

BIES

BUIKSLOTERHAM INTEGRATED ENERGY SYSTEM

Naar een duurzaam en geïntegreerd energiesysteem voor een wijk in transitie



Een onderzoek uitgevoerd door:



Met ondersteuning van:



Rijksdienst voor Ondernemend Nederland



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Foto: AEROPHOTO-SCHIPHOL

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Lead project partner:	TU Delft (Faculteit Bouwkunde)
Project partners:	Stichting Stadslab Buiksloterham; EnergyGO; Metabolic
Project start date:	1 sept 2015
Project duration:	10 months (+ 3,5 months extension)
Project end date:	1 aug 2016 (end date eligible costs) + extension from main funding agency (RVO, NL) until November 15 th 2016)



1 Content

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2 Project info

2.1 Project title

BIES: Buiksloterham Integrated Energy System

Subtitle: Towards a Sustainable and Integrated Energy System for an Urban District in Transition.
(Original sub-title in Dutch: Naar een duurzaam en geïntegreerd energiesysteem voor een wijk in transitie.)

2.2 Authors

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2.3 Project partners

The main funding Agency of the project was the Netherlands Enterprise Agency (Rijksdienst voor Ondernemend Nederland, RVO). The project was funded within the programme 'Systeemintegratiestudies'.

The project received cofounding from the AMS Institute (<http://www.ams-institute.org/>).

3 Management summary

The traditional way of supplying energy to the built environment is no longer suitable: New buildings with high energy performance and decentralised renewable energy generation, together with the desire to become fossil-free, involve the need for new, more flexible and more integrated energy systems. The aim of BIES was to develop feasible and potentially desirable energy supply scenarios for the built environment, at district level. The district of Buiksloterham was used as a test case, but the results are also applicable to other new construction sites with high energy ambitions and high densities. Both technical and organisational boundary conditions were considered.

The results of the project aimed to obtain:

- 1) Insight into the feasibility and added value of integrated district energy systems.
- 2) Insight into innovative products or services essential to the development of sustainable and integrated energy systems of the future.
- 3) An approach for developing integrated district energy systems ('bis').

Within the project several basic district energy supply scenarios were determined. For the evaluation of these, key performance indicators (KPI's) were developed within the categories energy, economy, circularity and implementation. For the latter the PSTLG indicators were used (Political, Social, Technological, Legal and Governance).

Firstly, the current energy use of the existing buildings and the expected energy demand of all new buildings was estimated. Secondly, the potential of local energy generation from renewables and 'waste' was determined. As a third step, three basic options for the new buildings were considered: 1) traditional supply, using natural gas and electricity from the grid; 2) All-electric with a heat pump using ground source heat; 3) district heating and electricity from the grid. Also, the 'reference situation' for the area has been determined: the situation that will occur when no new interventions or incentives are being implemented.

The main findings of the evaluation of the three energy supply options for the new buildings and of the defined reference situation of the area are:

- It is very difficult to transform the energy supply system of the existing buildings into a sustainable and integrated system. The use of natural gas cannot easily be converted to a renewable system and the electricity potential on the roofs of existing buildings covers only one third of the electricity demand of the existing buildings.
- There is a large potential of 'low-quality' renewable heat (i.e. heat at temperatures near environmental temperature, typically between 15 and 30 degrees), for example from waste water heat recovery or solar systems. The potential electricity production from solar and wind energy is also substantial (covering 2/3 of the electricity demand of the new dwellings), but this is based on full use of all roof surfaces.
- The basic energy supply options that were investigated for the new buildings all lack an integrated approach. Therefore, these systems are not flexible towards the integration of renewable resources. This means the potential of renewables cannot be fully exploited and

secondly, these systems are not able to cope with the fluctuating character of renewable energy generation.

- Of the three options for the new buildings, option 1 (natural gas and electricity) was the most economical option. However, the performance on energy and circularity are obviously not meeting the ambitions, and moreover this option is not possible due to political choices for the area. Option 2 scores better than option 3 on economy, energy and circularity. The implementation of option 2 however is more difficult due to political reasons as well as governance issues as it requires more cooperation.

