Business case optimisation for the development of energy neutral residential neighbourhoods

Marco Vogelzang

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TU Delft
Faculty of Architecture and the Built Environment
MSc Management in the Built Environment

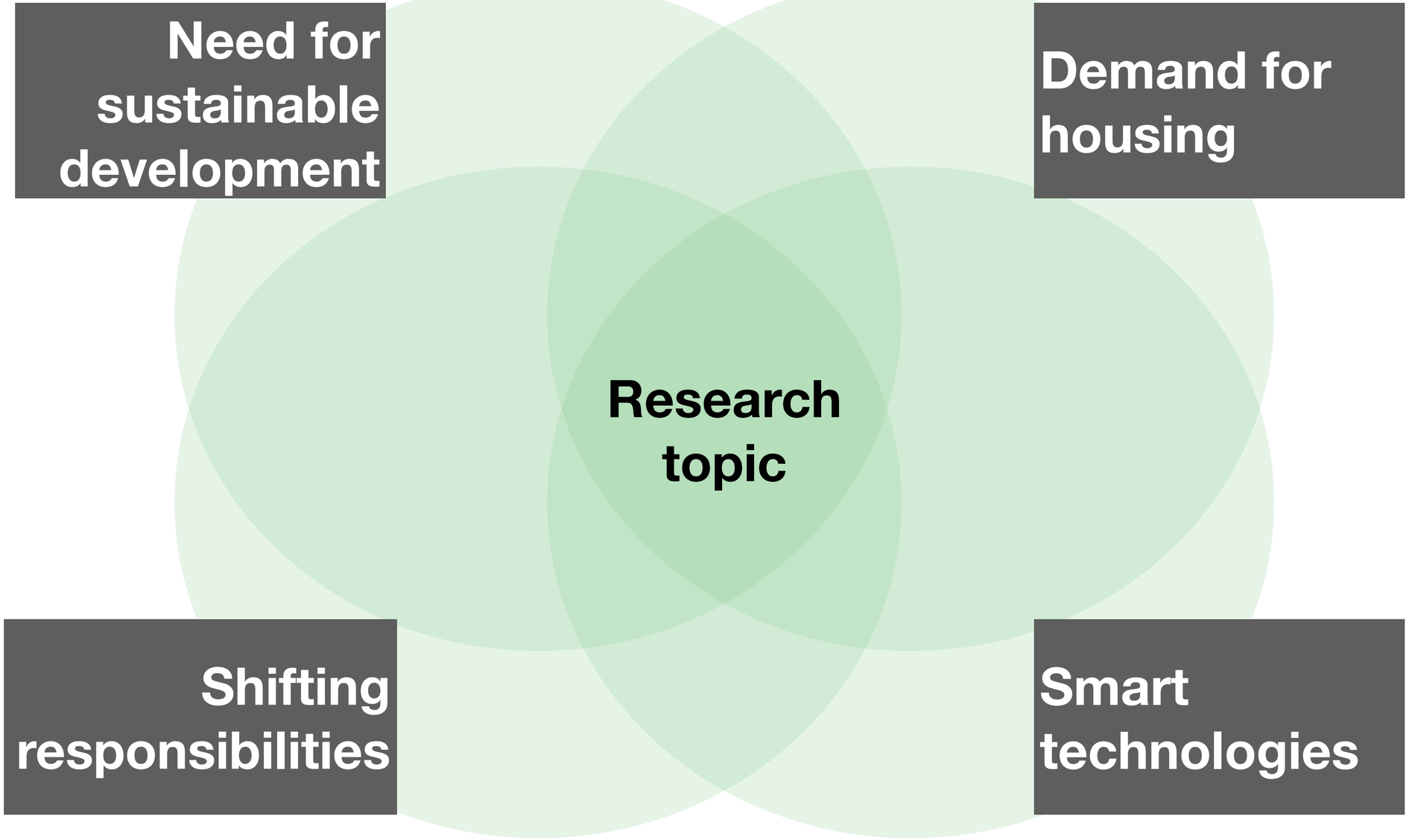
Het Verborgen Geheim, Rotterdam

Content

- Research introduction
- Theoretical findings
- Explorational case studies
- Development of the Decision Support Tool (DST)
- Added value DST
- Conclusions
- Discussion
- Recommendations

https://hetverborgengeheim.nl/woningen

Research motives



Need for sustainable development

- 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).
  - Natural gas depletion in the Netherlands

http://images0.tcdn.nl/feed/article2367906.ece/BINARY/u/IMG_Gas_in_Groningen_2_1_221595OH.jpg

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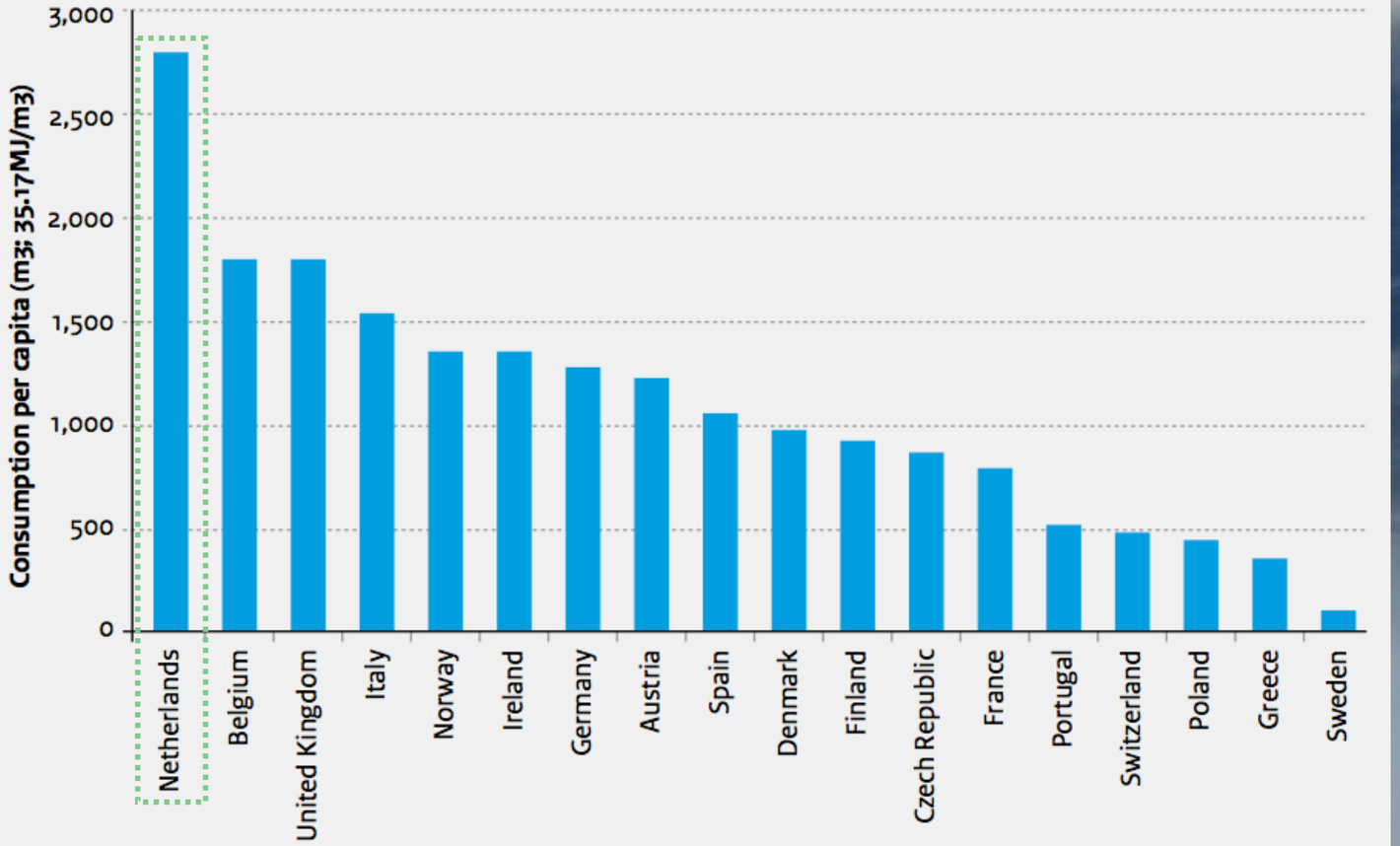

Een boerderij in in het Groningse dorp Startenhuizen is zwaar beschadigd door de aardbevingen. © Kees van de Veen

Hof: toch strafrechtelijk onderzoek naar bevingsschade door gaswinning Groningen

Figure of Bazelon *et al.* (2010)

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Need for sustainable development

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  - Increasing coal usage since 2014

http://blogs.bcu.ac.uk/views/files/2015/11/Climate-change-image.jpg

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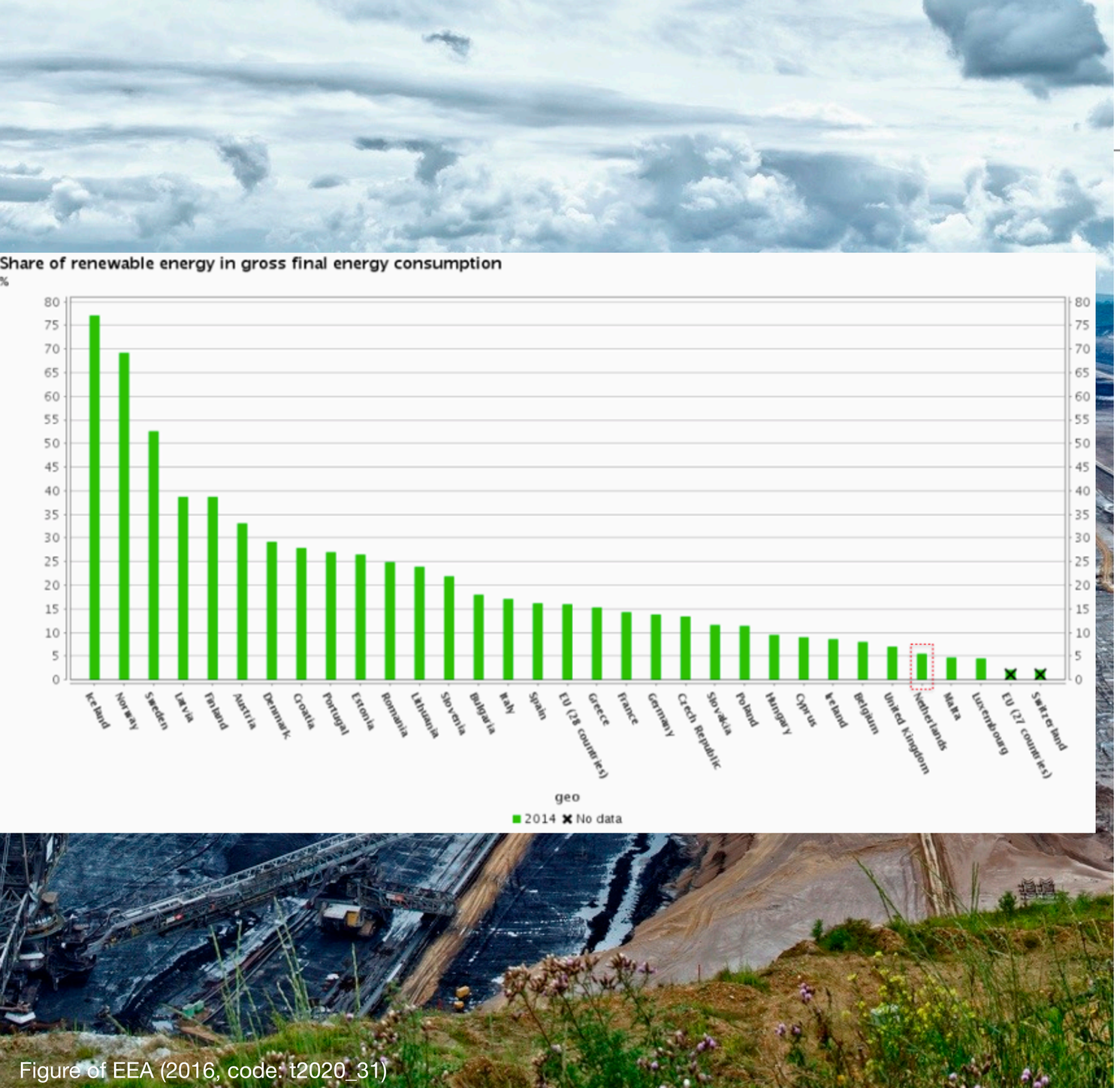

Figure of EEA (2016, code: t2020_31)

Need for sustainable development

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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 Parlement and Council of the EU, 2010).

Need for sustainable development

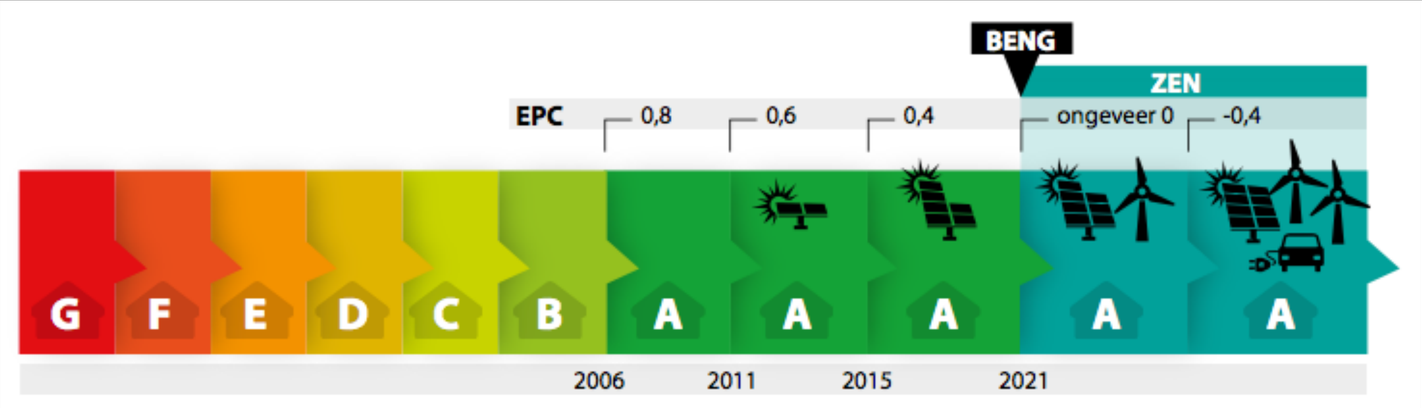

Figure of Bouwens & Bouwmeester (2017)

