area

We found Amsterdam Airport Schiphol's urban airport area at a critical historical moment: Ever since the Haarlemmeerpolder was reclaimed in 1850, urbanization—including the airport—was concentrated in relatively small, separated areas such as Schiphol East and Centrum, Hoofddorp, Nieuw Vennep, or Zwanenburg. In planning imagery, these were ”red” islands in a sea of ”green”. Today, the Haarlemmermeerpolder is at a tipping point that will inverse this image: urbanization has continued, strip development has emerged along major axes such as Kruisweg and the Amsterdam Ringweg, and Schiphol has expanded many times. The current balance between ”red” and ”green” is unstable and will — notably in the northern part of the polder — quite likely change soon into an image of ”green” islands in a sea of ”red”, as a quick look on the already projected next urban development projects in the urban airport area reveals.

Even though occurring slowly and incrementally, this is a radical transformation of the condition of the living environment in the urban airport area. Sooner or later, it will change the way how people will operate in building houses and infrastructure, in how they will design and use the landscape, on the nature of agriculture and, more generally, on the everyday use of the city region. The contemporary, space-consuming, expansive planning and design habits that allow for individual actors to pay only minimal attention to other developments in the area will not be feasible anymore: the imperative of coordination, communication and integration results from increasing density of buildings, functions, and use.

In planning terms, Amsterdam Airport Schiphol's urban airport area is in the process of continuous urbanization and densification. It concurs with the continuous growth of aviation at the airport itself, thereby intensifying conflicts and problems of urban and airport development. We believe that today's watershed opens up a great potential for finding new solutions based on specific integrations of elements of airport and urban development—specific solutions for elements, based on shared problems and mutual potential, elaborated and implemented by adequate constellations and coalitions of actors. In the following, we propose four such problems/potentials with some images of the future of how a solution might change the airport region to a better one. This is not a conclusive list, or a definite statement, but a first sketch that is intended to spur the imagination of decision-makers, stakeholders, users, and academics. We hope that this will lead to action, and to a re-imagination of what airports and cities are in general, and what Amsterdam Airport Schiphol urban airport area is in particular. For the Airport of Schiphol, which has gained worldwide recognition with its ”Airport City” concept, this regional approach could represent the next big step for profiling itself as one of the world's most innovative airport. The municipality of Haarlemmermeer, in turn, aims at becoming one of the world's most sustainable municipalities. This cannot be achieved without strongly taking the airport into account.

1. The airport as employer: KLM City and Airport Area Circular Line

Amsterdam Airport Schiphol is the heart of a business cluster that employs 65'000 people. Since there is no housing at the airport itself, all of them are commuters. Many live in Hoofddorp, which can be considered a modern-day Airport Town, but others travel much further along the highways to places such as Beverwijk. Schiphol would like to increase the use of public transit for both passengers and employees, yet the feasibility of more or improved lines lacks sufficient settlement densities in its surrounding urban airport area.

Hoofddorp is characterized by a low-density, suburban settlement pattern. Local planners would like to increase the density in its centre to make the urban structure more sustainable, yet state that there is no demand for apartments in the municipality, as its inhabitants look for more suburban housing types.
The Urban Design Research Studio (UDRS) proposed to combine an improved public transit system in the airport area with dense, mixed-use node development to tackle both problems. The proposal sketches out an extension of the existing Zuidtangent rapid bus line and a route for the planned Westtangent that would result in a Airport Area Circular Line around the noise landscape, with major transit stations at Schiphol-Noord, Schiphol-Centrum, and De Hoek in Hoofddorp. Around the stations, dense urban development would provide housing for airport employees. This development would improve the connectivity of the settlement edges towards the noise contour and allow for increased settlement densities right next to the large open area of the noise landscape.
In Hoofddorp, companies such as the airport, airlines, caterers, or ground handlers could team up with developers to form housing corporations for employees, who could commute with the rapid bus line a few stops to Schiphol Centrum or Schiphol Noord. In new ensembles which could be imagined bearing names such as ”KLM-City”, different housing typologies could cater for specific needs. Considering the great number of employees and the working hours, there will be enough demand for apartments and small studios in denser configurations. This development would, in turn, make the improved rapid bus line connection more feasible.