The options were evaluated and shared and discussed with stakeholders of the area. As a result of the evaluation a fourth option for the new buildings was developed, as well as recommendations for the area as a whole. The main feature of option 4 is a low temperature heat grid, that enables the integration of renewable energy or waste water heat recovery. Also, a heat pump and thermal buffer are included, in order to make flexible use of the renewable electricity produced. The optimal configuration as well as optimal temperature level still require further research. For the area as a whole it is also recommended to implement a low or medium temperature heat grid, instead of a high temperature heat grid, since the latter disables the possible integration of much of the local energy potential. In the report some 'game changer' innovative systems are pointed out, such as thermal energy storage, domestic hot water production in combination with low temperature heat supply and waste water heat recovery systems. Also non-technical aspects are needed, such as new parties that can play a role in the development, investments and exploitation of shared energy systems.

The findings will be further developed in the Europe project SUI ('Smart Urban Isle' <http://jpi-urbaneurope.eu/project/smart-urban-isle/>). The findings are very relevant for all new construction sites as well as renovation plans. At the end of the project, the results are being included in the development of the energy concept for plot 20 in Buiksloterham.

4 Extended abstract

4.1 Keywords

District energy system; renewable energy, district heating; local energy system; circularity

4.2 Introduction

The traditional way of supplying energy to the built environment is no longer suitable: New buildings with high energy performance and decentralised renewable energy generation, together with the desire to become fossil-free, involve the need for new, more flexible and more integrated energy systems.

The aim of BIES was to develop feasible and potentially desirable energy supply scenarios for the built environment, at district level. The district of Buiksloterham was used as a test case, but the results are also applicable to other new construction sites with high energy ambitions and high densities. Both technical and organisational boundary conditions were considered.

The results of the project aimed to obtain:

- 1) Insight into the feasibility and added value of integrated district energy systems.
- 2) Insight into innovative products or services essential to the development of sustainable and integrated energy systems of the future.
- 3) An approach for developing integrated district energy systems ('bis').

4.3 Literature

For the project a new approach to obtain the result was developed, partly based on existing literature. Mainly the energy potential mapping approach (Dobbelsteen et.al, 2007 and Broersma et al., 2013) was used as a starting point for developing the technical energy concepts. Furthermore the more broader literature on sustainable energy for districts was used in the development of energy concepts as well as approach, such as the 'toolkit duurzame gebiedsontwikkeling' (2012) and Jablonska,B. et al. (2011).

For the detailed analyses of the energy concepts as well as the evaluation of their performance, many literature resources were consulted. Important for the starting point of the analyses were assumptions related to the energy demand of buildings, taken from RVO (2015). Also information related to the performance specific energy technologies, such as PV systems or district heating systems, costs, etc. was gathered from literature. A detailed list can be found in the final report on the project (Jansen et.al, 2016, in Dutch); literature on district heating include for example de Beer et al., (2014) and Lund et al., (2014).

Apart from literature much information was gathered by asking stakeholders active in the area.

4.4 Methods

The study was carried out according to the following steps:

Step 1: Inventory of the status quo

- This step involved the inventory of existing buildings and existing plans for new buildings, using amongst other the ‘bestemmingsplan’ (land use plan set up under the authority of the municipality) and the existing report on the circular ambition of Buiksloterham (Metabolic and Delva Landscape Architects, 2014).
- The inventory also included stakeholders and existing energy infrastructure.
- This phase took longer than expected, since the data was not always easily available.

Step 2: Definition the Key Performance Indicators (KPI's)

- For the project indicators were developed within the categories energy, economy, circularity and implementation. For the latter the PSTLG indicators were selected: Political, Social, Technological, Legal and Governance.