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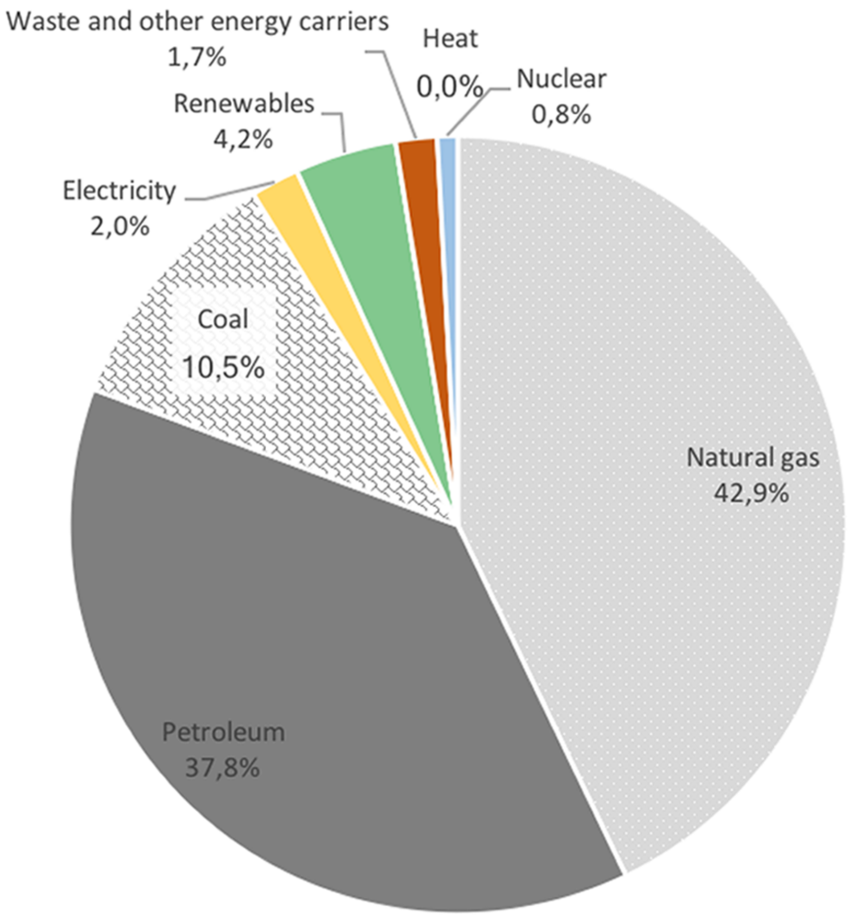
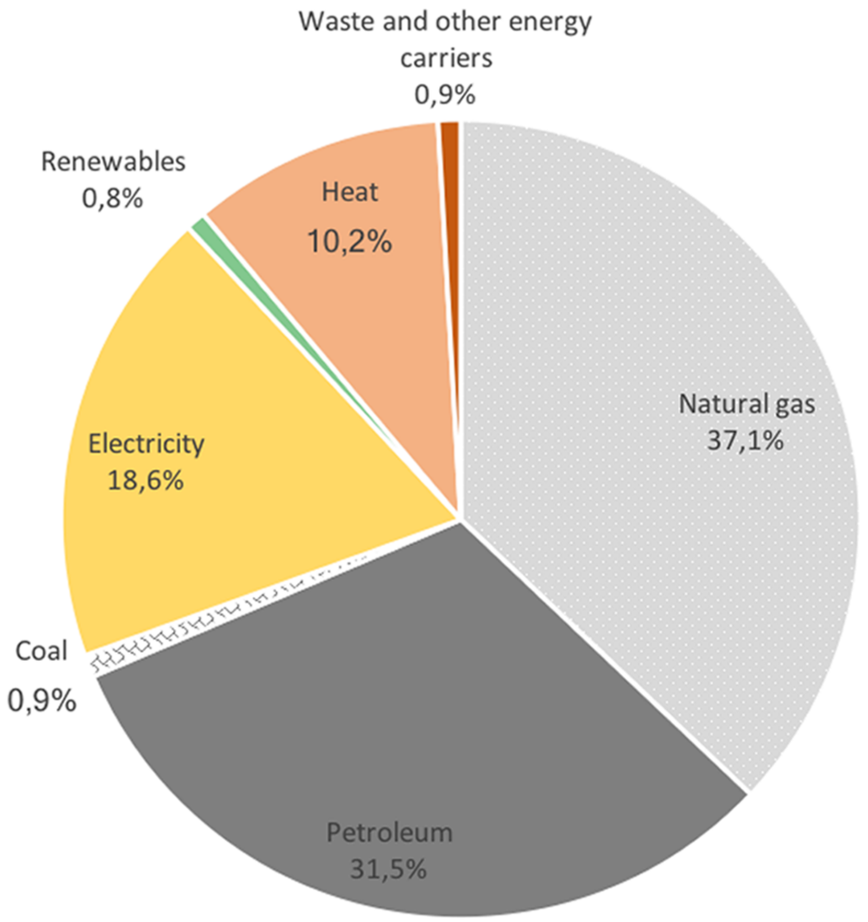
- The EU acts: Energy Performance of Building Directive (EPBD); after 2020 all new buildings consume nearly zero energy (European Parlement and Council of the EU, 2010).
- National plan in NL to comply to EPBD: BENG-legislation (Haytink & Valk, 2017; RVO, 2016).

Need for sustainable development



Primary energy usage
2013

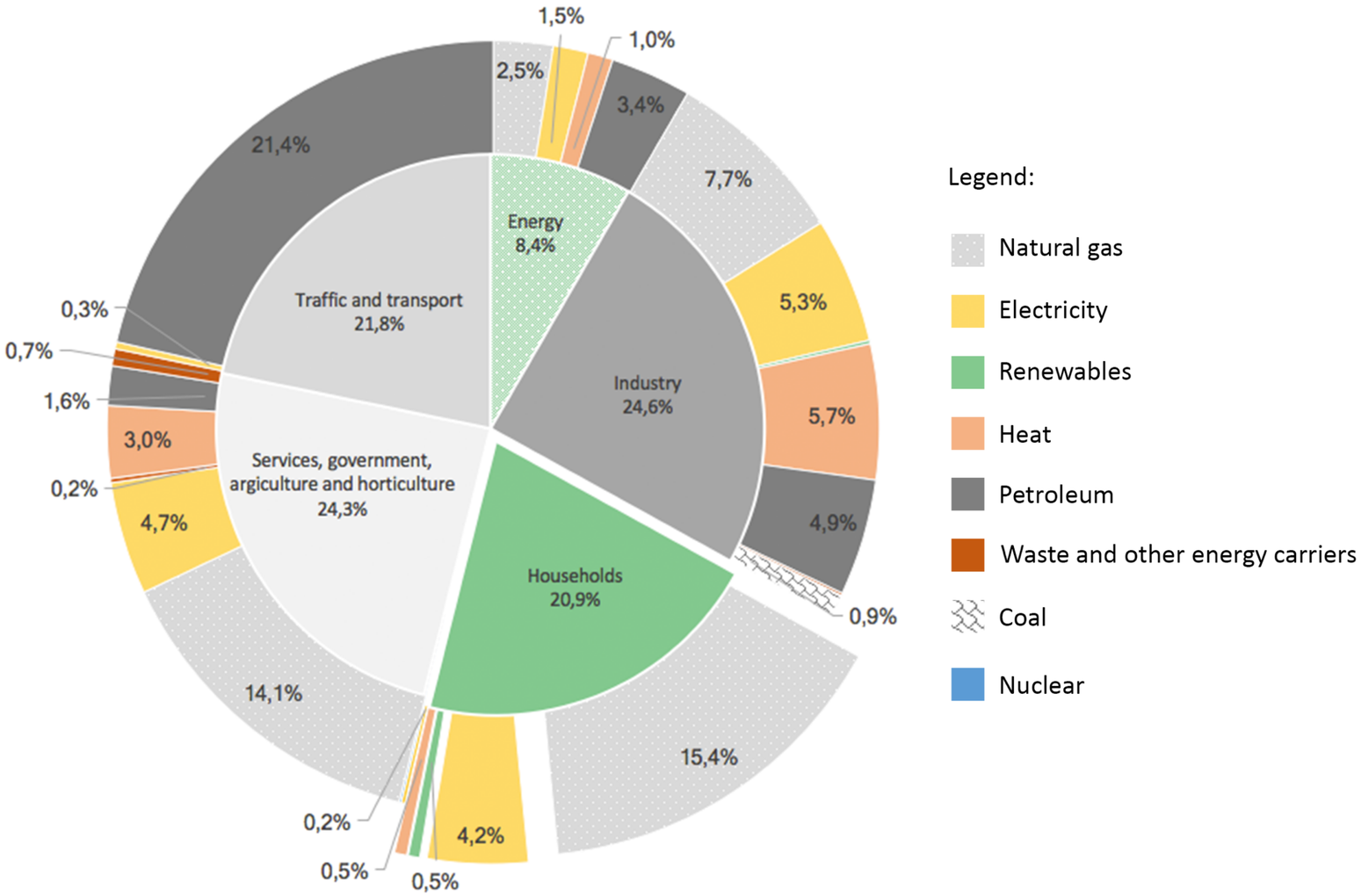


Final energy usage
2013

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

Figures based on CBS (2017)

Need for sustainable development



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

Figure based on CBS (2017)

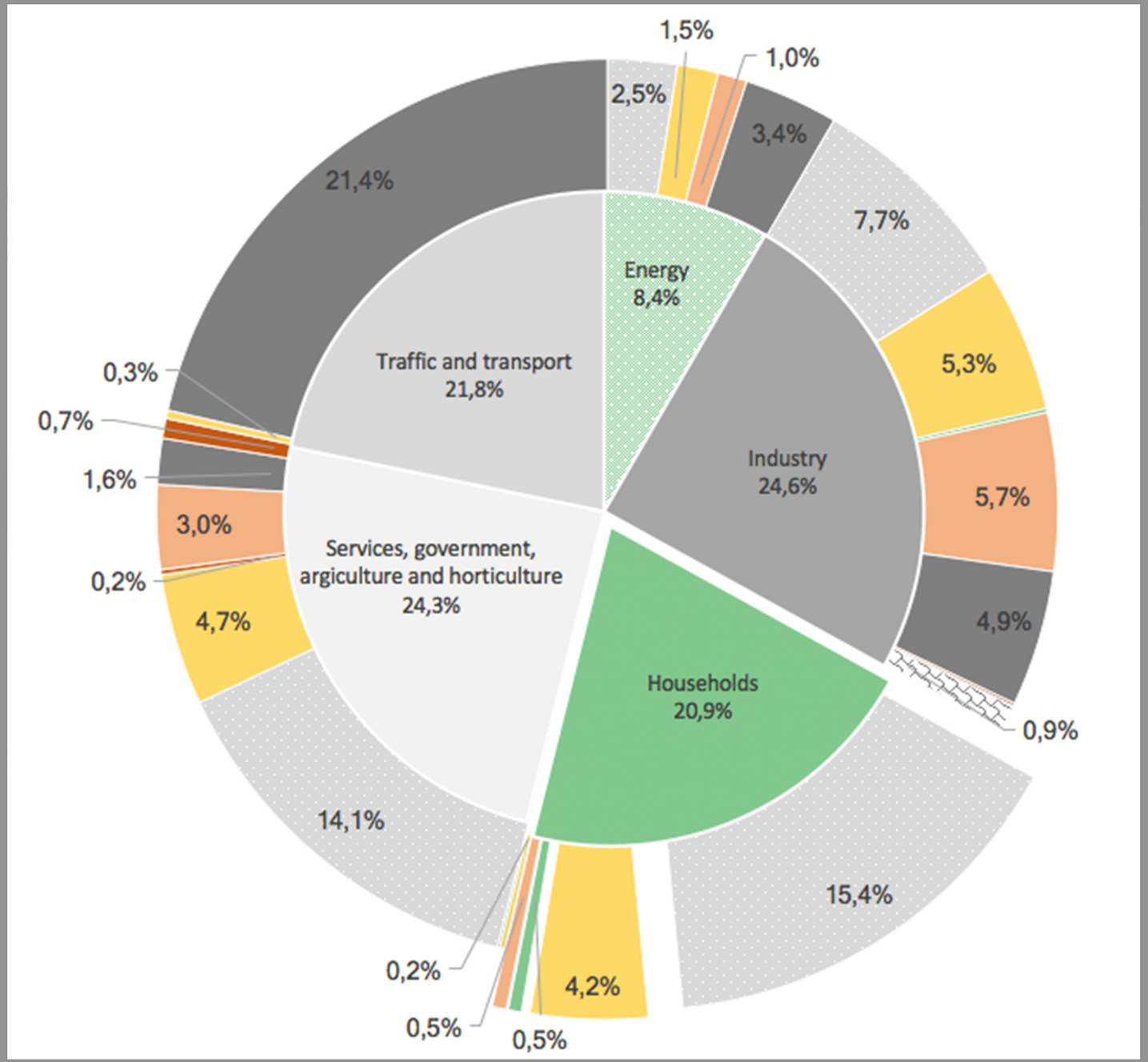


Figure based on CBS (2017)

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

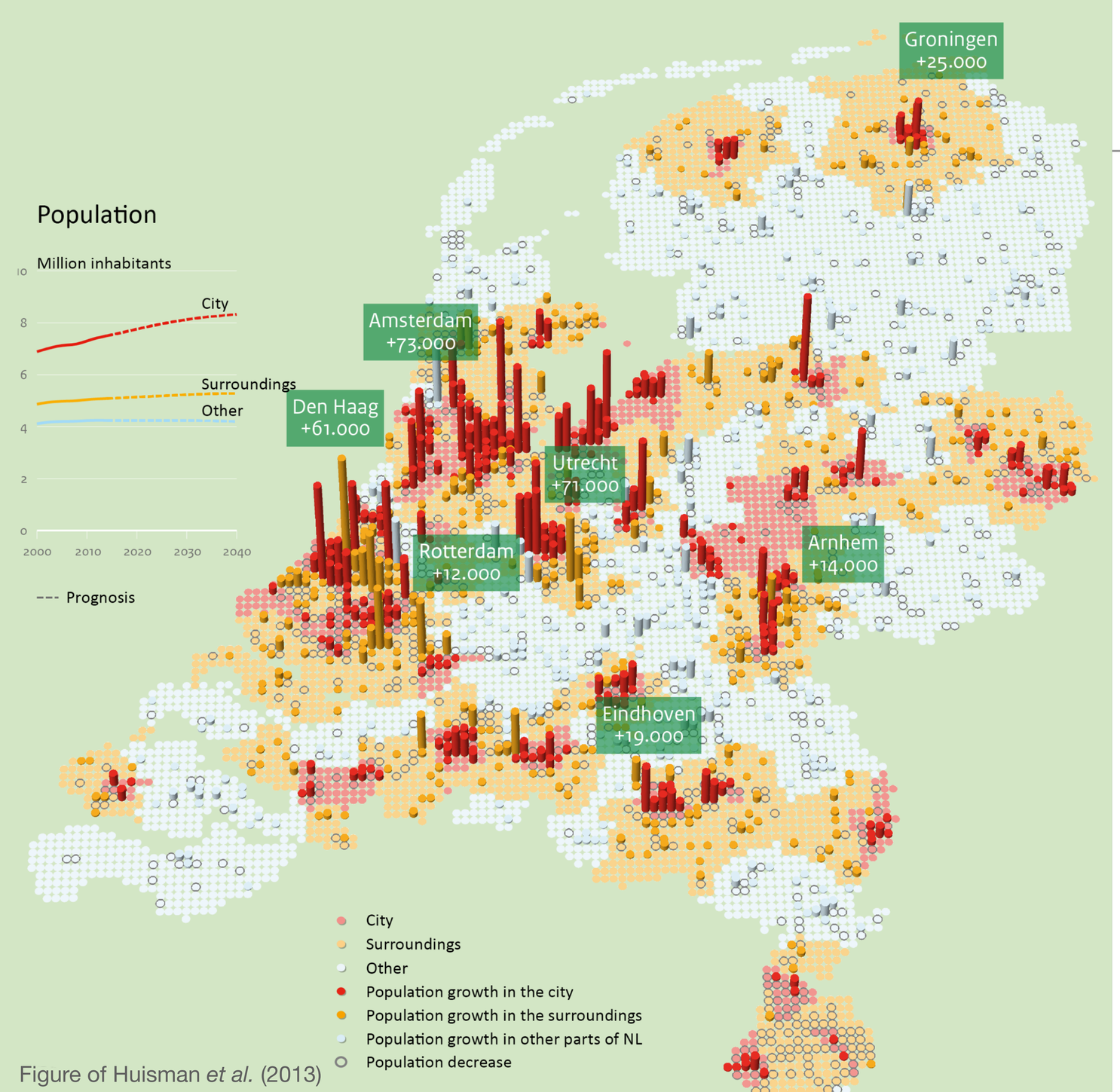


Figure of Huisman *et al.* (2013)