2. Allocating in the urban airport area: Airport Corridor and Airport Tangent
In academia and business, the ”airport corridor” on the front side of the airport is often considered an upcoming prime location for companies. In their master thesis, Karl Wruck and Eric Bloch found that this holds true only under certain conditions in the case of Amsterdam: The area between Zuidas and Schiphol-Centrum is highly compartmentalised and currently treated as a back yard from Amsterdam's quarters and Schiphol, with apparent little coordination of traffic, urban, and landscape development. Yet the area has great potential, since it is very well located within the metropolitan region. With the Nieuwe Meer, it has a very attractive landscape element. To develop Amsterdam Airport Corridor, a concentrated effort is needed by all municipalities, the airport, and transport authorities to connect the now separated enclaves, provide high-quality urban space, and relations to the landscape. If successful, the Airport Corridor could become Amsterdam's new southern city edge, just as the IJ-shores have developed over the past decades, but it would at the same time be close to the Airport and to the village of Badhoevedorp
In the airport back yard, there has been so far little attention to corridor forming, yet it can be observed also here: Along Kruisweg, an urban corridor has emerged which runs tangential to the airfield—the Airport Tangent. Profiting from the large capacity but easy accessibility of Kruisweg with its parallel access roads, business, logistics, hotels, and housing have proliferated. In conjunction with earlier urban structures such as Hoofddorp or Rozenburg, a diverse juxtaposition of uses, architectural typologies, urban spaces, activities, and atmospheres has emerged. In planning terms, this is a unique strip development in the Netherlands. However, policy makers do not regard the Kruisweg as such, but rather consider it an inter-municipal highway. By multiple re-routings of the B 202, the once clear structure along the polder grid has fanned out into a wide ”wriggle” of roads. For any further development along the Airport Tangent, its reality as an urban boulevard needs to be acknowledged: the Kruisweg is the main street of new urban axis that connects Aalsmeer with Haarlem and Hoofddorp to the Airport. It is the place with the greatest potential for densification, public urban space, but also specific uses such as spotter's places, airport logistics, or transit-oriented development: The Airport Tangent should become an important backbone of the city-region.

3. The airport as flows machine: The Green Airport
Airports have a huge turnover of essential streams: people, goods, water, waste, and energy. They concentrate flows, consume many resources and produce emissions, waste, and waste water. For travellers, workers, and employees, the airport is a daily living environment characterised by traffic infrastructure, a labyrinth of indoor spaces, noise and fumes.
The Urban Design Research Studio (UDRS) designed a transformation scenario for Amsterdam Schiphol Airport's central area, Schiphol Centrum, to address both issues. The potential of the airport as a node in a flows network lies at the heart of the proposal. At Schiphol Centrum, these flows should be used to close cycles on all scales. Flows from and to the surrounding polder landscape will be connected, and the noise landscape will become easily accessible by pedestrians and cyclists.
The huge built-up area of Schiphol Centrum will be used for the generation of energy, water infiltration and recycling, and greenhouses. Roof spaces will be used either for photovoltaic cells or greenhouses. Office

buildings will be gradually merged with greenhouses that recycle CO_2 to O_2 and provide crops like fresh vegetables. In an estimate for the fully transformed Schiphol Centrum in 2060, calculations showed that a yearly food production of 16'500 t could be achieved, which corresponds to the output of about a quarter of the entire Haarlemmermeer polder. Solar energy could contribute 20% of Schiphol Centrum's energy consumption, which was estimated to be 20% higher than in 2013. Biomass and waste treatment could add another 6.4%.
In the passenger terminal, large winter gardens will improve the air quality, lighting, and spatial experience. The building structure will be dense and compact to leave open the existing green wedges for water infiltration and outdoor recreation. Here, small office villas will gradually be built over the years, forming a building exhibition for autarkic sustainable architecture. Schiphol Centrum will therefore become a showpiece for two different approaches for sustainable urbanism: economies of scales for the main terminal and office buildings, and small-scale autarky for the office villas. As a Green Airport, it will become the main reference case for airports and airport areas all around the world by hosting an annual exhibition and conference to report on its progress.