Step 3: Estimation of the energy demand and the renewable energy potential

- The energy use of existing buildings was obtained from www.energieinbeeld.nl. On the basis of the inventory of step 1, the energy demand for heating, cooling, domestic hot water and electricity consumption of the new buildings was estimated by using typical energy demand data from RVO (2015).
- Secondly the potential generation of renewable energy on-site was estimated based on average roof surfaces for solar and wind energy and based on average production of waste and waste water.

Step 4: Development of basic energy concepts

- Three basic energy concept were developed, based on proven and existing technologies. The efficiencies of the technologies involved were taken from RVO (2015) and from the experience of the project partners. Also an idea of the energy concepts that can be expected for the new buildings was developed, based on experience in the area and existing agreements between stakeholders. This situation is called the ‘0-alternative’, the situation that is expected to occur when no new developments or interventions take place.

Step 5: Stakeholder meeting 1

- In February 2016 a first stakeholder meeting was organised, where around 25 people active in the area were present. The basic energy concepts were discussed with these stakeholders, which led to more insight into the practical feasibility of these concepts. The discussions led to a more attention being paid to the specific local situation in Buiksloterham.

Step 6: Development of ideas for improved energy concepts

- As a result of the evaluation of the basic variants ideas for improvement were developed. Attention was paid to both the new buildings as to the situation in Buiksloterham as an area with existing buildings.

Step 7: Stakeholder meeting 2

- In May 2016 a second stakeholder meeting was organised, where the ideas for improvement were presented and further developed.

Step 8: Final report

- Lastly, the evaluation of the basic energy concepts as well as the ideas for further improvement were finalised. Several literature sources as well as stakeholders were consulted to obtain the correct data as much as possible.

4.5 Findings and arguments

4.5.1 Summarizing the results

The area consists of existing and new buildings. Given the diverse nature of existing buildings, the energy concepts for the new buildings were particularly discussed, while some recommendations for the existing buildings and the integration between the two are proposed.

For the new buildings three basic concepts for energy were developed and assessed for a set of KPIs. The basic concepts were:

- Concept 1: Traditional energy supply based on gas and electricity
- Concept 2: All-electric (heat pump and ground source thermal storage)
- Concept 3: District heating with electricity

The assessment has shown that concept 1 is by far the most favourable in terms of costs, followed by concept 2, and then 3. Concept 2 is the most favourable related to energy performance and overall sustainability. These findings may also apply to other locations with new buildings. Given the existing agreements in Buiksloterham in fact only concept 3 is applicable.

The assessment also showed that in fact, none of the basic concepts is truly an integrated energy system, where synergies are sought and flexibility for the grid is achieved. Also the expected large quantity of installed PV power may even lead to necessary changes in the power grid.

To overcome these shortcomings a fourth option was developed, based on maximum use of local heat, use of a collective heat pump and a mini heat network. Storage of thermal energy is an essential part here, since in this way more local heat can be exploited and it can increase flexibility in the network due to the potential flexible use of the heat pump. The ideal temperature and scale for such a collective energy concept and mini heat network remains to be investigated.