Research motives

- Urban growth
  - One million new dwellings needed in the Randstad region in the next 25 years (Huisman et al, 2013; Nabielek, Kronberger-Nabielek & Hamers, 2013; Van Duinen, Rijken & Buitelaar, 2016).
- Shift from public to private sector (Heurkens, 2012; Peek & Van Remmen, 2012)
- Digitalisation and smart ‘everything’ (Townsend, 2013)

Problem statement

*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.*

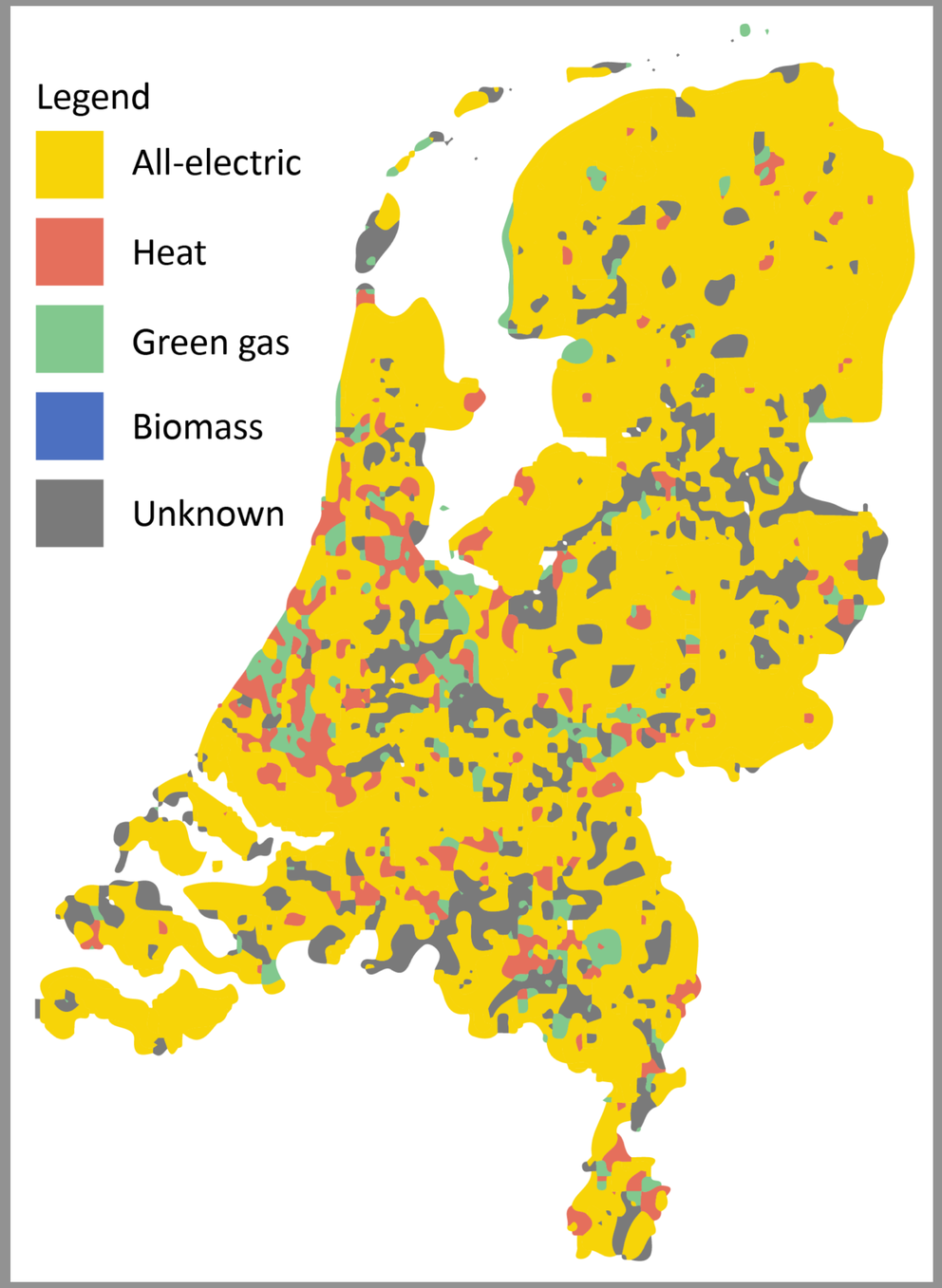


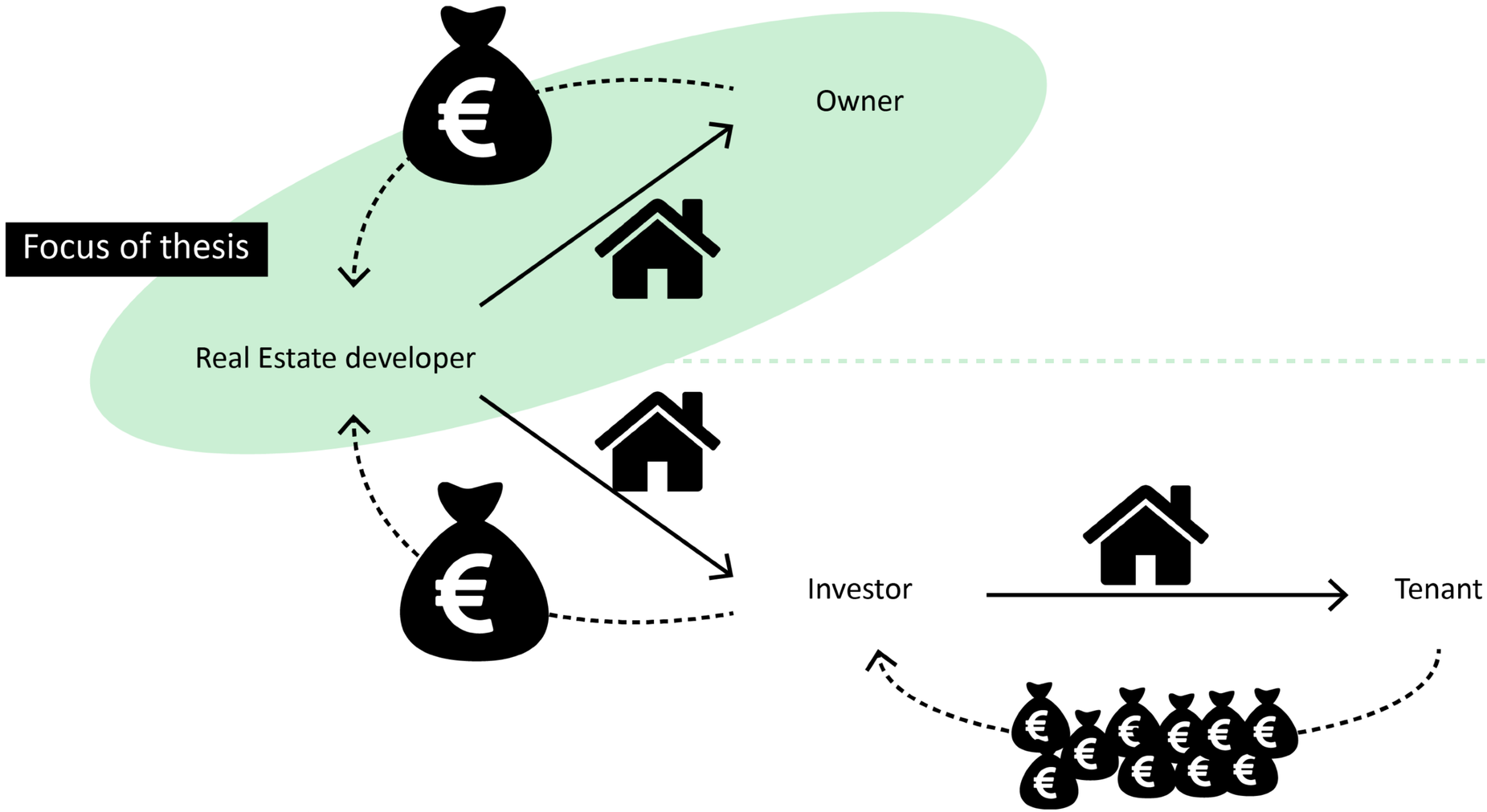
Figure based on Molengraaf (2017).

Research focus

- All-electric
- New constructions

Research focus

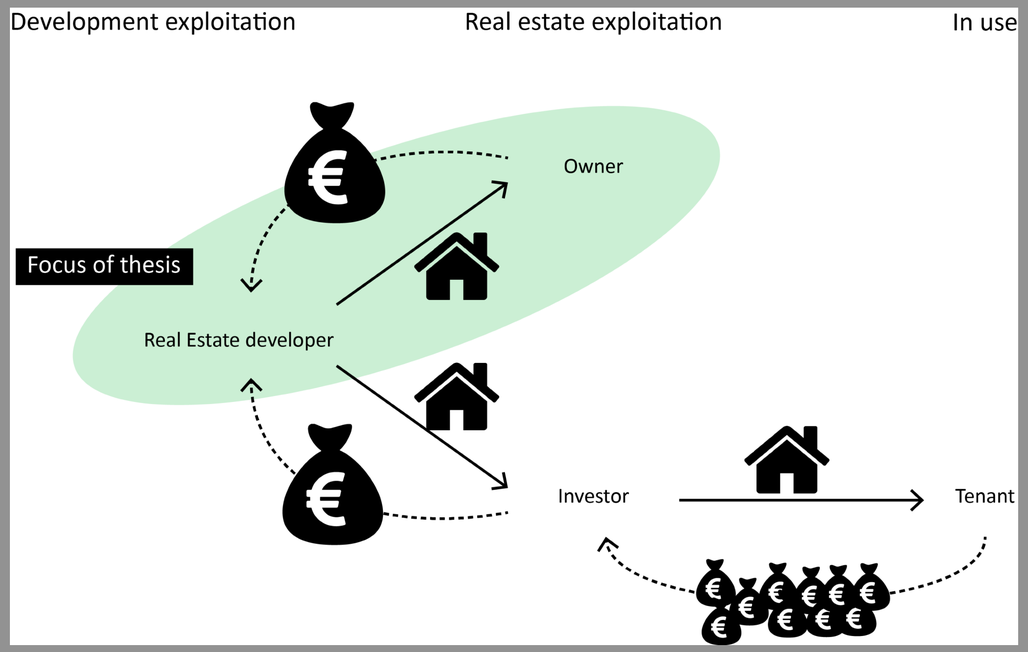
Development exploitation | Real estate exploitation | In use



Owner-occupied

Rental

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



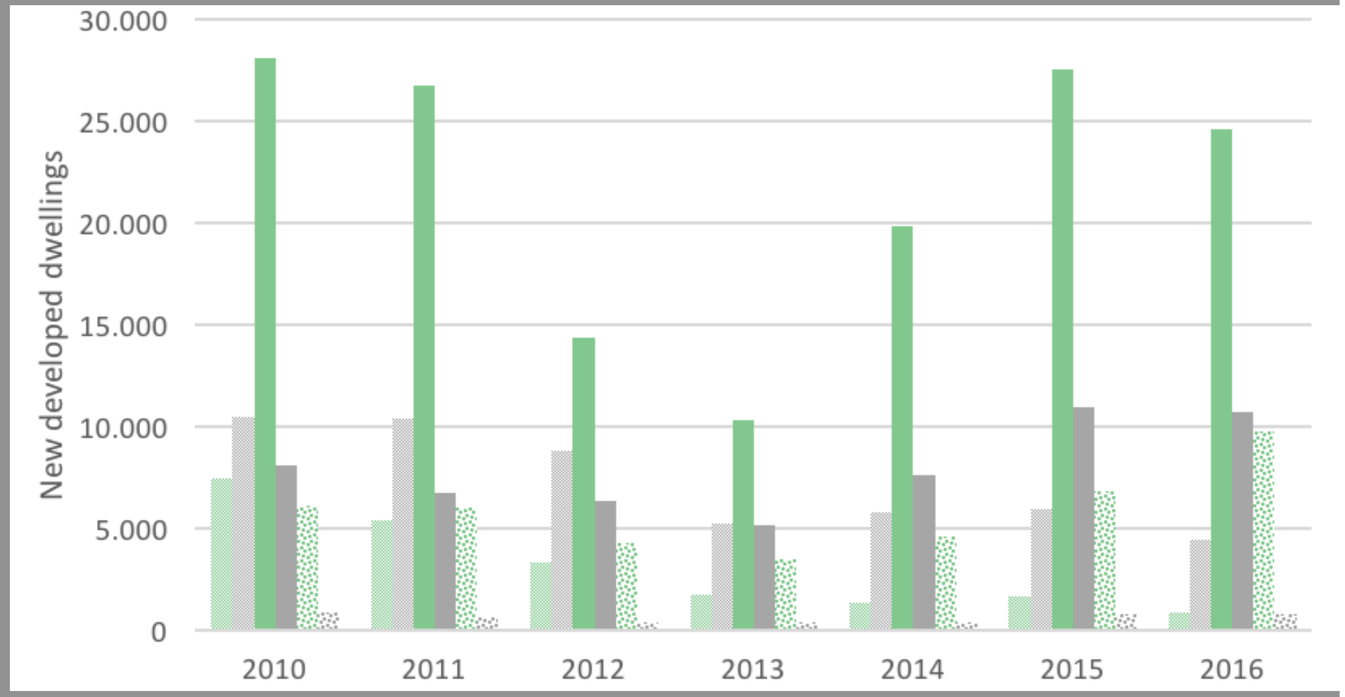


Figure top based on Putman (2010) and Vlek et al (2016).
Figure top based on CBS (2017)

Research focus

- All-electric
- New constructions
- Owner-occupied

Government and housing associations Owner-occupied

Government and housing associations Rental

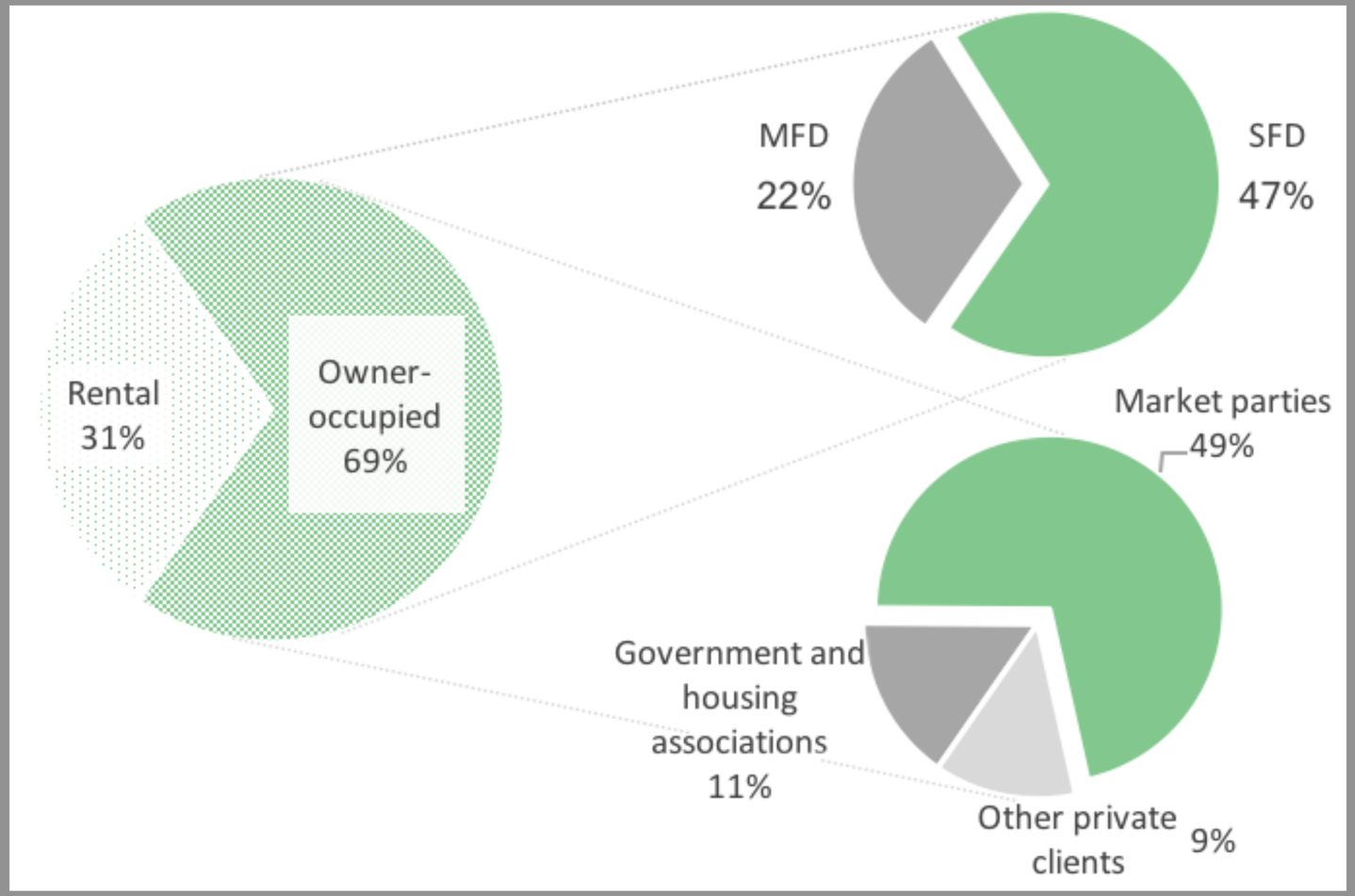
Market parties Owner-occupied

Market parties Rental

Other private clients Owner-occupied

Other private clients Rental

Research focus



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

Figure based on CBS (2017)

