Business case optimisation for the development of energy neutral residential neighbourhoods

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In 2015, the power plants used 32 percent more coal than in 2014, while natural gas usage decreased by 12 percent. This shift of natural gas to coal already introduced in 2012.

-CBS, 2016
Research motives

- Need for sustainable development
- Demand for housing
- Shifting responsibilities
- Smart technologies

Research topic
Overexploiting the world’s fossil resources for energy consumption, which causes climate change and rising energy prices (CBS, PBL & WageningenUR, 2007, 2016; IPCC, 2014, RVO, 2017).

• Natural gas depletion in the Netherlands
• Overexploiting the worlds fossil resources for energy consumption, which causes climate change and rising energy prices (CBS, PBL & WageningenUR, 2007, 2016; IPCC, 2014, RVO, 2017).

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- Natural gas depletion in the Netherlands

Need for sustainable development

Hof: toch strafrechtelijk onderzoek naar bevingsschade door gaswinning Groningen
Need for sustainable development

- Overexploiting the world’s fossil resources for energy consumption, which causes climate change and rising energy prices (CBS, PBL & WageningenUR, 2007, 2016; IPCC, 2014, RVO, 2017).
- Natural gas depletion in the Netherlands
- Increasing coal usage since 2014
Need for sustainable development

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- Natural gas depletion in the Netherlands
- Increasing coal usage since 2014
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• Natural gas depletion in the Netherlands

• Increasing coal usage since 2014

• Buildings in the EU use 40% of the total energy usage (Burman et al., 2014).

• The EU acts: Energy Performance of Building Directive (EPBD); after 2020 all new buildings consume nearly zero energy (European Parliament and Council of the EU, 2010).
Overexploiting the world’s fossil resources for energy consumption, which causes climate change and rising energy prices (CBS, PBL & WageningenUR, 2007, 2016; IPCC, 2014, RVO, 2017).

- Natural gas depletion in the Netherlands
- Increasing coal usage since 2014
- Buildings in the EU use 40% of the total energy usage (Burman et al., 2014).
- The EU acts: Energy Performance of Building Directive (EPBD); after 2020 all new buildings consume nearly zero energy (European Parlement and Council of the EU, 2010).
- National plan in NL to comply to EPBD: BENG-legislation (Haytink & Valk, 2017; RVO, 2016).

Figure of Bouwens & Bouwmeester (2017)
Need for sustainable development

- NL economy runs on fossil fuels.
- Energy transition: shift towards a carbon free economy
Need for sustainable development

- Households consume 20% of final energy usage in NL
- Households are heavily dependent on natural gas
Need for sustainable development

- Possible
  - Proof of concept by Zero-on-the-Meter

- Future requirement
  - BENG-Legislation

- Cheaper
  - Business case; TCO
  - Rising natural gas prices
Urban growth


Shift from public to private sector
(Heurkens, 2012; Peek & Van Remmen, 2012)

Digitalisation and smart ‘everything’ (Townsend, 2013)
The real estate developer is taking a leading position in urban area development and is facing new legislation about nearly energy neutral developments, which both increases the construction costs of new developments and the complexity of the project.
Research focus

- All-electric
- New constructions

Figure based on Molengraaf (2017).
Research focus

Development exploitation  Real estate exploitation  In use

Focus of thesis

Real Estate developer

Owner

Investor

Tenant

Owner-occupied  Rental

Figure based on Putman (2010) and Vlek et al (2016).
Research focus

- All-electric
- New constructions
- Owner-occupied

Figure top based on Putman (2010) and Vlek et al (2016).
Figure top based on CBS (2017)
Research focus

- All-electric
- New constructions
- Owner-occupied
- Single-family

Figure based on CBS (2017)
• All-electric
• New constructions
• Owner-occupied
• Initial phase of development
Research framework & questions

- How can a real estate developer optimise its business case to realize energy neutral residential neighbourhoods consisting of all-electric, single-family and owner-occupied dwellings?