4. The noise landscape: The Small Green Heart as functional regional park

As the urban structure around airports grows, airports are increasingly integrated into their urban surroundings. The noise landscape is that part of the landscape around airports which is affected by heavy aircraft noise and other restrictions but had not been built over before the airport fully developed. Due to noise and other restrictions, the noise landscape can be built over only in a very restricted way. At the same time, this open area comes under increasing pressure to fulfil more functions than just classic agriculture. In the future, the noise landscape will probably increasingly be characterized by ambiguity between technical, ecological and recreation requirements. Geographically close to the airport but topologically often far away from the actual node, it holds great potential for spatially and energetically better integrated airport regions.
The Urban Design Research Studio (UDRS) proposed a transformation scenario for the noise landscape around Amsterdam Schiphol Airport. The scenario is based on an analysis of the existing urban structure. An application of the Space Syntax method showed that accessibility through the road network was poor, mainly because of the interrupting Polderbaan runway and the highways A5 and A9. Around it, under the noise contour, a wealth of specific, often small-scaled functions were found and mapped. These were termed ”niches” (cf. Christensen, 1985) which are open for unexpected, often low-value programs, private utopias, or spill-over functions that have relocated here. Examples include scrapyards, graveyards, or restaurants and small offices. Agriculture still prevails, with some farmers experimenting with new multi-functional crops like elephant grass.
A small trend scenario showed how Schiphol's noise landscape is under pressure of urbanization, notably on its edges and by uses less affected by airplane noise. Office buildings, infrastructure lines and logistics parks are planned or under construction. The UDRS proposed a strategy to counter this development by developing the vision of a regional park for the noise landscape. The Amsterdam Metropolitan Region is expecting much growth, and regional recreational and ecologically valuable spaces are rare. Existing landscapes such as Waterland or the Vinkeveense Plassen can be considered musealised cultural landscapes. Thus, instead of these areas, the main reference for the future of the noise landscapes are the dunes – a highly functional, yet recreational and ecologically valuable landscape of regional scale. Schiphol's noise landscape holds the same potential by combining recreation, sustainable agriculture, and landscape ecological services in connection to its surrounding urban texture.
Schiphol Airport itself will be the main node to connect essential flows from the noise landscape, such as water, waste, and energy. A close-knit pedestrian and bicycle network will make the noise landscape accessible. Built-up structures with their specific programmes will be kept, and where adequate, enhanced or enlarged. Agriculture will be transformed into more ecologically valuable products and procedures. The noise landscape will become both a beautiful yet contemporary landscape, and a biological machine that supports the urban functions with its crops, absorption capacities, water, and energy: the new ”Small Green Heart” for Amsterdam Metropolitan Region.

6. Governance

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Table of Content

6.1 Research questions and approach

Work packages 1c+d focused on governance arrangements supporting better airport regions. The research questions central to the work packages were:

1.c. How can a transition towards this sustainable development path be facilitated?
1.d. What development guidelines can be given to decision-makers to enable this transition?
2.d. What is the adequate conceptual governance model for this?

These questions have been answered along two research lines:

- Process line: focuses on today's processes of governance in airport regions in general (literature review and analysis of stakeholder perceptions of governance and possible coalitions – Fain 2014; Van Wijk et al., to be submitted July 2014) and in particular cases of governance in the Schiphol airport region (the historical analysis of the evolution of the Bestuursforum Schiphol over a period of 25 years – Van Wijk et al., submitted June 2014) and in the Zürich airport region (Nüssli and Schmid, submitted July 2014, Nüssli, under review).
- Substantive line: focuses on the governance of a flow or resource perspective to the planning and design of airport regions, in particular the management of flows contributing to circularity in the region of Schiphol (in collaboration with 1ab) (thesis Kwakernaak, Van Bueren et al., 2014) and in other airport regions, as reported in work package 2b.
  Also, the accessibility of airport regions in relation to the quality of the regions have been studied. In particular, it has been investigated if Bertolini's node-place can be applied to airport regions and which lessons for improvement can be derived from this. However, acquiring and processing data turned out to be challenging and the analysis is still in progress at the time of writing this report.