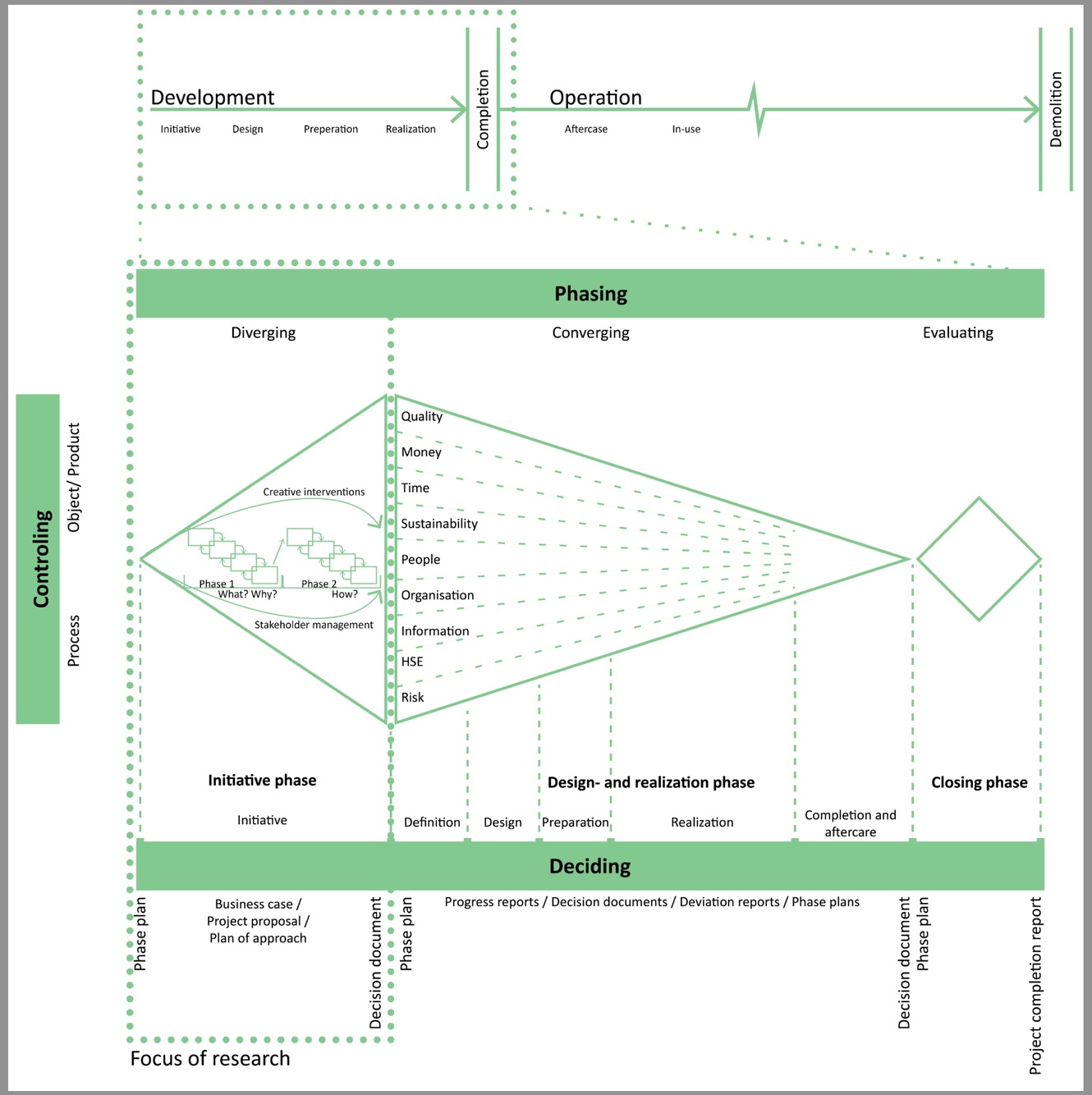


Figure based on De Jong (2016) and Versteijlen et al (2010).

Research focus

- All-electric
- New constructions
- Owner-occupied
- Single-family
- Initial phase of development

Research framework & questions

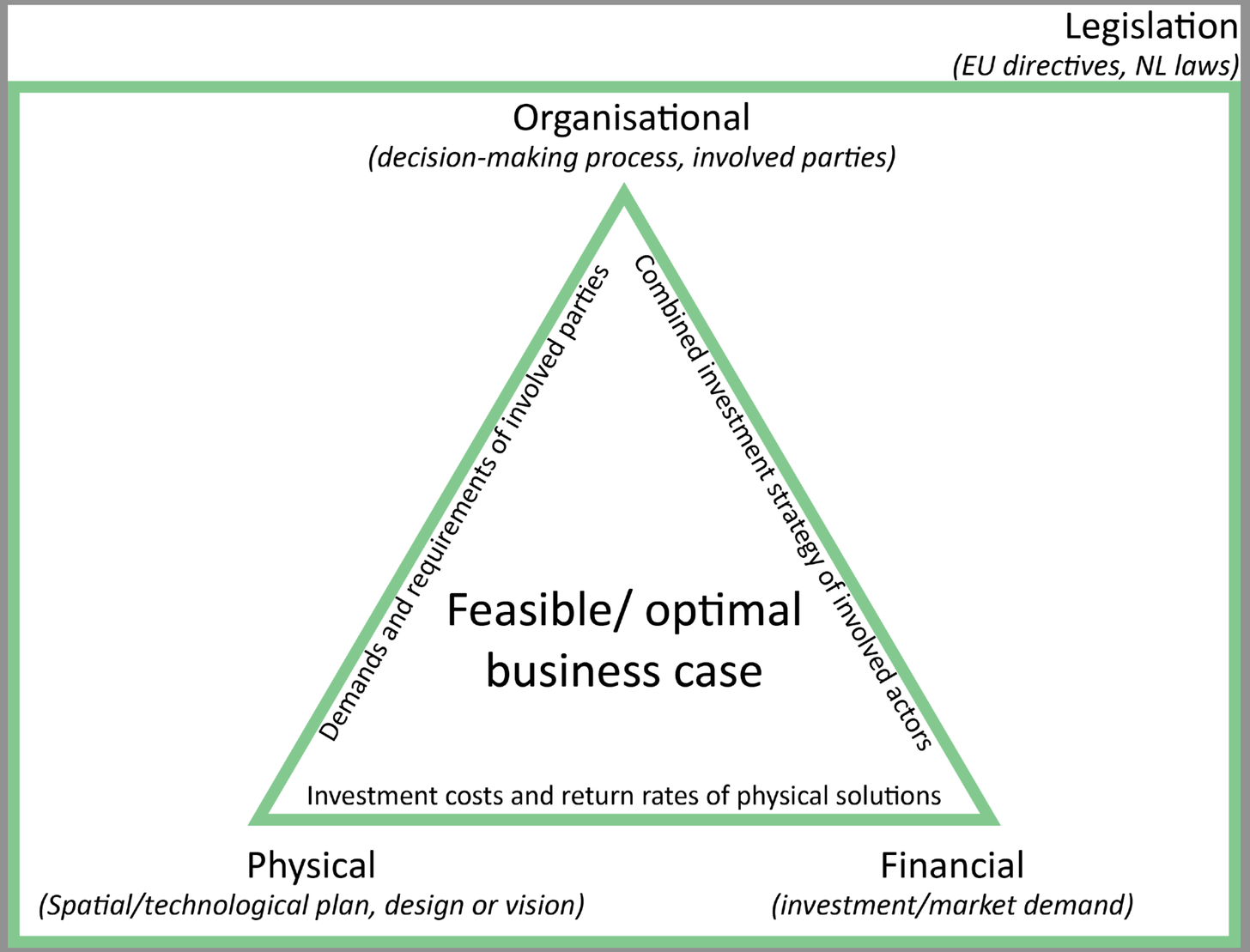
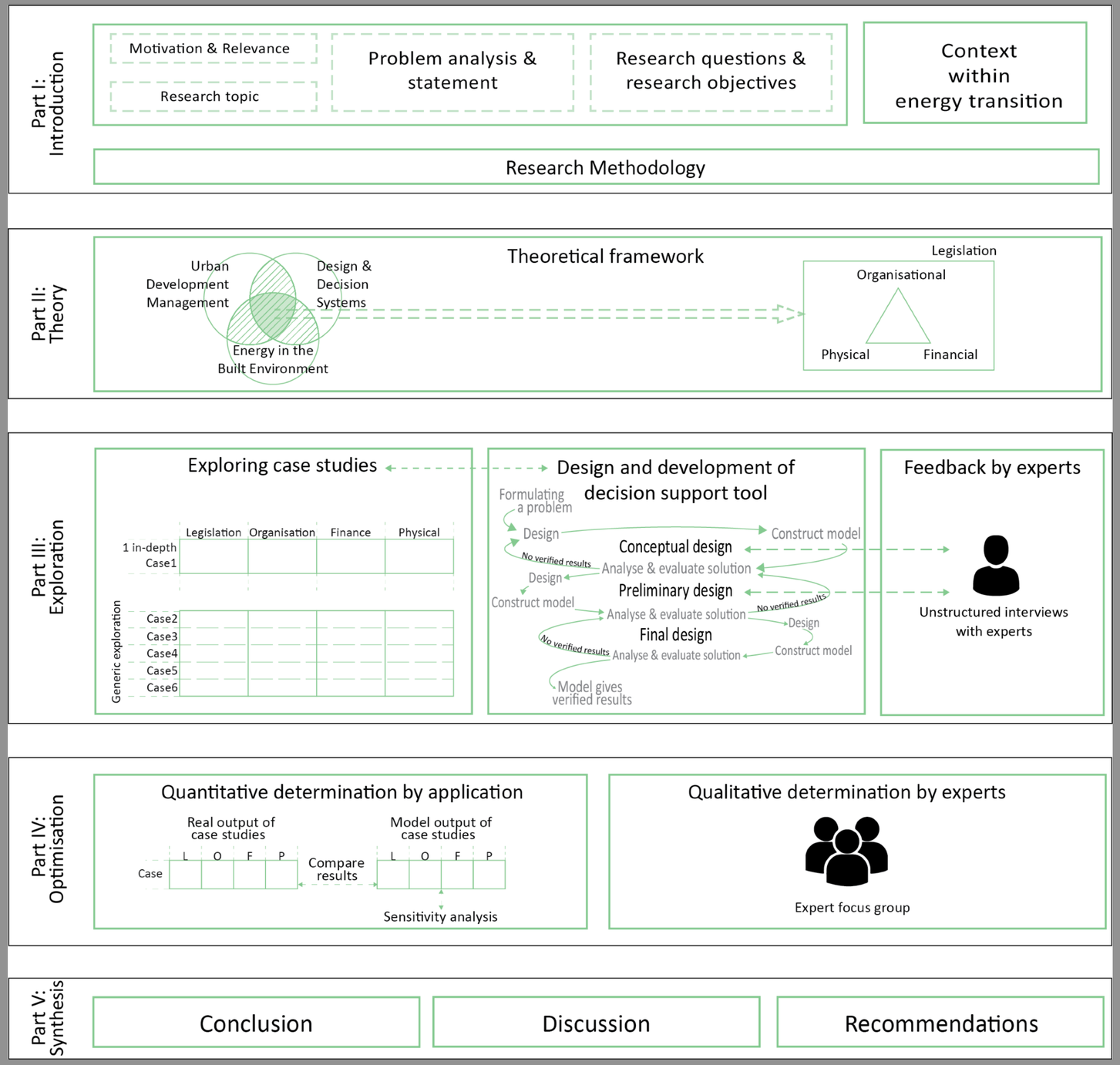


Figure based on the analysis framework of Versteijlen *et al.* (2010)
and the components of a business case as described by Van der Cammen (2007)

- 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?

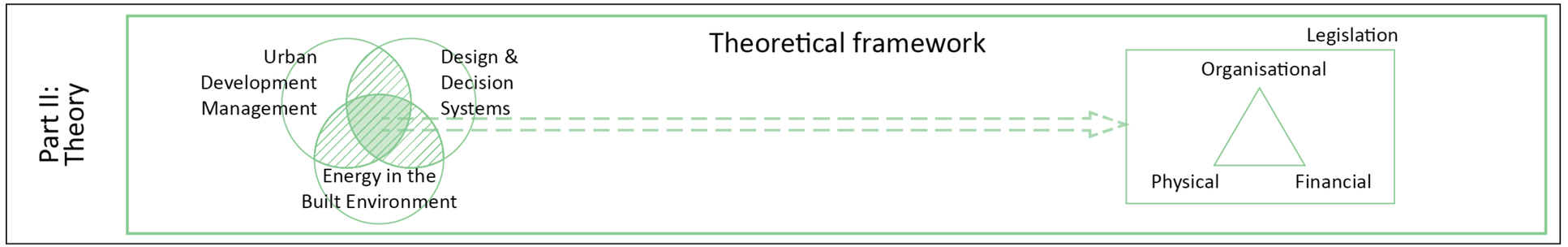
- Sub-research questions
  1. Current practises
  2. Development of Decision support tool (DST)
  3. Added value of DST