- Sub-research questions
  1. Current practises
  2. Development of Decision support tool (DST)
  3. Added value of DST
Research design

- Research methods
  - Literature study
  - Expert meetings
  - Case study
    - Desk research
    - Semi-structured interviews
  - Computational modelling
    - LP-modelling technique
    - Unstructured expert interviews
  - Validation of added value
    - Applying modelling technique
    - Expert focus group
Barriers in multi-actor decision-making for sustainable urban area development

Suitable quantitative optimisation technique

Main barriers and solutions of business case:
- Energy legislation
- Energy innovation
- Finance
Research design
Research design

Part V: Synthesis

- Conclusion
- Discussion
- Recommendations
Part 2: Context & theory

• Defining ‘energy neutral’

• Urban area development and real estate developer

• Barriers in multi-actor decision-making

• Optimisation of business case
  • Legislation
  • Financial
What is... ‘ENERGY NEUTRAL’?

Building-related
Heating, cooling, ventilation

Energy demand
What is ‘ENERGY NEUTRAL’?

- **Household-related**
  - Appliances - laptops, phones, more

- **Building-related**
  - Heating, cooling, ventilation

**Energy demand**
What is… ‘ENERGY NEUTRAL’?

Household-related
Appliances - laptops, phones, more

Building-related
Heating, cooling, ventilation

Renewable supply

Energy demand
What is... 'ENERGY NEUTRAL'?

Household-related
Appliances - laptops, phones, more

Building-related
Heating, cooling, ventilation

Renewable supply
Energy neutral
Energy demand
What is... ‘ENERGY NEUTRAL’?

- **Zero-on-the-Meter**
  - Renewable supply

- **Energy neutral**
  - Energy demand

- **Household-related**
  - Appliances - laptops, phones, more

- **Building-related**
  - Heating, cooling, ventilation
What is… ‘ENERGY NEUTRAL’?

- **Material-related**
- **Household-related**
  - Appliances - laptops, phones, more
- **Building-related**
  - Heating, cooling, ventilation
What is ‘ENERGY NEUTRAL’?

- PlusEnergy
- Zero-on-the-meter
- Energy-bill-zero
- Nearly Energy Zero Building (nZEB)
- Building regulations (since 01-01-2015)
- Building regulations (before 01-01-2011)

Figure based on Dwars (2013).
• Goal UAD: Development of a specific area within a town or city or the expansion of a town or city (Franzen et al., 2011).

• Goal real estate developer: Increasing its own return (Putman, 2010).
Goal UAD: Development of a specific area within a town or city or the expansion of a town or city (Franzen et al., 2011).

Goal real estate developer: Increasing its own return (Putman, 2010).

Real estate development
- By bringing together ideas, management, labour, capital and land (van Gool et al., 2013).
- By risk-bearing investment in land acquisition, plan development and preparations (Putman, 2010).
- Sell after completion.

Developing investor vs. real estate developer (De Jong, 2016; Peek & Remmen, 2012; Putman, 2010; Van Gool et al., 2013).
Barriers in multi-actor decision-making for sustainable results

- Information gab / scattered knowledge (Glumac, 2012; WBCSD, 2007)
- Conflict of interests (Glumac, 2012; Golobic & Marusic, 2007)
- Fragmentation of decision making and financial value (Cheng et al., 2008; WBCSD, 2007)
- Need for a feasible business case (Franzen et al., 2011)
Knowledge is scattered

• Dealing with interests in multi-actor decision making
  • Municipality: High energy ambitions
  • Real estate developer: Profitable business case
  • Future home owner: Low costs/ high quality
  • E-grid company: Capacity of the current grid

• Solution space

• Linear programming as (mathematical) optimisation method
Linear programming
in multi-actor decision-making

Figure of Van Loon et al (2008: 33)
Linear programming in multi-actor decision-making

Figure of Binnekamp et al (2006: 40)
Linear programming in multi-actor decision-making

Figure of Binnekamp et al (2006: 40)
Linear programming in multi-actor decision-making

Dynamic solution space

Finding the common solution space by negotiable constraints

Finding fundamental different design alternatives

Left: Figure of Van Loon et al (2008: 33)
Middle: Figure of Van Loon et al (2008: 11)
Right: Figure of Binnekamp et al (2006: 40)
Energy legislation

- Trias energetica (Duijvenstein, 1997)
- BENG
  - BENG1: Max. thermal energy demand
  - BENG2: Max. primary energy demand
  - BENG3: Min. 50% renewable energy supply
- Balancing agreement
- Environmental Performance of Buildings (MPG)
Energy changes

- From central to decentral electricity grid (Molengraaf, 2017).
- Effect of a zero-on-the-meter dwelling on a conventional electricity grid is six times peak (Molengraaf, 2017).