Together, these research lines added up to the development of an interactive workshop with serious gaming elements in which participants were introduced to opportunities for making airport regions better from a resource point of view, from an urban design point of view and from a governance point of view.
The research results and the answers to the questions will be discussed briefly in the sections below. More detailed information can be found in the papers based on this research.

6.2 Process line: Governance at present: a patchwork of adaptive arrangements

Due to the growth of cities and airports, regional planning has increasingly become important in airport regions (Freestone, 2009). The reciprocal relationships between airport and the surrounding, often strongly urbanised areas need careful planning. Planning efforts tend to focus especially on managing conflicts between airport growth and urban growth, most notably in the field of noise, and on economic development of the region at the cost of nature and environmental values.

Within the research on governance within the Better Airport Regions project, governance arrangements supporting planning and developments at two particular airport regions have been studied in detail through qualitative case study research: in the Amsterdam airport region (the cases of the *Bestuursforum Schiphol* and the exploration of current opinions on governance and sustainability by means of Q-methodology – research carried out by Michel van Wijk, Ellen van Bueren and Marco te Brömmelstroet, supported by Jane Fain and Maarten Kwakernaak) and in the Zürich airport region (the cases of the integrated development of Zürich North resulting from the planning of the Glattalbahn and the case of inert urban planning in Ausserschwyz – research carried out by Rahel Nüssli, in collaboration with Christian Schmid). These case studies resulted in an overview of present governance approaches to address regional planning issues.

Characteristic aspects of these approaches are:

- Multi-actor decision-making: problems of regional planning are beyond the control of a single actor. Resources required for decision-making, such as authority, finances and political power, are dispersed over a multitude of public and non-public actors. To achieve their goals and safeguard their interests, actors need each other's resources and have to coordinate resource allocation.
- Multi-level governance: Regional planning requires coordinated action of various administrative levels (municipal, regional, provincial, national), various sectorial fields (transport, economic development, housing, spatial planning, water management, nature etc.) and various types of organizations (public, private, non-governmental organisations). In the Netherlands, spatial planning policies have been decentralized from the national to the local level in the past decade. In Switzerland, the direct democracy model is still in place, giving spatial planning a very local character, but the Glattalbahn case showed that inter-municipal collaboration is no longer impossible.
- An ever changing role division between state, market and civil society. In the Netherlands, relationships in the past decades were strongly influenced by the new public management paradigm, at present relationships are being influenced by notions of the participatory society or big society. In Switzerland, direct democracy is still dominating decision making, but a slight movement towards more centralization can be noticed.
- Planning problems are dynamic. The multiple stakeholders involved in regional planning each have their own perspective on planning, the issues and problems at stake and how they should be addressed and solved. In processes of interaction, actors define the problem and solutions. However, instead of being solved, planning problems tend to evolve into new problems and are therefore also called wicked and persistent.
- Existing regulatory frameworks never fully match the needs of the stakeholders in the ever changing contexts in which they operate. Regulatory frameworks reflect codified and solidified rules and practices and thus need to be adapted to changed circumstances.
- Adaptive arrangements for regional planning. The multi-actor and multi-level character of decision-making and the dynamic context of planning have contributed to flexible institutional settings, arenas, in which planning problems are addressed. These arenas may have a more permanent and formal character, such as regional transport authorities addressing a single issue at a regional level, but there are also arenas with a more loose, informal character, such as the meetings amongst regional stakeholders in the process to develop the new national structure vision on the Mainport Amsterdam Schiphol Haarlemmermeer (referred to with the acronym SMASH).