Research design

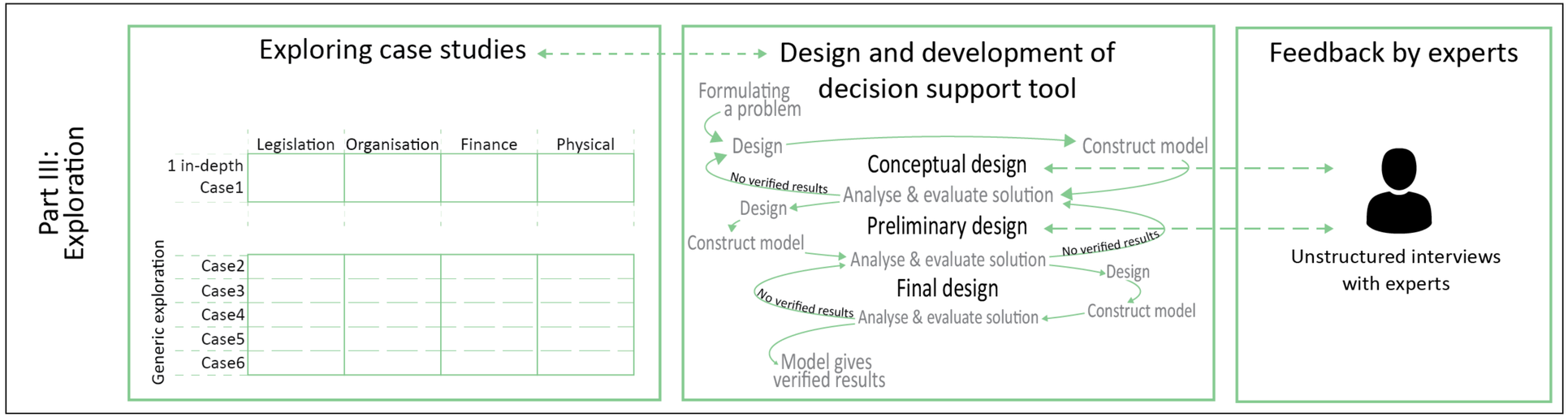
- Research methods
  - Literature study
  - Expert meetings
  - Case study
    - Desk research
    - Semi-structured interviews
  - Computational modelling
    - LP-modelling technique
    - Unstructured expert interviews
  - Validation of added value
    - Applying modelling technique
    - Expert focus group

Research design



- 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



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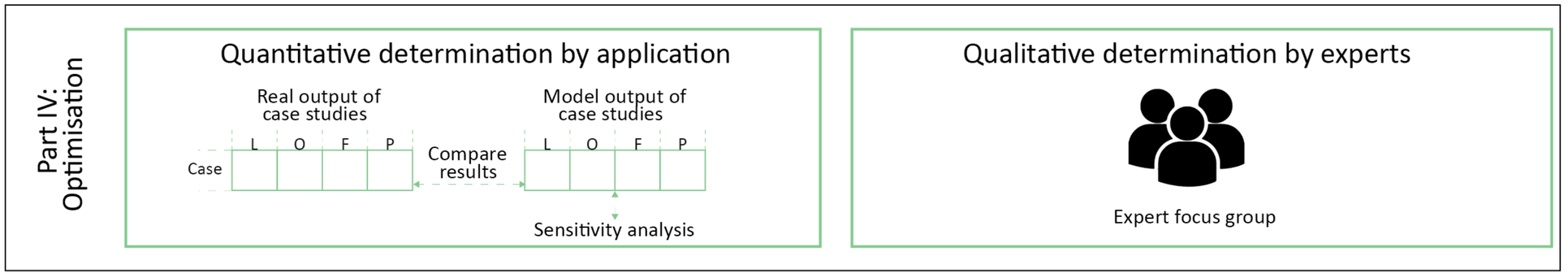


Research design

Prof. Schoemaker Plantage, Delft

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

https://soomedia.nl/wp-content/uploads/2016/04/Prof-Schoe-C4-HR1.jpg

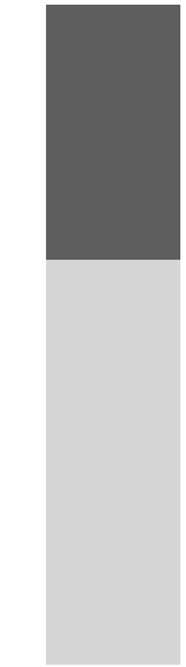
What is…
‘ENERGY NEUTRAL’?

Energy
demand

Building-related

Heating, cooling, ventilation

What is…
‘ENERGY NEUTRAL’?



Energy
demand

Household-related

Appliances - laptops, phones, more

Building-related

Heating, cooling, ventilation

What is…
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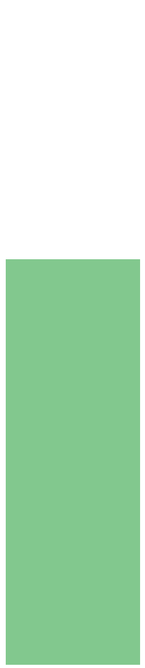
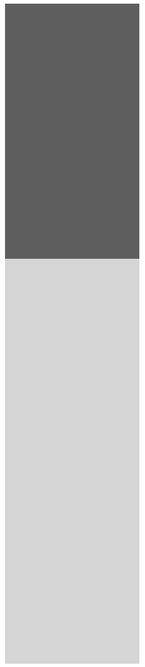


Renewable supply



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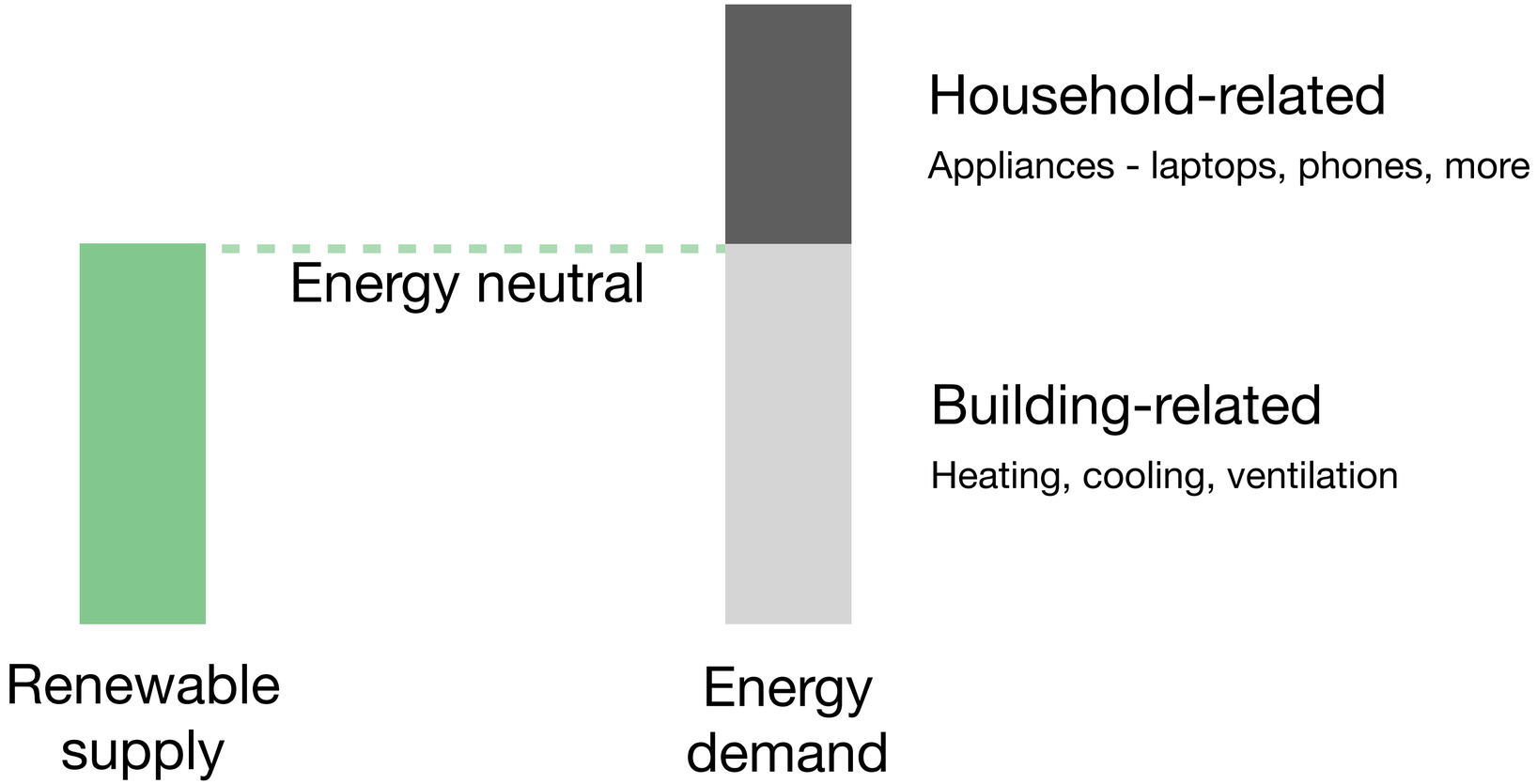

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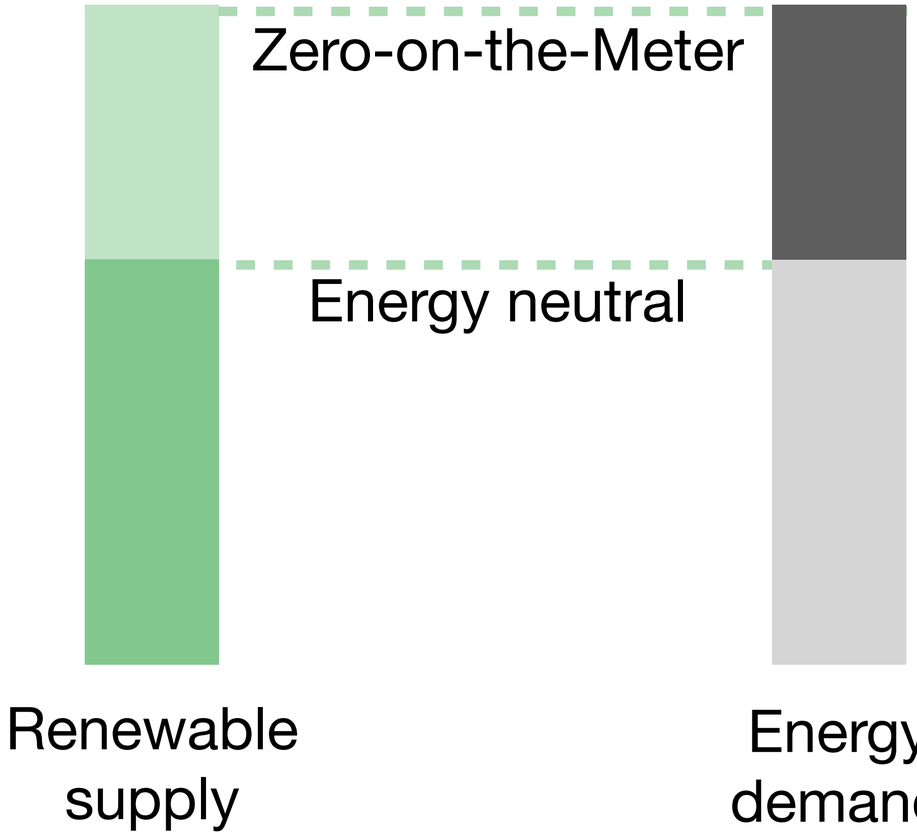

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Appliances - laptops, phones, more

Building-related

Heating, cooling, ventilation

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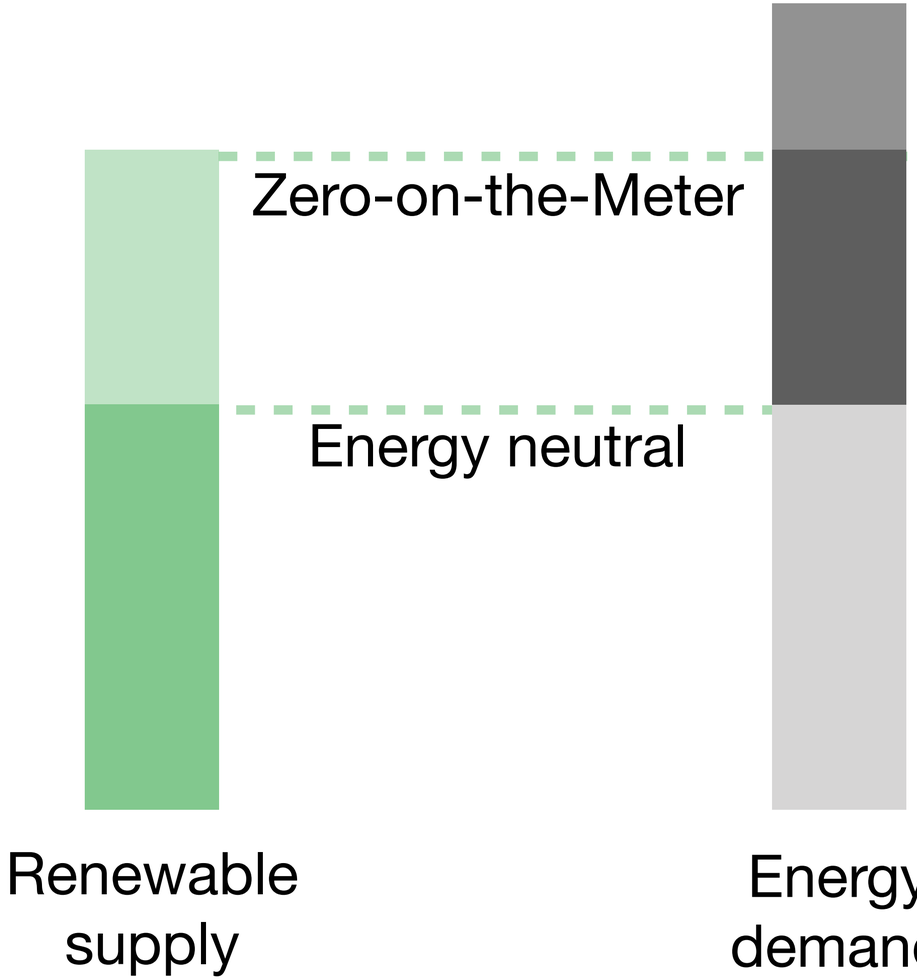

Material-related

Household-related

Appliances - laptops, phones, more

Building-related

Heating, cooling, ventilation

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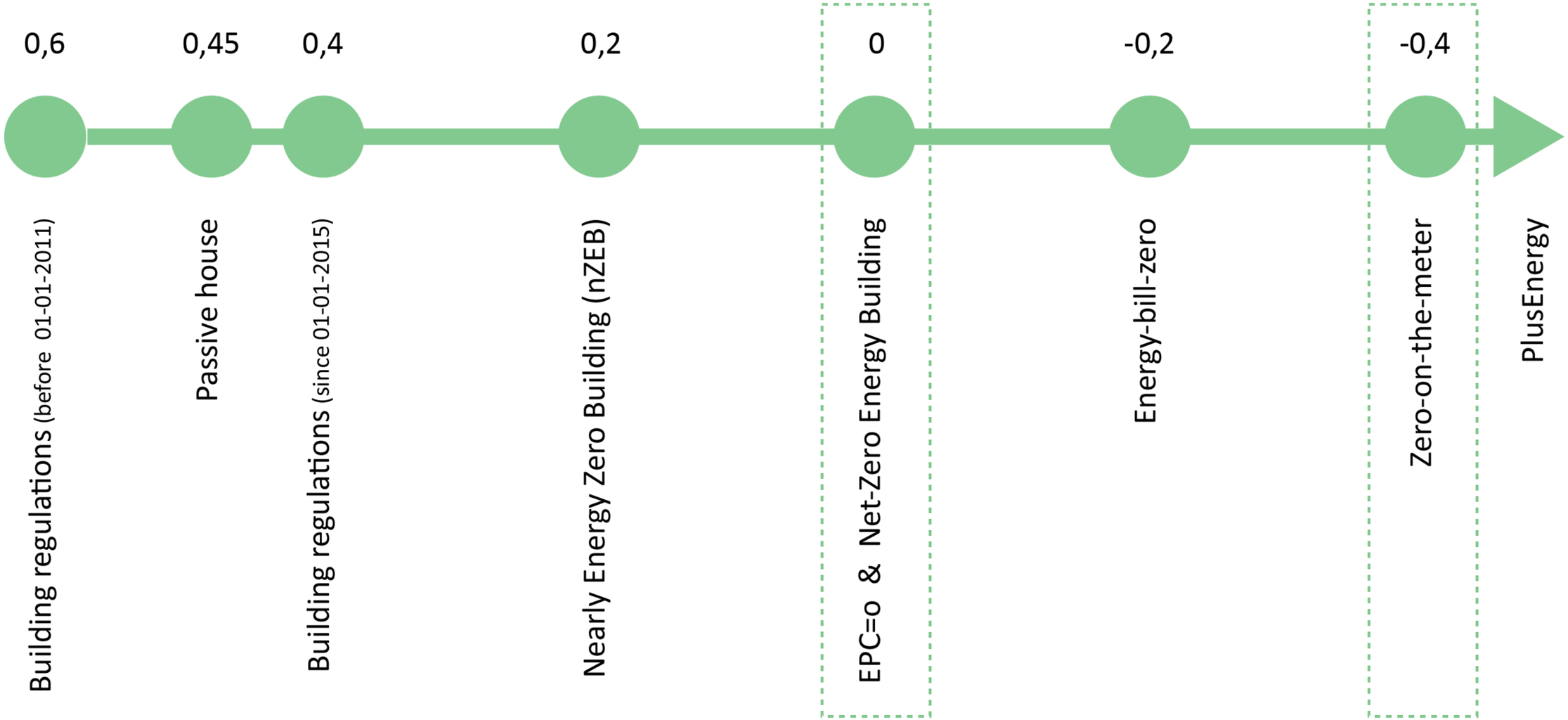

Figure based on Dwars (2013).