Figure of Molengraaf (2017)
• Project delivery methods

• Integral involvement of sustainability from the start of the project (Rovers, 2008; Schiltmans, 2013; Wamelink et al., 2010)

![Organisational diagram](image-url)

Figure based on Rahola & Straub (2013).
<table>
<thead>
<tr>
<th>Ground exploitation</th>
<th>Development exploitation</th>
<th>Real estate exploitation / In use</th>
</tr>
</thead>
</table>

- Owner

Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)
Finance - basics

| Ground exploitation | Development exploitation | Real estate exploitation / In use |

Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)
Ground exploitation | Development exploitation | Real estate exploitation / In use

Real Estate developer

Bank

Owner

Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)
Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)
Finance - basics

Ground exploitation

Development exploitation

Real estate exploitation / In use

Additional costs
Advisors, fees, etc.

Real Estate developer

Bank

Owner

Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)
Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)
Finance - basics

Ground exploitation

Development exploitation

Real estate exploitation / In use

Additional costs
Advisors, fees, etc.

Construction company

Real Estate developer

Bank

Owner

Bank

Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)
Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)
Finance - basics

Ground exploitation

Development exploitation

Real estate exploitation / In use

Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)
Finance - basics

Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)
• Split-incentive (Astmarsson et al., 2013; Bullier & Milin, 2013).

• Other preferences home buyers (De Vries, 2010).

• A <-> G-labelled buildings €27.000 difference (Brounen, 2015, 2017).

Selling price

Revenues

Costs

Profit
Additional costs
Construction
Ground
Finance

Increased selling price

Selling price

Energy efficiency investment
Profit
Additional costs
Construction
Ground

Revenues

Costs

Increased selling price

Energy efficiency investment
Profit
Additional costs
Construction
Ground
Finance

Selling price

Revenues

Costs

Energy efficiency investment

Ground

Construction

Additional costs

Profit
Finance

Increased selling price

Selling price

Revenues

Costs

Extra profit
Profit
Additional costs
Construction
Energy efficiency investment
Ground

Increased selling price

Extra profit

Profit

Additional costs

Construction

Energy efficiency investment

Ground
Finance

Selling price

Revenues

Costs

Profit

Additional costs

Construction

Extra profit

Ground

Energy efficiency investment

3rd party investment (e.g. ESCO)
Part 3: Exploring case studies

- Purposive sampling (Bryman, 2012; Kumar, 2014)

- Results
• ZEN-database

• ZEN: Follow-up program of Lente-Akkoord

Sampling (1)

- 'Professor Schoemaker Plantage' in Delft
- 'Het Verborgen Geheim' in Rotterdam
- 'Park Harga' in Schiedam
- 'De Boomgaard' in Nijkerk
- 'Eilanden van Sion (eiland "Waterlelie")' in Rijswijk
- 'Zuiderhoeve' in Haarlemmermeer
- 'Eilanden van Sion' in Rijswijk
- 'Sonate 2.0' in Voorhout
- 'Eilanden van Sion (eiland "Zwaan")' in Rijswijk

Project name and location

Amount of dwellings

- Owner-occupied MFD
- Owner-occupied - SFD
- Rent - MFD
- RENT - SFD
• 1st choice: in-depth investigated

• 2nd choice: Desk research + semi-structured interviews

• 3rd choice: Desk research + personal communication
Van Omme & De Groot: Het Verborgen Geheim
AM: Prof. Schoemaker Plantage
Results exploring case studies