Of the cases studied, the Ausserschwyz case was an exception; in this case there were no incentives for inter-municipal problem solving and no signs of adaptive governance arrangements. Under influence of the airport presence and the low taxes the town has become a popular residence. The urban infrastructure needs to be adapted to the increased population and usage. However, until today, local residents declined to invest in the upgrading of the infrastructure in direct votes. This is a commonly known barrier to planning in Switzerland. However, in the planning of Zürich North, the development of the Glattalbahn, a light rail connection between Zürich and the airport, succeeded to escape from this mechanism. The creation of an infrastructural connection contributed to an identity change of the local residents. Instead of being independent local villagers, they also got used to the idea that they were part of a larger urban region and that they could benefit from the economic development of this region, including the airport related spinoff. The first developments of the plans for the Glattalbahn took place in collaborative processes between different municipalities, a process which was highly uncommon in Switzerland. However, citizens gradually gained confidence in this informal process of inter-municipal collaboration and confirmed this trust by saying yes to the development of the light rail project in a public vote.

Also in the planning of the Amsterdam-Schiphol region, the abovementioned characteristics of governance arrangements are recognized. The planning takes place in changing coalitions of actors, addressing issues with ad hoc, loosely institutionalised arrangements (Van Buuren et al., 2012). From the 1980's onwards, a number of such governance arrangements have been established in this region (Kasarda and Lindsay, 2011). The focus and geographical scope of these arrangements often overlap, resulting in a considerable overlap of participating stakeholders as well (Fain, 2014). By 2013, these structures are being reconsidered by key stakeholders (RLI, 2013). The overlapping arrangements and memberships contribute to a feeling of an overcrowded governance arena lacking efficiency and effectiveness (ibid., also confirmed by the stakeholders interviewed in this research). However, new arrangements suggested by interviewed stakeholders in this project showed a preference to similar types of arrangements, involving similar stakeholders, addressing similar issues.

6.3 Including a resource perspective to the regional planning agenda: challenges

In the Better Airport Region project, regional planning is approached from a resource perspective, in addition to the commonly used approaches addressing transport, accessibility and socio-economic development. As major resource consumers, airport regions have to become more sustainable to consolidate their competitive position amongst global cities (Boschken, 2013).

The understanding of cities as major resource consumers has inspired scholars from a variety of disciplines in designing solutions to make cities more sustainable. In recent years, especially resource-oriented perspectives are becoming increasingly popular amongst scientists and local politicians (Monstadt, 2009). This system perspective emphasizes that urban development, especially in ageing societies, can perhaps be considered more as a co-evolutionary development of several subsystems, than as the result of intended planning and design.
Considering the city as a living organism is a strong frame. It immediately invokes an image of contemporary urban problems and how they will accumulate to even worse unsustainable futures, leading some to follow the metaphor even further and speak of obesity and addictions. However, the urban metabolism metaphor helps to diagnose the condition of cities, but it is interesting to see whether it also offers guidance to address the problems (Alexander, 2005).

Urban systems' perspectives with a focus on resources are highly applicable for urban decision-makers. They seem to offer the vocabulary and methods to realize political ambitions with regards to sustainability. Scientists and practitioners often work side by side to collaborate on the operationalization of this concept, making use of rules of thumb to guide decisions. However, there still seems to be a gap between the popularity of these resource perspectives and the decision-making context in which they need to be applied. Scientifically and methodologically, the perspectives and approaches are still in development. Also, these perspective do not blend in with current institutional planning frameworks.

The urban system perspective including resources perspectives still have difficulty to offer a tangible frame of reference for urban decision-makers (Alberti et al., 2003). In a publication on 'energy landscapes' Blaschke et al. (2012) observe that spatial planning and energy modelling are still treated as separate domains. In their opening article of a special issue on urban system approaches, Kennedy et al. (2012) conclude that: "Translating such integrative interdisciplinary research to practitioners (such as city staff and elected officials) and nongovernmental organizations will be the next frontier, generating real-world impacts on cities worldwide."