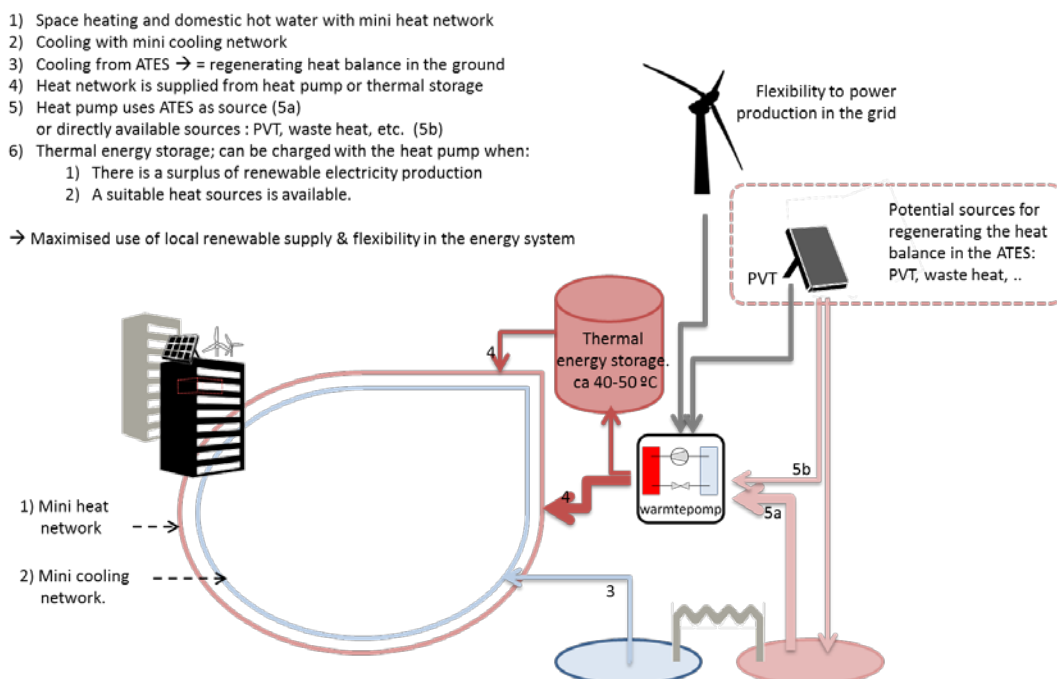


Figure 1: scheme of a fourth energy concept for the new buildings, developed to overcome the shortcomings of the basic variants 1 2 and 3.

From the assessment of this fourth, alternative concept, it appears that the integrated approach can lead to more benefits than the basic concepts using proven technologies. They can increase the use of local renewable heat and increase the flexibility for the electricity grid. Collective systems can also have a higher efficiency, especially when thermal storage is involved. However, the problem with this kind of development is particularly the governance; only few parties can make large investments and exploit such systems. In Buiksloterham this proves especially difficult due to the different timing of different developments.

4.5.2 Recommendations on a technical level

Low temperature heat networks are essential for enabling the maximum use of renewable and waste resources. The energetic and economic performance of low-temperature energy systems may benefit from:

- Further development for long-term thermal energy storage systems.
- Booster heat pumps and other solutions that enable the supply of domestic hot water in combination with low temperature supply.
- Energy-efficient heat pumps that have high performance with small temperature lifts. (i.e., which only have to bridge a small temperature difference between the available heat source and the heat to be delivered)
- Heat recovery from wastewater (decentralized).

To improve the electricity supply the occurrence or rather avoidance of a large peak power due to installed PV and a large peak demand for heat pumps and / or electric transport needs to be considered. This is possible, inter alia, by enabling flexible use of electrical equipment, of which the heat pump is an important example. In order to increase the flexibility also storage is of great importance.

4.5.3 Recommendations on non-technical level

Also less technical innovations are essential to realize innovative energy concepts. The BIES project in particular encountered that the lack of steering makes it difficult to develop collective and integrated systems. Furthermore, there is a lack of (energy service) companies that finance and exploit a collective energy system and can offer a competitive and transparent service to do so.

On a scientific level it is recommended to develop more knowledge on an integrated assessment of 'future fit' and sustainable energy systems: not only CO₂ and costs are relevant, also circularity will be crucial in the (near) future: including circular use of materials, of water flows and nutrients. The use of space will become relevant as the conversion of renewable resources into useable energy requires both space and materials. The impact on the larger energy system is also a factor of interest that is currently not always included, while for a fully renewable energy future this becomes more and more important.

4.6 Conclusion

The BIES project investigated the feasibility of integrated and renewable energy systems for Buiksloterham. Buiksloterham functioned as a case study and the results are also applicable to other new development areas.

It is not possible to develop Buiksloterham into an energy neutral area within the current legal framework (without wind energy it is not possible). About 1/3 of the energy use in buildings (building-related energy plus user-related energy) can be supplied with renewable energy. It is possible to identify which concept results in the highest fraction of renewable supply: The BIES project concluded that a low temperature supply of heat is essential for a maximised use of renewable input and a high overall sustainability performance. The fourth energy concept developed seems to meet the ambitions related to maximum renewable supply and system integration. This concept is based on local heat generation, thermal storage at relatively low temperatures, produced from solar energy or by upgrading low temperature (waste) heat by means heat pumps. These conclusions are also applicable to other new construction sites with high density (fsi approximately 2.3) and high energy requirements (EPC between 0 and 0.4).