<table>
<thead>
<tr>
<th></th>
<th>‘Het Verborgen Geheim’</th>
<th>‘Prof. Schoemaker Plantage’</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Partnership model</strong></td>
<td>Public realization</td>
<td>Private realization</td>
</tr>
<tr>
<td><strong>Incentive for real estate developer</strong></td>
<td>MEAT-tender</td>
<td>Changing legislation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Market circumstances</td>
</tr>
<tr>
<td><strong>Organisational</strong></td>
<td>Involvement of ESCo</td>
<td>Design-and-Build contract</td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td><strong>Financing</strong></td>
<td>ESCo</td>
<td>Increasing selling price by additional borrowing capacity for ZOM</td>
</tr>
<tr>
<td></td>
<td>Low ground price of the municipality (£19.419 / dwelling)</td>
<td>(£29,000,-)</td>
</tr>
<tr>
<td><strong>Physical</strong></td>
<td>All-electric with ground source heat pump powered with PV-panels</td>
<td></td>
</tr>
</tbody>
</table>
Figure based on Klimaatgarant and Het Verborgen Geheim (2016).
Part 4: Development DST

- Objective of the model
- Components
- System structure
Development of the DST

- Optimal dwelling program with related all-electric energy supply installations and financing method
- Objective function (real estate developer): Maximal profit
- Within the given constraints (such as energy legislation, density)
Top view

Terraced dwellings

Semi-detached dwellings

Detached dwellings

Lot (size)

Dwelling

1 120m²

2 108m²

3

4 200m²

5

6 400m²

Type 1 & 3:
Corner dwelling of terraced dwellings

Type 2:
Mid-terraced dwellings

Type 4 & 5:
Semi-detached dwellings

Type 6:
Detached dwellings

A
UFA: 100m²

B
UFA: 125m²

C
UFA: 150m²
Energy supply

- **Thermal:**
  - E-boilers
  - Air Source Heat Pump (ASHP)
  - Ground Source Heat Pump (GSHP)

- **Electricity**
  - PV-panels
  - Wind
Part 5: Added value DST

- Application of DST
- Expert focus group
• 5,8 ha

• 51% can be developed

• 170 dwellings
  • No detached dwellings

• Zero-on-the-Meter

• Ground price: €19,419,-

• ESCO: Only invests in PV-panels, ventilation and GSHP

• No additional selling price

---

Figure of land-use plan, Gemeente Rotterdam (2013)
Results

Dwelling mix

Breakdown of project expenses (ex. VAT)

MAX PROFIT

Constraints

Energy ambition:

Zero-on-the-Meter
Not allowed

Urban design
Lot size
1970 m²

MIN
170
MAX
27700

Dwellings
170

Total inv.
€ 4,737,200.50

Extra in selling price
€ -

Extra inv. Esc o
€ -

Inv. Real estate dev.
€ 4,737,200.50

Profit (ex costs)
€ 6,320,360.10

Profit (incl costs)
€ 1,383,167.60

Construction costs
€ 24,191,800.75

Total construction costs
€ 25,574,968.35

Yearly electricity demand
(89.525) kWh taken from c grid

Roof available
0 m²

PV-panels
5153 m²

Wind power
- kW

Financing mix

Total cost of ownership in relation to reference dwelling

BENG-requirements

69
Results

Dwelling mix

Breakdown of project expenses (ex. VAT)

MAX PROFIT

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Energy ambition</th>
<th>Zero-on-the-Meter Allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>170</td>
<td>100%</td>
<td>170</td>
</tr>
<tr>
<td>170</td>
<td>100%</td>
<td>170</td>
</tr>
</tbody>
</table>

Urban design

- % of MAX
- MIN
- MAX

Dwellings

- 170
- 27700

Vehicle categories

- 19704
- 71%
- 3

Total inv

- € (4,810,045.50)

Extra in selling price

- € 4,810,045.50

Extra inv. Esco

- € 4,810,045.50

Inv. Real estate dev.