In particular, the Better Airport Regions research has highlighted a number of tensions present when trying to make airport regions more sustainable from a resource point of view. These tensions have been derived from the case studies conducted within the governance research (see previous section), from a literature research on resource perspectives on planning (van Bueren et al., 2014), from experiences with resource planning in other airport regions (carried out in this project by Michaeli et al., TUM) and an empirical exploration of how stakeholders in particular projects succeeded to share resources and coped with risks and uncertainties (conducted by graduate student Maarten Kwakernaak).

The closing of loops and use of renewables meets the following challenges:

- The sharing or exchange of resources requires new relationships between stakeholders who were previously not connected or connected differently. These new or changed interdependencies between actors make sense from a resource point of view. However, from a utility maximizing point of view these interdependencies might be undesirable. These new connections are of a long term character and may conflict with values as autonomy and flexibility.

- Capitalizing the potentials for sharing or exchanging resources might involve relationship building between stakeholders based on geographical proximity. This may lead to relationships between stakeholders that would otherwise not have occurred. For example, a local farmer starts supplying his crops to an airline carrier. Formal and informal institutions to guide interactions and transactions between these actors have to be developed or adapted.
- Contributions to a circular economy in airport regions, for example through the sharing of resources or the closing of loops, thus requires the use of previously unused or used differently, and infrastructure and technology. In addition, it requires new or changed institutions.
- Resource based perspectives also introduce new roles to processes of planning and design of airport regions. These new roles can be taken up by new or by existing actors. There are no 'natural' actors to pick up these roles or actors are not keen to pick up these roles. Most actors do not consider it their key priority.
- Decision-making arenas to put resource based perspectives to airport regions on the agenda are absent.

The successful projects addressing resource use in the other airport regions seem to confirm these challenges. Successful projects were those in with positive sum games. Also when ownership of land and / or assets is in one hand – such as the waste to heat network in Frankfurt to which the airport is connected - and when there is an actor in control of planning processes, with the authority to enforce planning requirements, projects tend to be successful (Kwakernaak, in progress; work package 2b).

6.4 Stakeholder game

We have developed a serious game to let stakeholders experience this resource perspective on airport region planning. This game has been played with stakeholders from the Amsterdam-Schiphol region on April 10th, 2014.
Within the Better Airport Region project, several studies on the resource potentials of the airport regions in Frankfurt, Zurich and Amsterdam have been made, prepared by the participating teams from TU Munich, ETH Zurich, Delft University of Technology and University of Amsterdam. For particular parts in the Amsterdam Schiphol region, 'resource potential maps' were made. These maps are based on an analysis of resource flows such as energy, water, and materials in a particular area, and of the opportunities to minimize these flows and replace non-renewable parts by renewable ones, resulting in the identification of planning opportunities to improve sustainable resource use in that area (Geldermans et al., forthcoming). These maps showed that there were several opportunities to improve the sustainability of this region from a resource perspective. Also the experiences with resource management and closing loops at other airport regions showed that there were several opportunities for improvement.

To bring the worlds of the resource potential planning and the world of the stakeholders involved in decision-making on the Amsterdam Schiphol airport region together, we have developed a serious game. Gaming offers a pleasant and interactive environment in which participants feel safe to explore new grounds and to test new ideas. Serious gaming has become a popular method to support physical planning. The roots of serious gaming can be traced back to the US military testing new strategies and tactics under different scenarios. Gaming is called serious to underline the purposeful educational function, and to distinguish it from entertainment games. Nevertheless, serious games might be fun as well. Serious games intend to offer a fun and especially safe environment in which players should feel free to learn and explore and test new ideas, concepts, strategies etc. In the game, an environment is created that – in a simplified way- resembles the complex world of the players (Mayer and Veeneman, 2002).