Urban area development & the real estate developer

- 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).

Urban area development & the real estate developer

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- Real estate development
  - By bringing together ideas, management, labour, capital and land (an 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

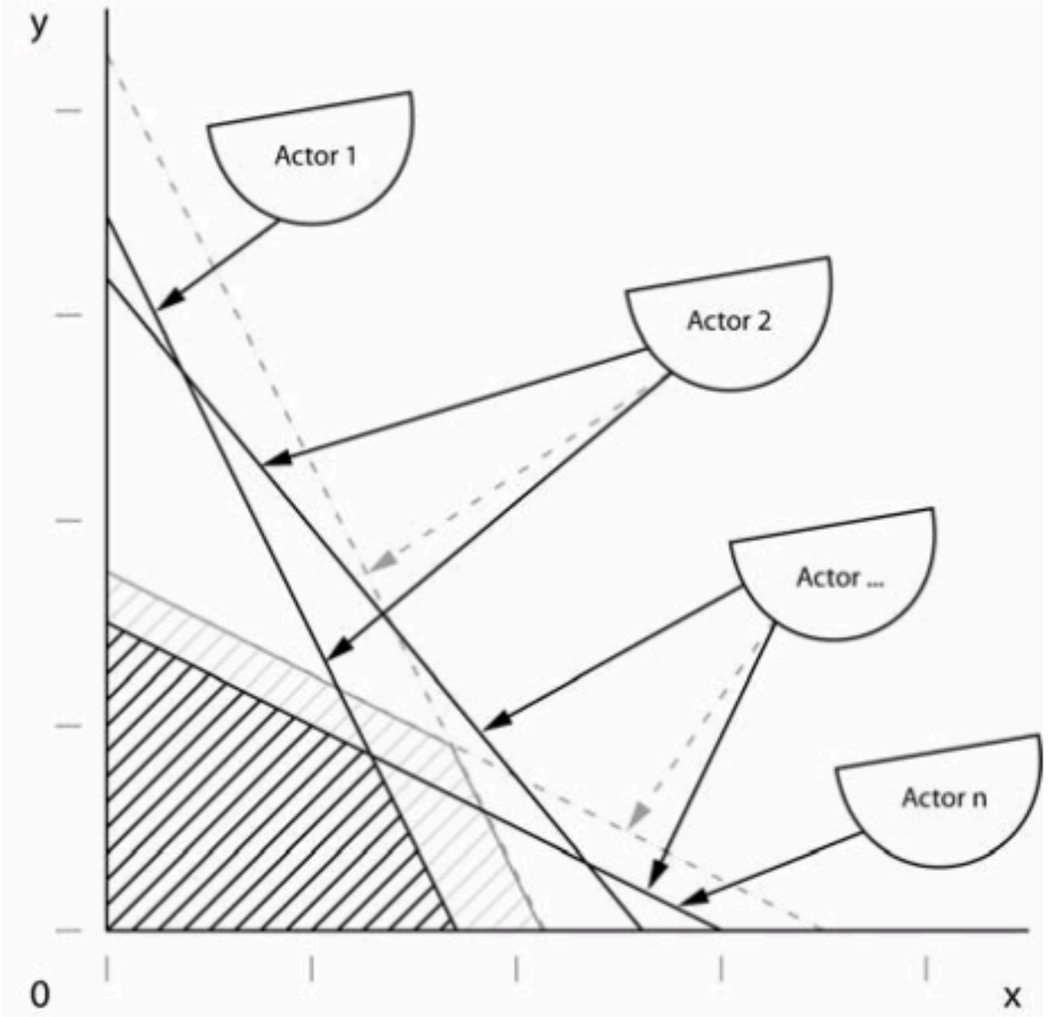


Figure of Van Loon et al (2008: 33)

Linear programming in multi-actor decision-making

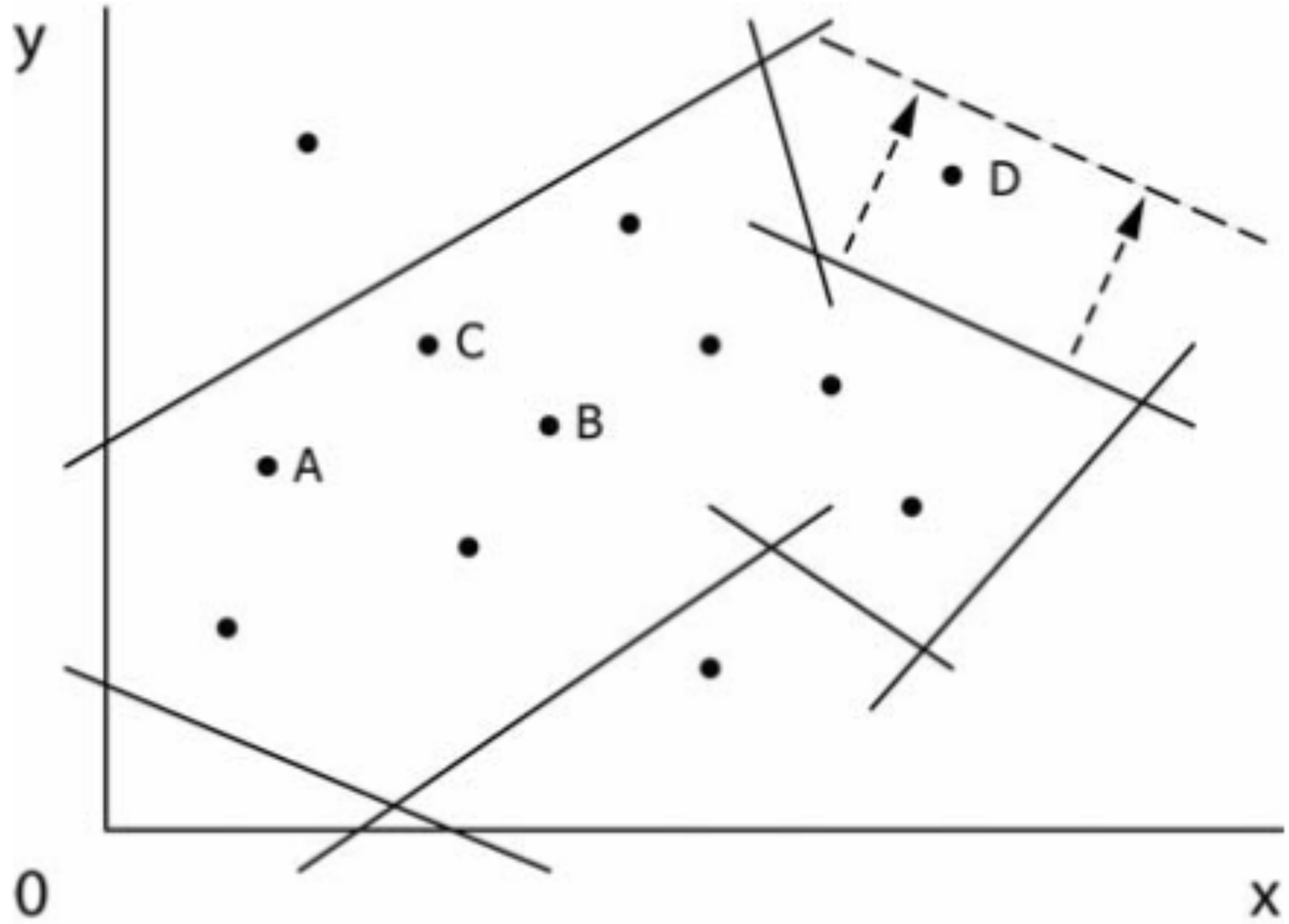


Figure of Van Loon et al (2008: 11)

Linear programming in multi-actor decision-making

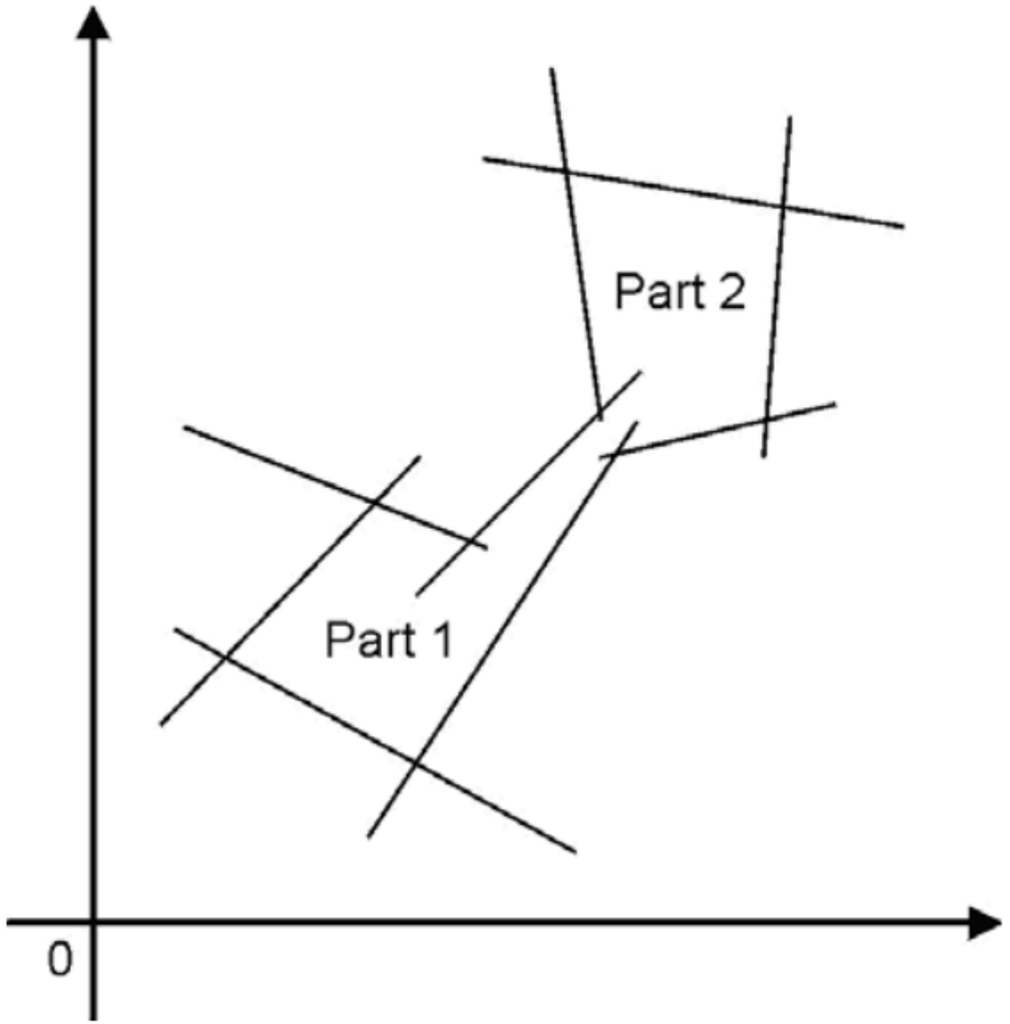


Figure of Binnekamp et al (2006: 40)

Linear programming in multi-actor decision-making

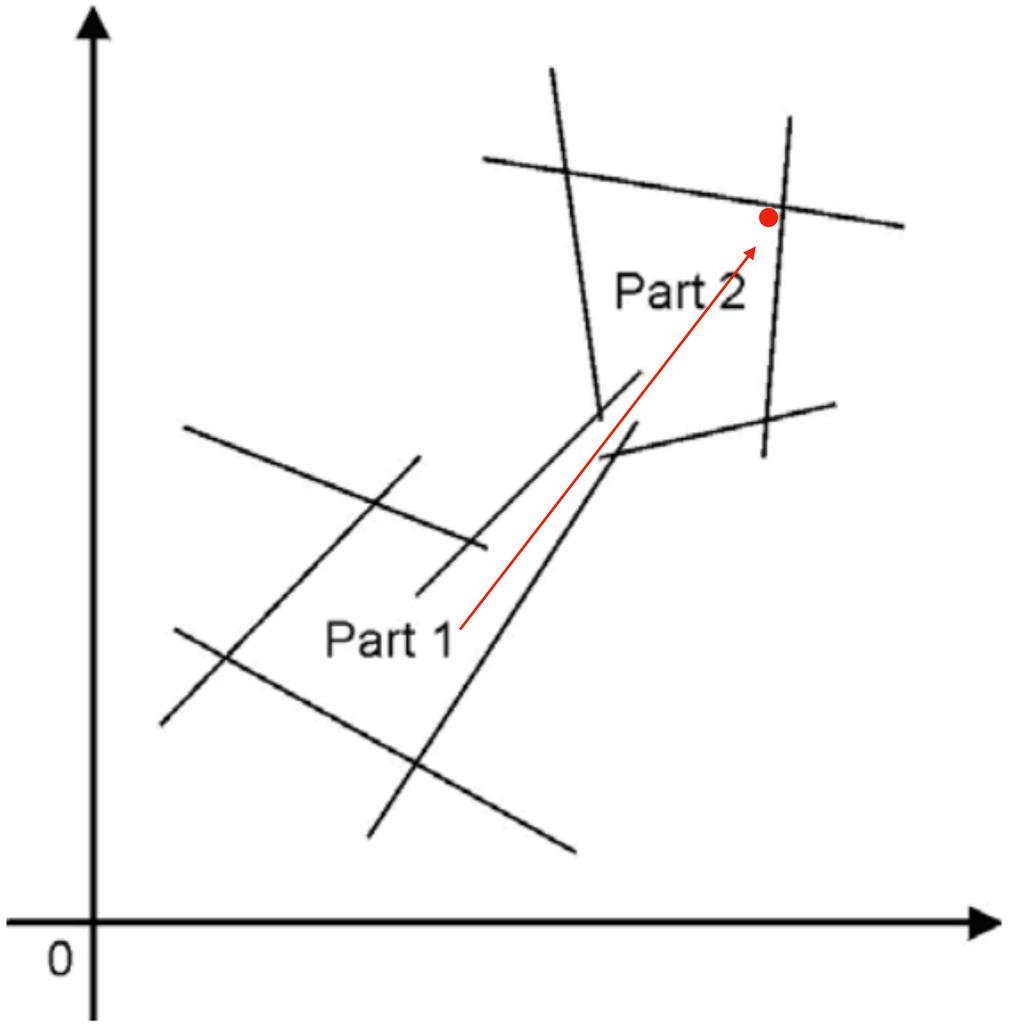
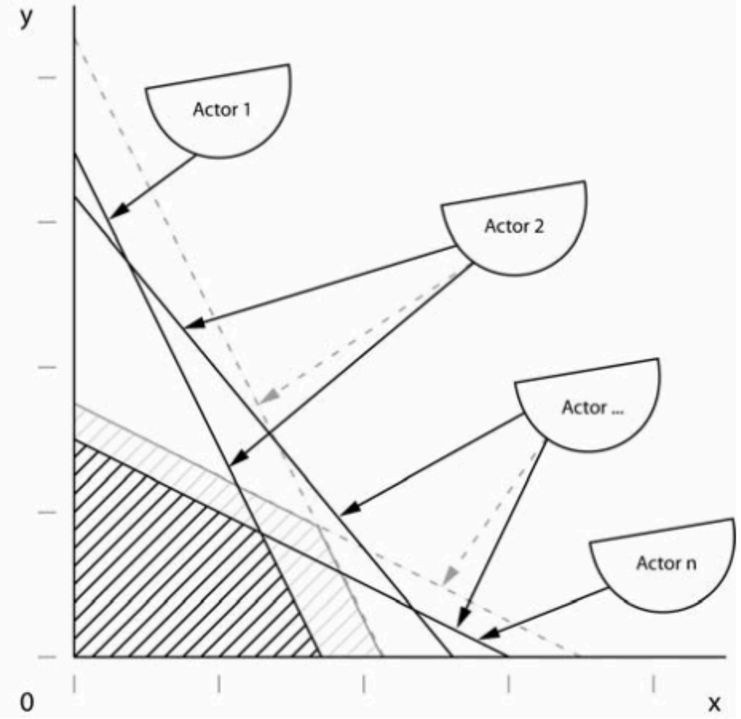
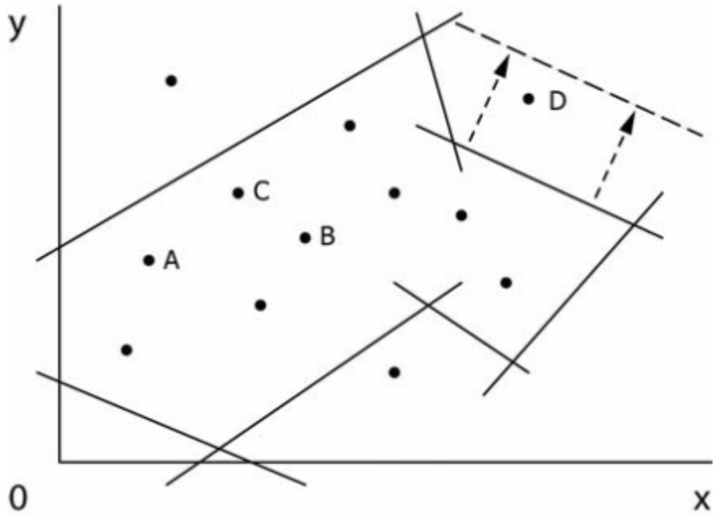