Apart from the energy figures however, the "best" sustainable or "most desirable scenario" depends on several indicators and factors. These are not all that easy to determine. A first start has been made in the BIES project, but more knowledge is required in this field. In the assessment of the most future proof and sustainable energy system an integrated approach is needed, that is: not only looking at CO₂ and costs but also including circularity parameters, as mentioned in section 4.5.

New energy-efficient energy systems require very good, early planning, appointments, and cost and support of existing energy suppliers. Extracting a CO₂ neutral society by 2050 depends not only on technological innovation; implementation aspects have a significant impact. Further detailed recommendations to further develop products and services are provided in section 4.5.

5 Impact and benefits for the Metropolitan Region Amsterdam

The city of Amsterdam has a large programme for new buildings¹. At the same time, the city's ambition is to become independent of natural gas for energy supply to the built environment by 2050. This means, new buildings should not be connected to the gas grid. Currently, plans for large-scale district heating networks are being developed, connecting many buildings in and around Amsterdam². Although this vision does not explicitly mention that these district heating networks should be 'high temperature heat networks', the energy system in Buiksloterham was meant as a high temperature district heating network.

The BIES project has investigated different possibilities to supply new buildings with as much renewable energy as possible. It concluded that a low temperature supply of heat is essential for a maximised use of renewable input and a high overall sustainability performance. It is therefore recommended that for all new development areas the feasibility of low temperature heat grids will be investigated as well. In the assessment of the most future proof and sustainable energy system an integrated approach is needed, that is: not only looking at CO₂ and costs but also including circularity parameters, as mentioned in section 4.5. The future of the currently investigated sources

¹ Koers 2025: <https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/koers-2025-amsterdam/> .

² <http://www.warmteiscool.nl/>

of high temperature 'waste' heat must be considered, next to the fact that a high temperature supply – also from geothermal sources - always entails reduced electricity production and is therefore strictly not real 'waste'.

Furthermore, the expected increase of installed PV power for all new areas entails two other points of attention: Firstly: a high share of solar energy will induce the need for a more flexible energy system. (Seasonal) energy storage, as explained in section 4.5.1, can play a crucial role in balancing the energy system. Secondly, the material aspect of PV systems must be included from the beginning: not only the 'energy pay-back-time' of the production of these systems is relevant; also the end-of life scenario after use must be considered, aiming for full circular use of all the elements and materials of these systems. Possibly, this must also include new business models.

Hence, the results of the project and all these aspects mentioned above are very relevant for the Metropolitan Region of Amsterdam.

6 Spin-off and valorisation

The project has developed insight into the feasibility and added value of an integrated energy concept for new buildings and developed a potential high-performing energy concept. This concept is potentially promising, but still needs further development of innovative technologies such as thermal energy storage, as well as further investigation. These questions are both relevant to education (mainly master theses) and research and can also play a role for companies whose product or service in the market can support such an energy concept.

Related to research activities, the 'Smart Urban Isle' project³ recently started at the Faculty of Architecture of the TU Delft will continue the research on local renewable energy systems for districts. This research, for which also Buiksloterham will function as a case study area, goes further in this respect where BIES has ended.

In addition to research, the actual developments in Buiksloterham can investigate to what extent such an energy concept can be achieved or what hurdles still need to be taken. There are already contacts between the stakeholders of some current developments. The results of BIES have reached the developers of various plots in Buiksloterham, including, for example plot 20, which is now under development. Also, the dissemination activities of the project have shown that there is great interest in the results with various stakeholders.

Lastly, the results are not only relevant for Buiksloterham, but also for the foreseen new developments in Amsterdam.