For the participants, the learning goals of the game were (1) to get inspired by novel ideas and concepts based on resource potential planning to make airport regions more sustainable, and (2) to commonly explore opportunities to implement these ideas and concepts. For the research team involved the learning goals were (1) to get feedback from stakeholders on the ideas and concepts developed by them, which could be used for improvement, and (2) to develop a first understanding of the feasibility of the ideas and concepts.

Analysis of the game results show, amongst others, that:

- Working with resource potential cards seems to be a useful method that can help to bridge the gap between ‘resource map makers’ and ‘policy makers’.
- The game set-up was especially useful for supporting the creation of a joint plan, less for developing an implementation strategy.
- The group that used the cards most succeeded to deliver the best plans, in the sense that they were voted as winners. The cards were generally considered usable and reliable.
- In the groups the cards did in general not play a big role in the making of the plan, however, in the debriefing of the session participants stated that they considered it a very good method to focus the discussion on sustainability issues from a resource/systems perspective.
- Groups were most enthusiastic about internal communication, consensus, shared vision and overall success of the game.
- Plans for implementing the suggestions for better airport regions from the cards included an entrepreneurial approach, facilitating individuals from a variety of organisations in the airport region with creative places to develop bottom-up projects, to the wish for a more strategically oriented arena like SMASH in which stakeholders can explore the development and implementation of resource oriented development of airport regions.

All in all, the game showed to be able to contribute to communicating the relevance of resource potential mapping, a tool that could help decision-makers in urban areas, to decision-makers and is worth further exploration, development and testing.

6.5 Conclusions

Together, the research lines in work package 1cd showed that today’s governance arrangements are appreciated by stakeholders for their flexibility and adaptiveness, but tend to focus on ‘the usual’ issues, involving the usual actors. Attention to flows or resources was considered important, but places and urgency to address these issues were absent.
The stakeholder game showed especially that:

- Stakeholders in the Schiphol airport region are interested in further exploring their region from an resource perspective.
- The resource perspective seems to allow for new or changed coalitions of actors, providing opportunities to reframe the deadlocked debate on economy vs. environment.

The cards and the interactive setting in which they were used thus show a promising route to open up a pathway of transition by bringing resource perspectives and stakeholders together. Some tangible arrangements and instruments to govern better airport regions have been presented on the game cards (see appendix). Stakeholders requested another meeting to further discuss possible governance arrangements and a conceptual model.

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7. Conclusion

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General outcomes
In its two-year term the Better Airport Regions project has brought a lot of insights, design and technical intervention proposals, new approaches and exchanges between researchers and stakeholders, to mention a few of the outcomes. This chapter cannot be comprehensive in mentioning all of these. Perhaps most important is the insight that airport regions indeed have a great potential for improvement, because that is needed when we want to become 'better'. Both technically, spatially, organisationally and inter-humanly potentials for better airport regions were explored and tested in meetings and conferences.

Products from BAR
It has been a very productive two years for all people involved in the BAR project. The research and dissemination process has been very intensive and the project has harvested a range of products:
- Design elaborations of Schiphol Airport region
- Scientific journal and conference papers, expert articles, books and other publications
- A formal final NWO report with the project's outcome
- This final content report, with a project package including annexes of the report, such as the BAR poster book, project reference book, pattern book and gamecards
- Contributions to conferences such as the international and national NWO-VerDus conference (16 and 17 June 2014), the AESOP conference (10 July 2014) and (later) an international conference on better airport regions

In addition, or rather underlying these products, we have gradually developed an approach towards airport regions. This approach is not a blueprint plan, nor a directive collection of consecutive steps. It is a approach, guided by certain elements that form the building blocks for a better airport region. The approach is informed by best-practice projects across Europe and based on sustainable management of essential flows, translating these to spatial design and bringing them to the stage via stakeholder participation sessions.

An important notion: the dimensions of circularity
During the process of research and dissemination – including the participation of stakeholders from the market – we came to the insight that the work we were doing, which had started with the notion that essential flow better be closed within the airport region, could be broken down into different dimensions:
- Data (points – 0D): surveying, collecting and analysing relevant data
- Flows and cycles (linear - 1D): defining normative rules for circularity, including economics
- Spatial planning and design (areas and volumes - 2D/3D): allocating circular systems, creating patterns
- Developments, scenarios and planning (time - 4D): planning the desired spatial configurations
- Action by stakeholders and society (internalisation - 5D): driving development, making it happen

In real life these are intertwined and possibly integrated.