- € 709,357.50

Profit (ex costs)

- € 6,120,357.10

Profit (incl costs)

- € 5,411,010.00

Construction costs

- € 24,345,055.75

Total construction costs

- $ 29,756,075.35

Yearly electricity demand

- 125,531 kWh taken from e grid

Roof available

- 1 m²

PV panels

- 5190 m²

Wind power

- 1.70664424 kW

Financing mix

- Rem. ESCo
- Rem. ZoM
- Rem. BENG
- Real Estate Developer
- ESCo
- ZoM-mortgage
- BENG-mortgage

Total cost of ownership in relation to reference dwelling

- € 7,000

BENG-requirements

- 60% of renewable energy

- 400% of renewable energy

- 200% of renewable energy

- 100% of renewable energy

- 0% of renewable energy

Dwelling type

- 1/3
- 2
- 4/5
- 6
Results

• Higher profit rate with ESCo

• Lower profit rate with higher energy ambition

• Lower profit rate with BENG-legislation

Legislation:
EPC: Thermal demand of 37 kWh/m²/a
BENG: Thermal demand of 25 kWh/m²/a
### Comparison

<table>
<thead>
<tr>
<th></th>
<th>Real life situation</th>
<th>Decision Support Tool</th>
</tr>
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<tbody>
<tr>
<td><strong>Dwelling mix</strong></td>
<td>12 semi-detached dwellings of 150m2</td>
<td>170 terraced dwellings of 100 m2</td>
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<tr>
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<td>24 terraced dwellings of 160 m2</td>
<td>2:1 (corner : mid-terraced)</td>
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<td>134 terraced dwellings of 114 or 121 m2</td>
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</tr>
<tr>
<td><strong>Heating installations</strong></td>
<td>170 GSHP</td>
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</tr>
<tr>
<td><strong>Financing</strong></td>
<td>Energy installations financed by ESCo</td>
<td>Energy installations financed by ESCo</td>
</tr>
</tbody>
</table>

- Same installations and financing method
- Smaller dwellings
Sensitivity analysis

• Input (exogenous) variables
  • Energy legislation (EPC/BENG)
  • Energy ambition (ZED / Zero-on-the-Meter)
  • Involvement of ESCo
  • Usage of additional borrowing capacity in selling price
  • Efficiency (COP) of both types of heat pumps
  • Max output PV-panels
  • Roof surface PV-panels

• Total 268 runs.

• Incrementally changed one input variable
Sensitivity analysis

- Total 268 runs.
- Incrementally changed one input variable.
Effect on finance

<table>
<thead>
<tr>
<th>EPC-legislation</th>
<th>‘Zero-on-the-Meter’ ambition</th>
<th>‘Zero Energy’ ambition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESCO involved</td>
<td>ESCO not involved</td>
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Effect on finance

‘Zero-on-the-Meter’ ambition

ESCO involved

ESCO not involved

Selling price ++

Selling price ==

Selling price ++

Selling price ==

‘Zero Energy’ ambition

ESCO involved

ESCO not involved

Selling price ++

Selling price ==

Selling price ++

Selling price ==

BENG-legislation

ESCO involved

ESCO not involved

Selling price ++

Selling price ==

Selling price ++

Selling price ==

EPC-legislation

ESCO involved

ESCO not involved

Selling price ++

Selling price ==

Selling price ++

Selling price ==
Effect on finance

- Increased effect of decisions in higher energy ambition
Effect on finance

- Increased effect of decisions in higher energy ambition
ESCo vs. additional borrowing capacity

- Increased effect of decisions in higher energy ambition
- Increased selling price often more profitable.
ESCo vs. additional borrowing capacity

- Increased effect of decisions in higher energy ambition
- Increased selling price often more profitable.
- Increased selling price often lower TCOs.