³ <http://jpi-urbaneurope.eu/project/smart-urban-isle/>

7 Key references

Final report in the project (in Dutch):

Jansen, S.C., Bokel, R.M.J., Müller, S., Elswijk, M., Roossien, B., Odijk, S. van., Vries, S. de, *BIES BUIKSLOTERHAM INTEGRATED ENERGY SYSTEM: Naar een duurzaam en geïntegreerd energiesysteem voor een wijk in transitie (in Dutch)*. November 2016

<http://www.ams-institute.org/solution/bies-buiksloterham-integrated-energy-system/>

The main references are:

Beer, J. de, Slingerland, E. and Meindertsma, W., *Warmteladder. Afwegingskader warmtebronnen voor warmtenetten*. Ecofys, 2014.

Broersma, S. Fremouw M and Dobbelsteen A.van den., *Energy Potential Mapping: Visualising Energy Characteristics for the Exergetic Optimisation of the Built Environment*, *Entropy* 2013, 15, 490-506; doi:10.3390/e15020490.

Dobbelsteen, A. A. J. F. vd., Jansen, S. C. and Timmeren, A. v. (2007). “*Naar een energiegestuurd omgevingsplan Groningen*” (In Dutch). Delft, Delft University of Technology.

Jablonska, B. et al., *Innovatieve energieconcepten en pilots voor energieneutrale gebiedsontwikkeling in 2050*, ECN-0--10-037, Januari 2011.

Lund, H., Werner, S. et al., *4th Generation District Heating (4GDH) - Integrating smart thermal grids into future sustainable energy systems*. *Energy* 68 (2014) 1-11.

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RVO, *Uniforme maatlat gebouwede omgeving, rekenmodel versie 3.5*. Online download from www.agentschapnl.nl/new --> instrumenten. Retrieved October 2015.

Toolkit duurzame gebiedsontwikkeling, *Met 20 bouwstenen naar een energieneutraal gebied; gids voor initiatiefnemers en projectleiders*, Aeneas, uitgeverij van vakinformatie bv, Boxtel, 2012.

The full list of references can be found in the public final report (in Dutch).

8 Key publications realized by project members

8.1 Final report in the project (in Dutch):

Jansen, S.C., Bokel, R.M.J., Müller, S., Elswijk, M., Roossien, B., Odijk, S. van., Vries, S. de, *BIES BUIKSLOTERHAM INTEGRATED ENERGY SYSTEM: Naar een duurzaam en geïntegreerd energiesysteem voor een wijk in transitie (in Dutch)*. November 2016. 106 pages.

Available for download from:

- <http://www.ams-institute.org/solution/bies-buiksloterham-integrated-energy-system/>
- <http://buiksloterham.nl/project/2549/bies--buiksloterham-integrated-energy-system->

8.2 Online dissemination

The project has been communicated from the beginning, through the network of Stichting Stadslab Buiksloterham (www.buiksloterham.nl).

The screenshot shows the website www.buiksloterham.nl with a navigation menu including 'Wensen', 'Localities', 'Projecten', 'Personen', 'Organisaties', 'Activiteiten', 'Berichten', 'Aanbod', and 'Gezocht'. The main content area features a project page titled 'BIES: Buiksloterham Integrated Energy System' with a sub-header 'Towards a Sustainable and Integrated Energy System for an Urban Area in Transition'. The text describes the project's goals, technical aspects, and results. The project duration is listed as '1 sept 2015 – 1 nov 2016'. The partners are listed as 'which partners are joining'. On the right side, there is a 'PROJECTLEIDERS' section listing Saskia Müller, Sabine Jansen, and Marcel Elswijk, each with their role and affiliation. Below that is a 'BETROKKEN ORGANISATIE' section listing TU Delft and Onderwijs. Further down is a 'BETROKKEN ORGANISATIES' section listing the Amsterdam Institute for Advanced Metropolitan Solutions (AMS) and Metabolic. At the bottom, there is a 'Stadslab Buiksloterham' logo.