The way we worked largely followed top to bottom: commencing with the inventory of data, which in themselves do not signify anything, unless connected to a time and place. This is the dimension of points, the zeroth dimension. When individual points are brought in relationship with another, information is formed on flows, and possibly also on cycles. This linear dimension is the first dimension. When more than two points are connected, a plain evolves in the second dimension, and with a fourth point the third dimension is born if this fourth point is not placed in the same plain as the previous three. This is the domain of spatial design (in 2D and 3D) where the flows and loops of the previous dimension can be allocated to certain places and where the design patterns find their ground. The fourth dimension is time, when spatial planning becomes a development over time. This of course can go unmanaged, but when under control it is called short- or long-term planning. A non-exclaimed dimension (at least not in the built environment) is what we call the fifth dimension, the dimension that exceeds time and place: the internalisation of ideas, notions and intentions within people, be it the researchers themselves or stakeholders from the airport region. This internal drive or force enables development and change, without it nothing happens. As research team we came across this insight while we fortunately experienced the power of inspired people who (informed by research results) set into motion actions, initiatives and developments.

The quintessential order
So, while our research processed roughly travelled from first careful steps of grasping the airport region by means of figures (often GIS-based) towards urban and regional designs and models for governance over time,

the order of conditionality is reverse: internalisation is needed to set developments in motion, which then define spatial plans, which accommodate flows and cycles that define the figures of separate characteristics. This reverse order was supported by stakeholders, who at the NWO-VerDus Conference concluded that for an action plan not the technical elaboration of essential flows is primary, however a new governance model that would later support sustainable developments within the airport region.

Recommendations: still to be elaborated scientifically
A two-year project can never be comprehensive in changing the future features and quality of airport regions. Therefore, we acknowledge the modest contribution we have made to making airport regions better, and we see the following aspects as to be further studied in future (scientific yet with an applied character) research:

- Better determination and deployment of the pros and potentials of airport regions, e.g. including climate adaptation and liveability.
- Studying the relationships, limitations and potentials of an airport or harbour area with their hinterlands.
- Further elaboration of integrated resource management systems.
- Testing and improving design patterns in designated hotspot or pilot areas.
- Expanding the BAR approach to other hub entities, international cases and different climates.
- Elaborating the 5D model for 'betterness', from big data till internalisation of the new thinking.
- Studying the complicated relationship of economy versus sustainability, in the light of 'better' growth[35] and infrastructures.
- Developing new economic models that integrate economy, technical sustainability, spatial and infrastructure planning.
- Elaborating new governance models for regional hub developments.

Recommendations: still to be elaborated for the Schiphol airport region
Specifically for the Schiphol airport region both researchers and stakeholders see perspectives for continuing the developments started with the BAR project. The following actions were broadly supported during the final NWO-VerDus conference, June 2014:

- Setting up a mutually beneficial governance model for Schiphol airport and region.
- Internalising resource management in the governance of Schiphol and its region.
- Designing, elaborating and developing an exemplar resource management system at Schiphol – creating the first circular airport region.
- Designing, elaborating and developing the Schiphol noise landscape as area with great advantages to the airport region.
- Further action of transforming the Schiphol airport region – a Schiphol airport region pathway plan aimed at becoming better and accommodating change only that benefits both airport and surrounding region.

From this list of actions it becomes clear that the earlier discussed internalisation is quintessential for further actions. Therefore it is promising that all important societal partners of the BAR project invited the researchers to a meeting where the action agenda is set for the coming years.

With this commitment the Schiphol airport region can only get better!

35 OECD growth agenda: stronger, cleaner and fairer

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Delft, 2nd of July 2014
Andy van den Dobbelsteen