**Involvement of ESCo has higher TCO**

Usage of higher selling price/additional mortgage space has higher TCO

- EPC Energy neutral
- EPC Zoro-on-the-Meter
- BEING Energy neutral
- BEING Zoro-on-the-Meter
Effect on installations and dwelling type

- Increased effect of decisions in higher energy ambition
- Increased selling price often more profitable.
- Increased selling price often lower TCOs.
- Efficiencies and financing method influences optimal energy installations
Legislation - dwelling size

- Increased effect of decisions in higher energy ambition
- Increased selling price often more profitable.
- Increased selling price often lower TCOs.
- Efficiencies and financing method influences optimal energy installations
- BENG-legislation lead to bigger dwelling size
- Increased effect of decisions in higher energy ambition
- Increased selling price often more profitable.
- Increased selling price often lower TCOs.
- Efficiencies and financing method influences optimal energy installations
- BENG-legislation lead to bigger dwelling size
- EPC-legislation more profitable
• Dwelling size 1st run was lower (100m2)

• New input:
  • COP GSHP
  • PV-panel
• Excluding ESCo: 10.15% profit
Results round 2

- Including ESCo; 20.70% profit
- Profit: additional
Comparison round 2

<table>
<thead>
<tr>
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<th>Real life situation</th>
<th>Round 2 with ESCo</th>
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| Dwelling mix         | 12 semi-detached dwellings of 150m2  
24 terraced dwellings of 160 m2  
134 terraced dwellings of 114 or 121 m2  
2:6 (corner : mid-terraced) | 2 semi-detached dwellings of 150m2  
168 terraced dwellings of 125 m2  
2:1 (corner : mid-terraced)          |
| Heating installations| 170 GSHP                                                                            | 170 GSHP                                              |
| Financing            | Energy installations financed by ESCo                                               | Energy installations financed by ESCo                  |

- Comparable!
- Value of input variables important.
Expert focus group

• What is the added value of the created model for various stakeholders?

• Single-actor exploration
  • Real estate developer
  • Municipality

• Different decision moments
  • Energy ambition in relation to ground price
  • Dwelling program
  • Installation technology and dwelling size

• Many other decision support tools
Part 6: Syntheses

- Conclusions
- Discussion
- Recommendations
Conclusions

• Conclusions based on case studies, results LP-model and expert focus group

• Zero-on-the-Meter can be reached commercially on a neighbourhood scale level.

• Business case of energy neutral residential neighborhood developments can be optimized in all its aspects
Conclusions

- Legislation
  - Balancing agreement key within all ZOM-concepts
- BENG1:
  - Formulation per m² leads to bigger dwellings
Conclusions

• Legislation
  • Balancing agreement key within all ZOM-concepts
  • BENG1:
    • Formulation per m2 leads to bigger dwellings

• Organisation
  • Integrated contracts (at least design-and-build)
  • Early involvement of advisors
  • All kind of public-private relations
Conclusions
Conclusions

• Financial
  • Usage of additional borrowing capacity in higher selling price increases feasibility in most circumstances (also lowest TCO)
  • Third financing (e.g. ESCo) helps to boost feasibility
  • Without one of those ZOM-energy ambition hardly possible
  • Postponement of investment by developing future proof-dwellings
Conclusions

• Financial
  • Usage of additional borrowing capacity in higher selling price increases feasibility in most circumstances (also lowest TCO)
  • Third financing (e.g. ESCo) helps to boost feasibility
  • Without one of those ZOM-energy ambition hardly possible
  • Postponement of investment by developing future proof-dwellings

• Physical
  • Conceptual approach of development
  • Installations on scale level of single-building
  • New innovations possible
Conclusion

• The DST has added value for multi-actor decision-making processes
  • Viewpoint from a single-actor perspective
  • Provide fast insight in (the feasibility of) the solution space
  • Learning layman and professionals
Discussion

• Research methods:

• Results cannot be generalised (Bryman, 2012; Kumar, 2005, 2014)
  • Objective of a case study is not to confirm or to quantify
  • Purpose sampling cannot be generalised to the whole population

• Interesting lessons learned for practise.