Figure of Binnekamp et al (2006: 40)

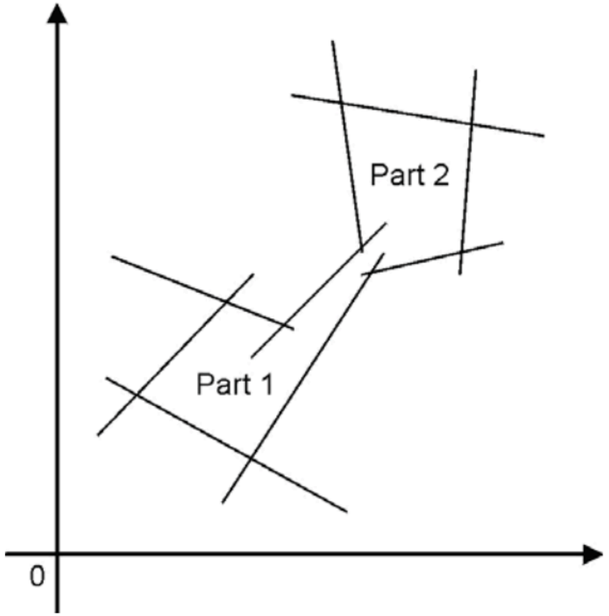
Linear programming in multi-actor decision-making



Dynamic solution space



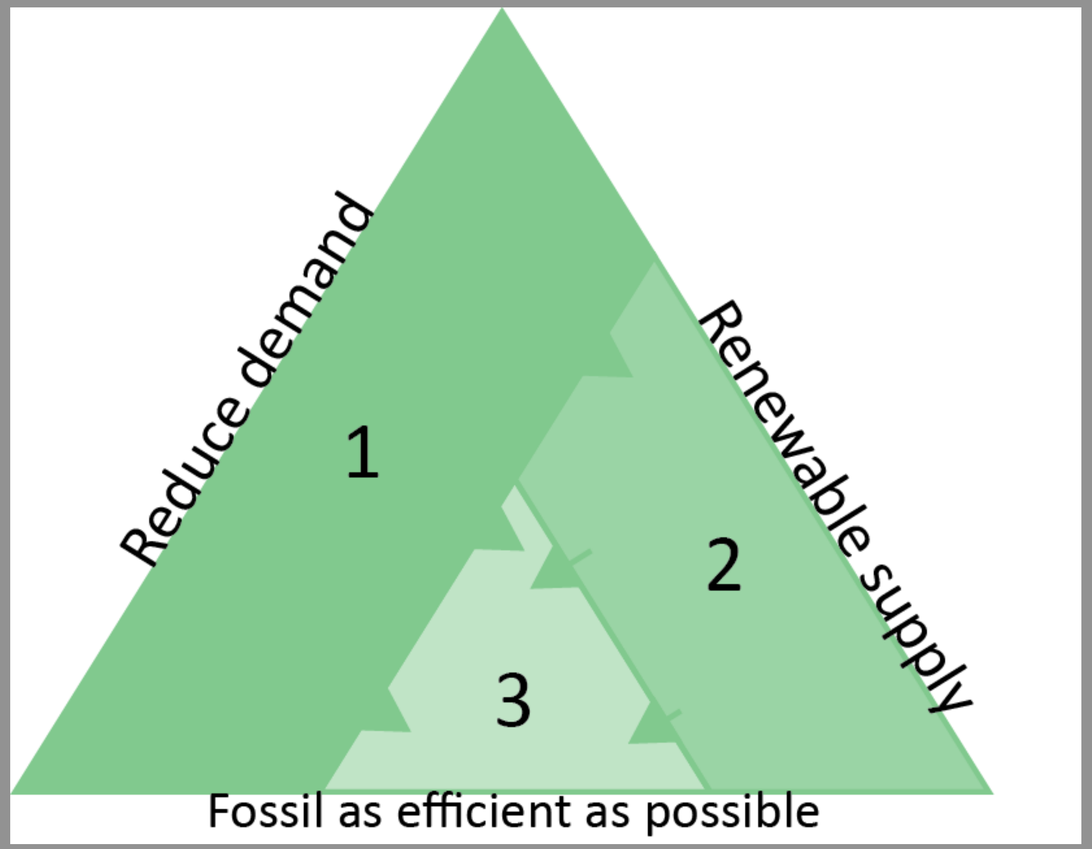
Finding the common solution space by negotiable constraints



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)

Figure bottom is of Bouwens & Bouwmeester (2017)

Energy changes

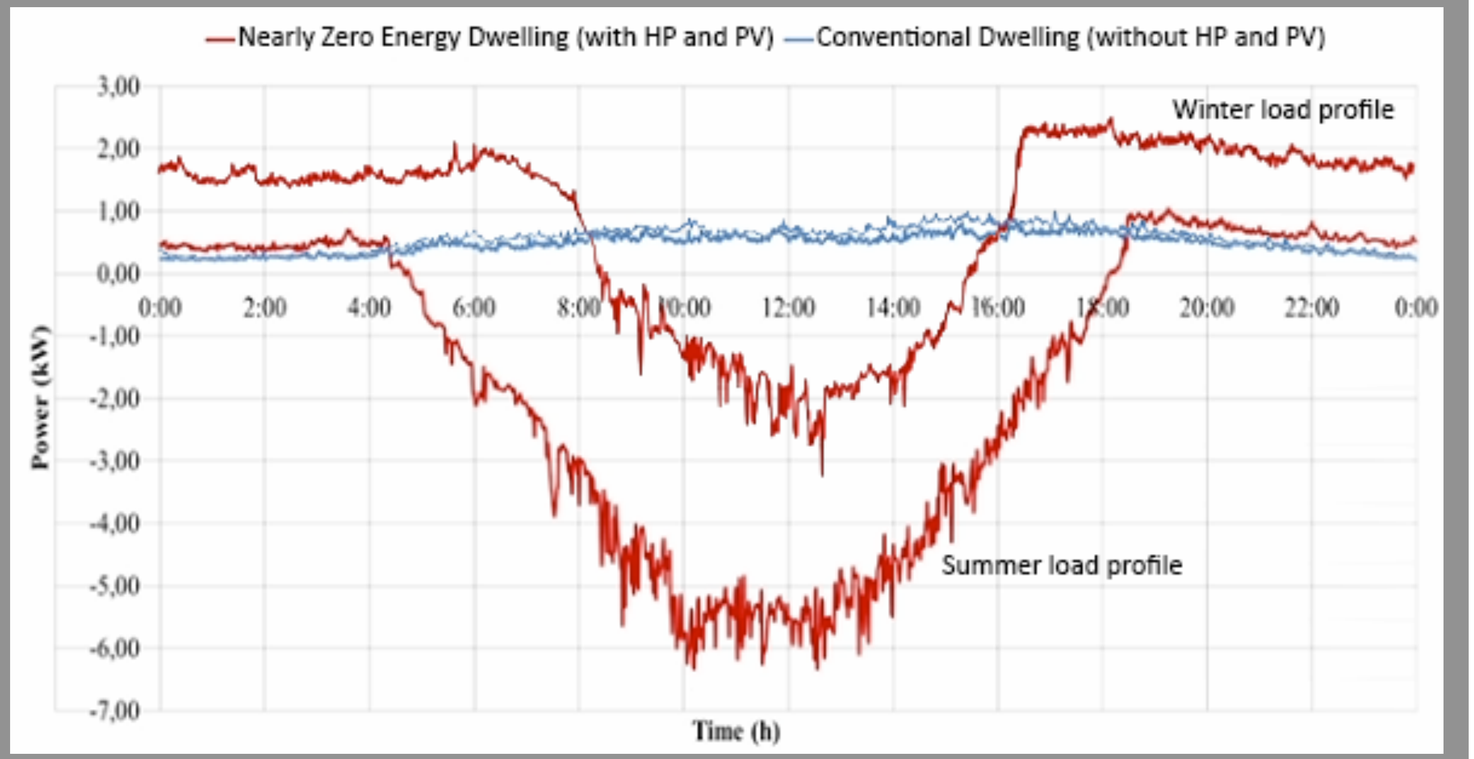
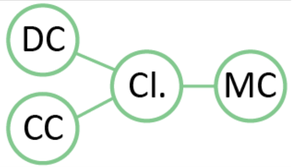
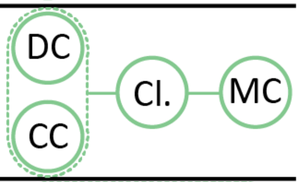
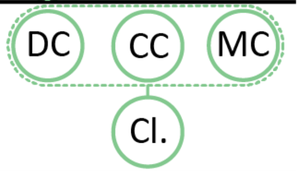


Figure of Molengraaf (2017)

- 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).

Organisational

- Project delivery methods
- Integral involvement of sustainability from the start of the project (Rovers, 2008; Schiltmans, 2013; Wamelink *et al.*, 2010)

Project delivery methods	Actor	Phases: Design / Build / Maintain	Contractual relations
Design-Bid-Build (DBB)	Cl. DC CC MC		
Design and Build (DB)	Cl. DC CC MC		
Design-Build-Maintain (DBM)	Cl. DC CC MC		

Cl. : client; DC: Design Companies; CC: Costruction Companies; MC: Maintenance Companies

Figure based on Rahola & Straub (2013).

Finance - basics

Ground exploitation

Development exploitation

Real estate exploitation / In use

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

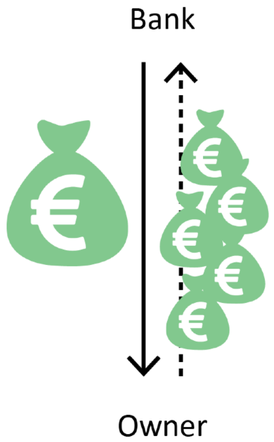


Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)

Finance - basics

Ground exploitation

Development exploitation

Real estate exploitation / In use

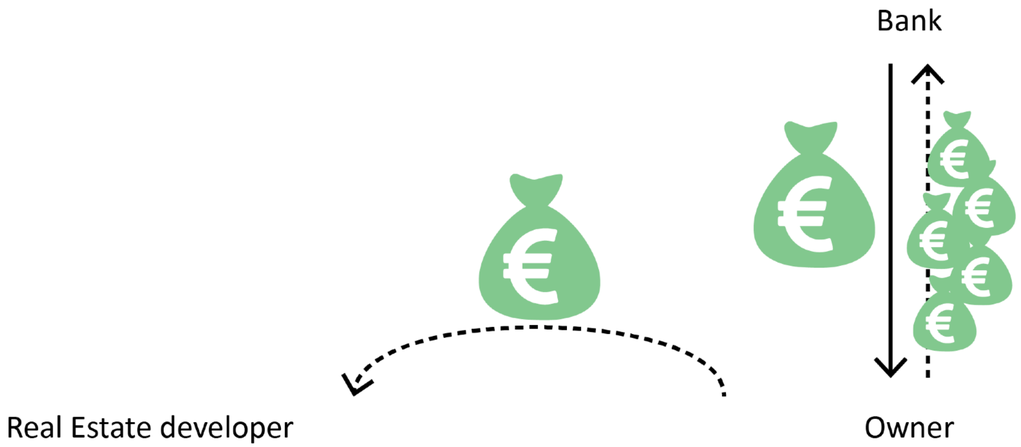


Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)

Finance - basics

Ground exploitation

Development exploitation

Real estate exploitation / In use

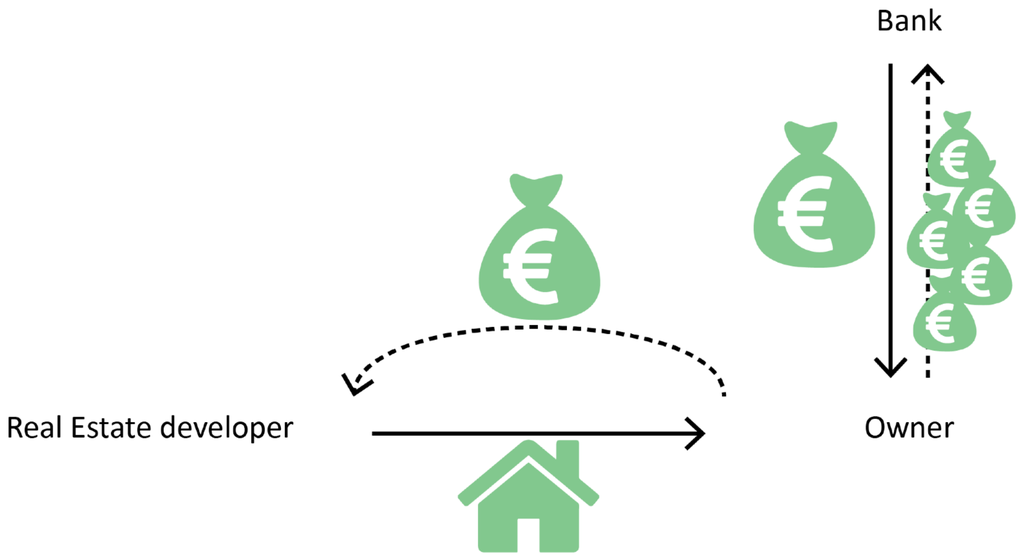


Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)