Figure 2: screenshot of the communication about the project in the website of Buiksloterham www.buiksloterham.nl

8.3 Dissemination events:

The project was and will be presented at the following events:

- September 21st 2015: The start of the project was announced during the ‘Energietafel’ meeting at New Energy Docks, Buiksloterham, where around 25 stakeholders of Buiksloterham were present.
- Two stakeholder workshops were organized within BIES, on Thursday, February 18th, 2016 and on Tuesday, May 10th, 2016.
- The preliminary results of the BIES project were presented at the meeting “Lessen en ervaringen systeemintegratie”, organised by Netherlands Enterprise Agency (RVO.nl) on July 7 in Utrecht.
- The results of BIES were briefly introduced by Sabine Jansen during the Exit gas event at “Pakhuis de Zwijger” on November 1st, 2016.
- The final report of the project was presented at the AMS institute on January 24th, 2017, where around 40 people were present. The session also included a lively discussion on the future of sustainable energy systems for new buildings⁴.

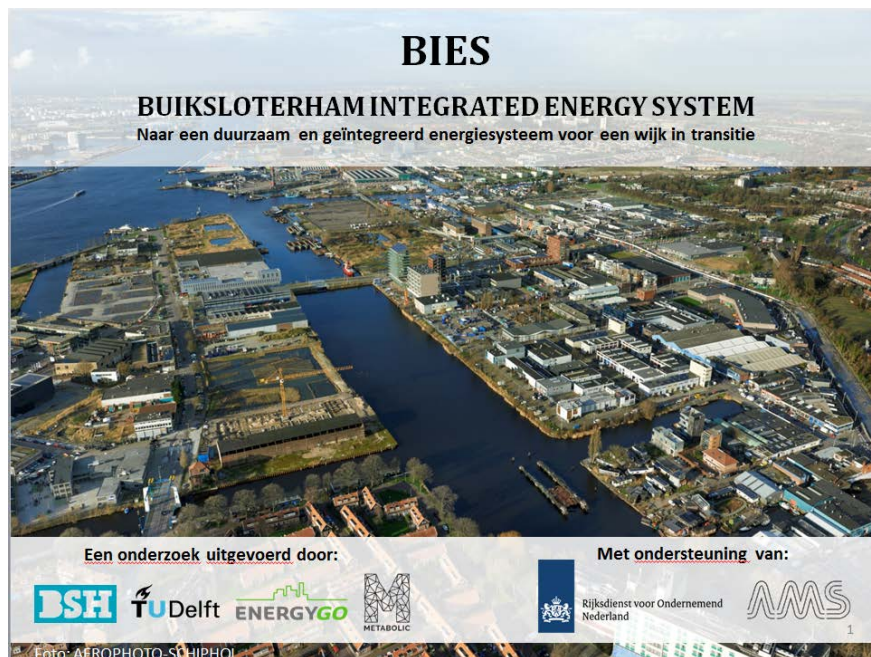


Figure 3: presentation of the final BIES report on January 24th, 2017 at the AMS institute.

- The results of the project will be presented to the students of the Faculty of Architecture within the master course “Innovation and Sustainability”.
- The results of the BIES project are included as a basis for the international SUI project⁵ in which members from Spain, Austria, Cyprus, Switzerland, Turkey and the Netherlands (including two international postdocs) participate.
- Many informal knowledge dissemination takes place through the Board of the “Stichting Stadslab Buiksloterham” (www.Buiksloterham.nl), especially by Saskia Müller and Frank Alsema. The results of BIES have reached the developers of various plots in Buiksloterham, including, for example plot 20, which is now in development.

⁴ <http://www.ams-institute.org/events/event/final-presentation-bies-project/>

⁵ <http://jpi-urbaneurope.eu/project/smart-urban-isle/>

9 Key data-sets realized by project

There is no data set developed by the project, but all assumptions related to the energy concepts are clearly described in the report, which is publicly available.

10 Annex

See <http://www.ams-institute.org/solution/bies-buiksloterham-integrated-energy-system/>