• Triangulation: Based on multiple case studies and outcomes of the LP-model
Recommendations

• Research
  • Broadening current research
    • Explore additional functionalities of DST
    • Involve comfort for end-user
    • Explore role of institutional investors and housing associations (split incentive in rental dwellings)
  
  • Deepening current research
    • Test DST in real decision-making process
    • Explore and explain market value of energy efficiency in dwellings (A+++ , A++)
    • Explore the role of the ESCO in the Netherlands (Bertoldi & Boza-Kiss, 2017)
Recommendations

• For practice
  • Use additional financing methods to make ZOM-dwellings financially feasible
  • Apply DST for fast exploration of solution space
  • Apply DST for training of professionals
  • Involve new parties early on in the process (energy advisors, end-users)
  • Keep a permanent eye on rapidly increasing possibilities of technology (Sarbu & Sebarchievici, 2014; Schiro et al, 2017).
Recommendations

• For policy
  • Reconsider the formulation of the BENG-legislation.
  • Keep additional borrowing capacity in green mortgage for ZOM in place.
  • Explore optimal amount of this capacity and its calculation method (see Blok, 2016).
  • Consider additional investments in case the balancing agreement is abolished.
  • Consider prohibiting a natural gas connection in new dwellings.
It is commercially possible to develop ZOM-neighbourhoods.

Thank you for your attention.
Business case optimisation for the development of energy neutral residential neighbourhoods

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P5 Presentation
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Discussion

• Level of sustainability
  • ZOM-concept uses many installations; increased environmental burden compared to natural materials
  • ZOM-concept does not match renewable supply to renewable demand, therefore still dependent on NL e-grid (39% efficiency)

• Recommended concept to real estate developer and municipality?
  • Future optimisations possible
  • Grid operator: increased impact on the grid
  • End-user: Higher replacement costs on long run (TCO)

• Lack integration to other sustainability concepts (social cohesion, health, water, biodiversity, etc.)
• For now a smart strategy, basics for future improvement
  • Taking into account negative impact on e-grid and environmental burden of materials
  • Taking into account the social and financial viewpoint
Discussion

• Future
  • New legislation has to ensure a higher level of sustainability (BENG, MPG, Balancing Agreement)
  • Increased energy ambition;
    • Building-, household and transport-related energy demand
  • Electric vehicles, smart grids and smart buildings
    • Batteries, renewable supply installations, household appliances work together to maximize the use of available renewable energy and prevent overloading the grid
Recommendations

• Research
  • Explore additional functionalities within the DST
    • Scale levels
    • Energetic solutions
    • Functions
    • More layers of sustainability/urban area development
    • MPG-legislation
  • Test DST in real decision-making process
  • Involve comfort for the end-user
  • Explore and explain market value of energy efficiency in dwellings
  • Explore role of institutional investors and housing associations (split incentive in rental dwellings)
  • Explore the role of the ESCO in the Netherlands (Bertoldi & Boza-Kiss, 2017)
  • Explore the effect of a new calculation method for the additional borrowing capacity (see Blok, 2016).
Recommendations

• For practice
  • Use additional financing methods to make ZOM-dwellings financially feasible
  • Apply the DST for a fast exploration of the feasibility and the solution space
  • Apply the DST for training of professionals
  • Involve energy advisors early on in the process
    • For selection of energy concept
    • For optimal implementation
  • Involve residents during development of their dwelling (see rebound effect of Majcen, 2016).
  • Keep a permanent eye on rapidly increasing possibilities of technology (Sarbu & Sebarchievici, 2014; Schiro et al, 2017).
Recommendations

• For policy
  • Reconsider the formulation of the BENG-legislation.
  • Keep the additional borrowing capacity in green mortgage for ZOM in place.
  • Explore the optimal amount of this capacity and its calculation method (see Blok, 2016).
  • Consider additional investments in case the balancing agreement is abolished.
  • Consider prohibiting a natural gas connection in new dwellings.
Need for sustainable development

- NL economy runs on fossil fuels.
- Energy transition: shift towards a carbon free economy

Figures based on CBS (2017)
Figure based on De Vries (2010), CBS (2017)

Variable costs of natural gas in the Netherlands from 2001-2016

Variable costs of electricity in the Netherlands from 2001-2016
Growth in usage of heat pumps

New heat pumps in relation to the newly built dwellings

Figure based on Van de Griendt (2016) & CBS, 2017