Finance - basics

Ground exploitation

Development exploitation

Real estate exploitation / In use

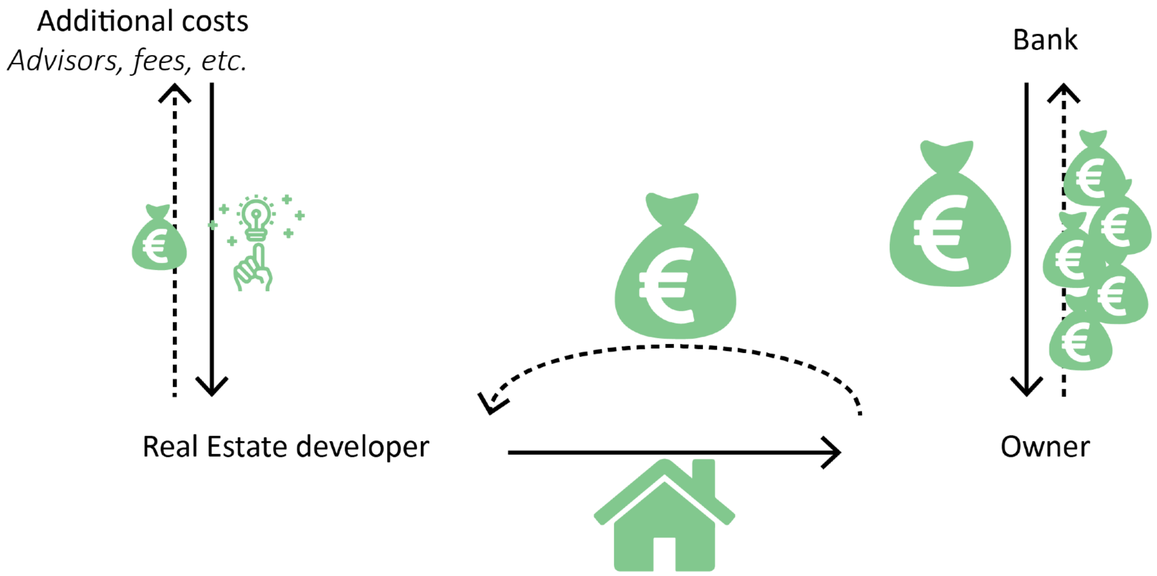


Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)

Finance - basics

Ground exploitation

Development exploitation

Real estate exploitation / In use

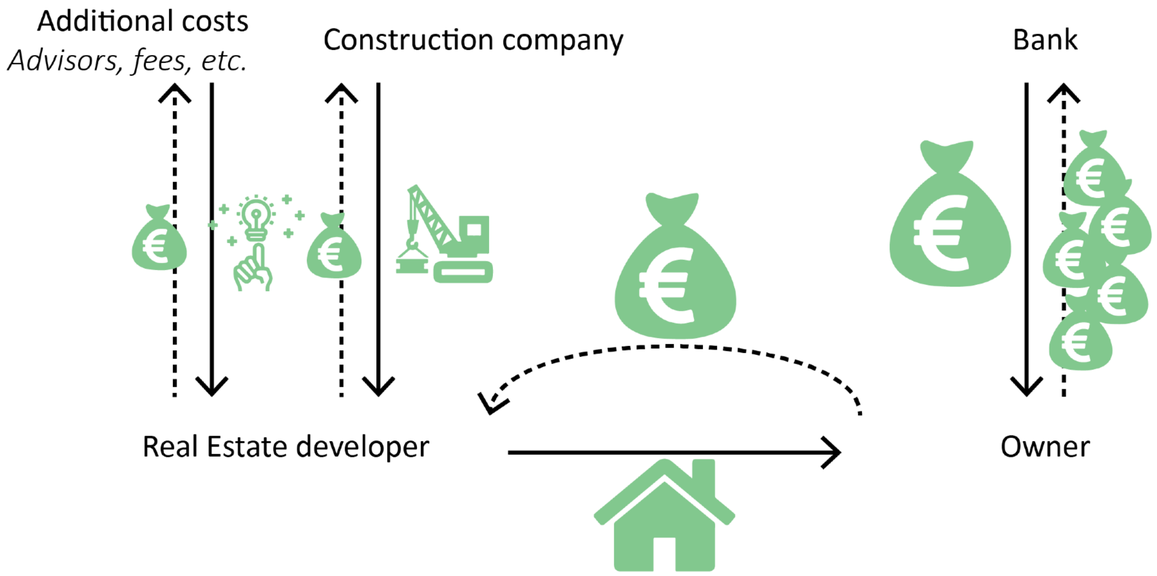


Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)

Finance - basics

Ground exploitation

Development exploitation

Real estate exploitation / In use

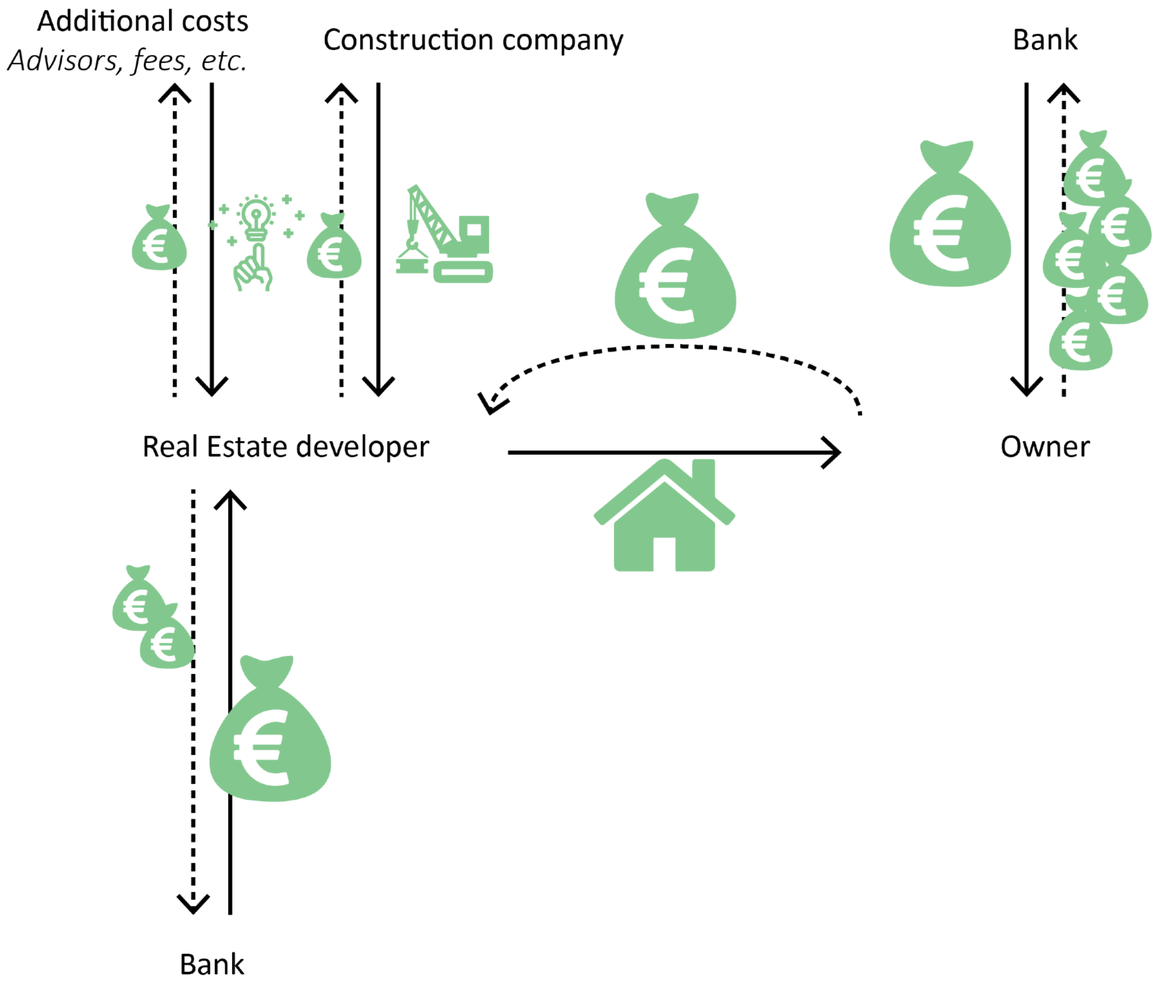


Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)

Finance - basics

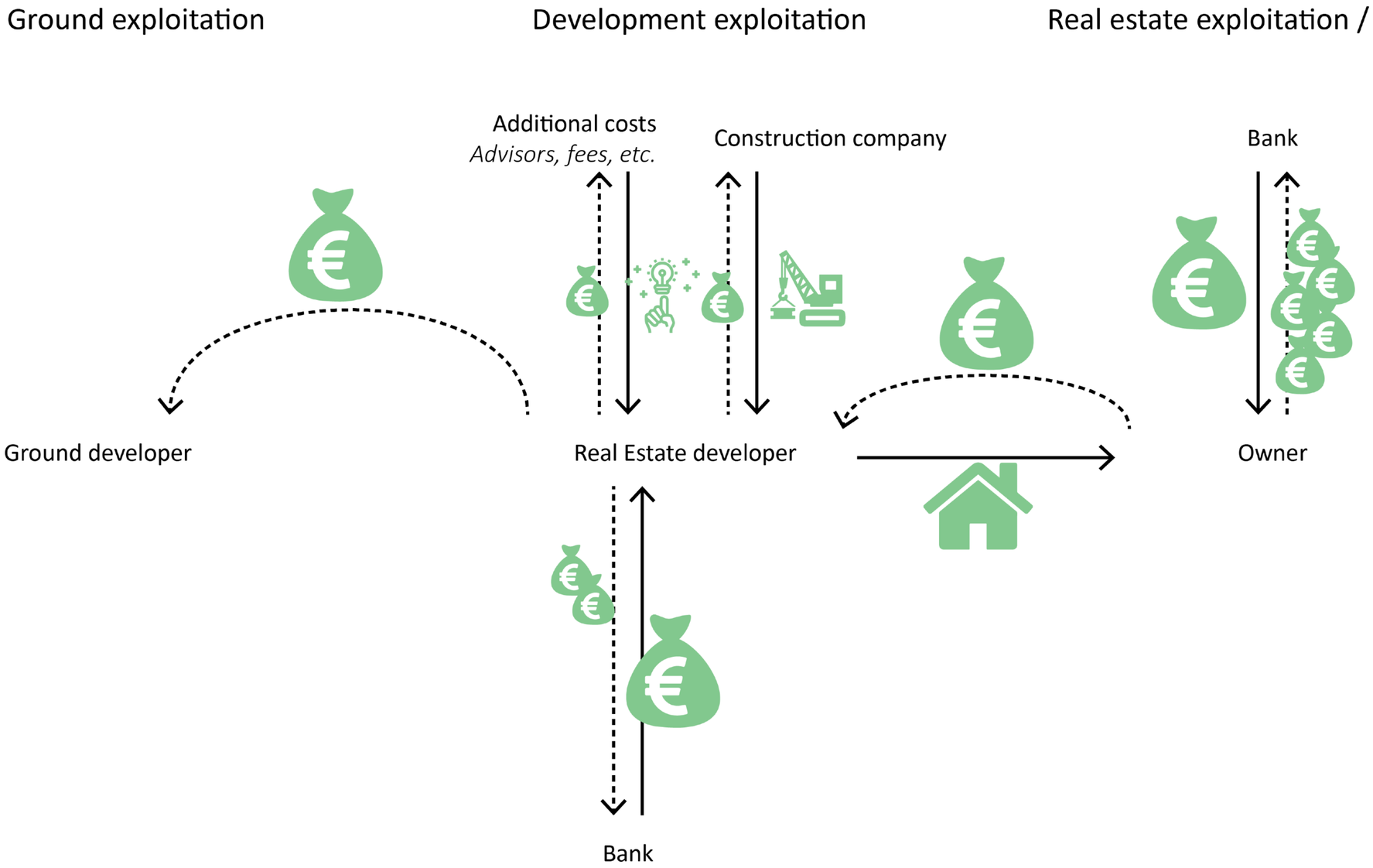


Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)

Finance - basics

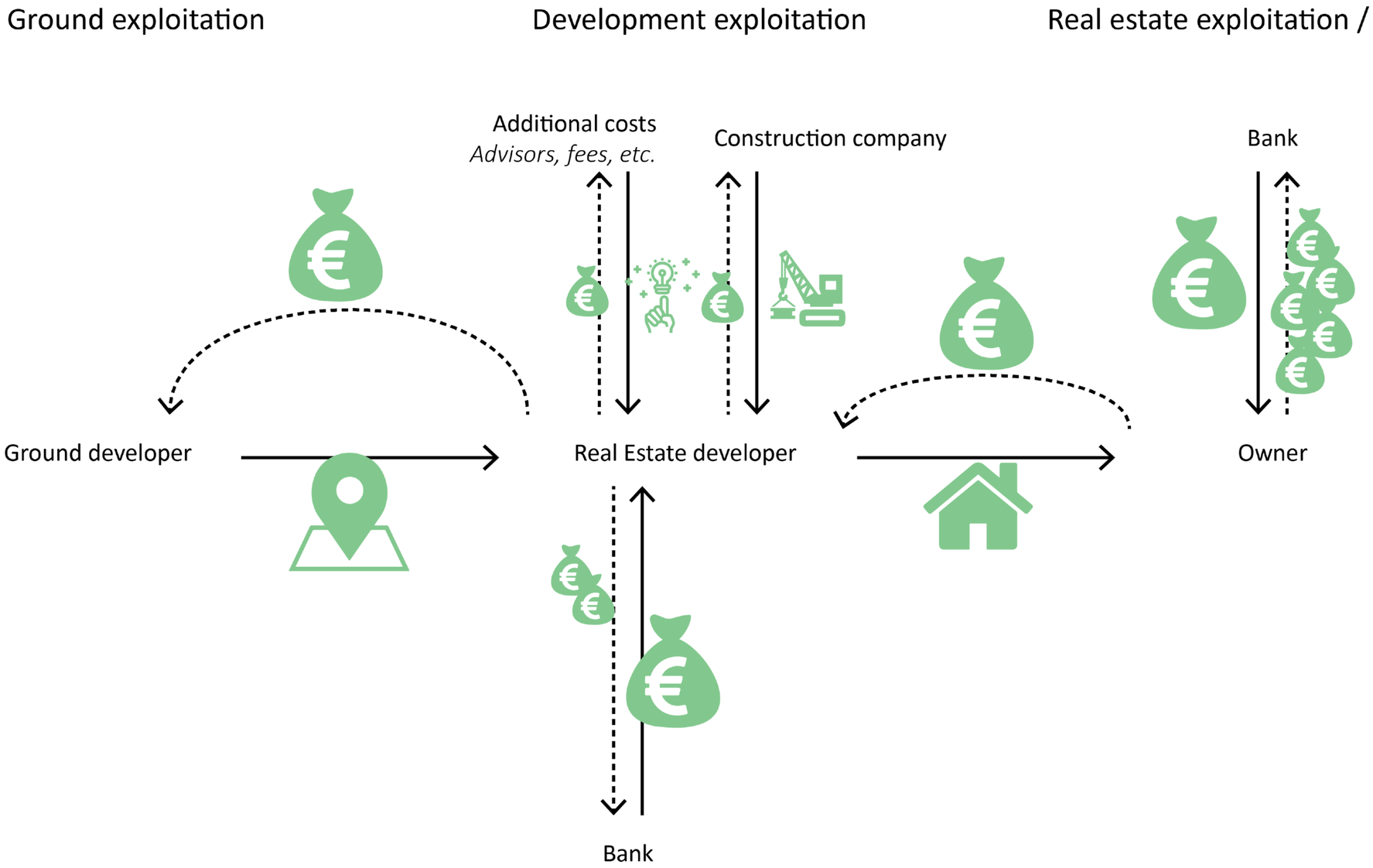


Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)

Finance - basics

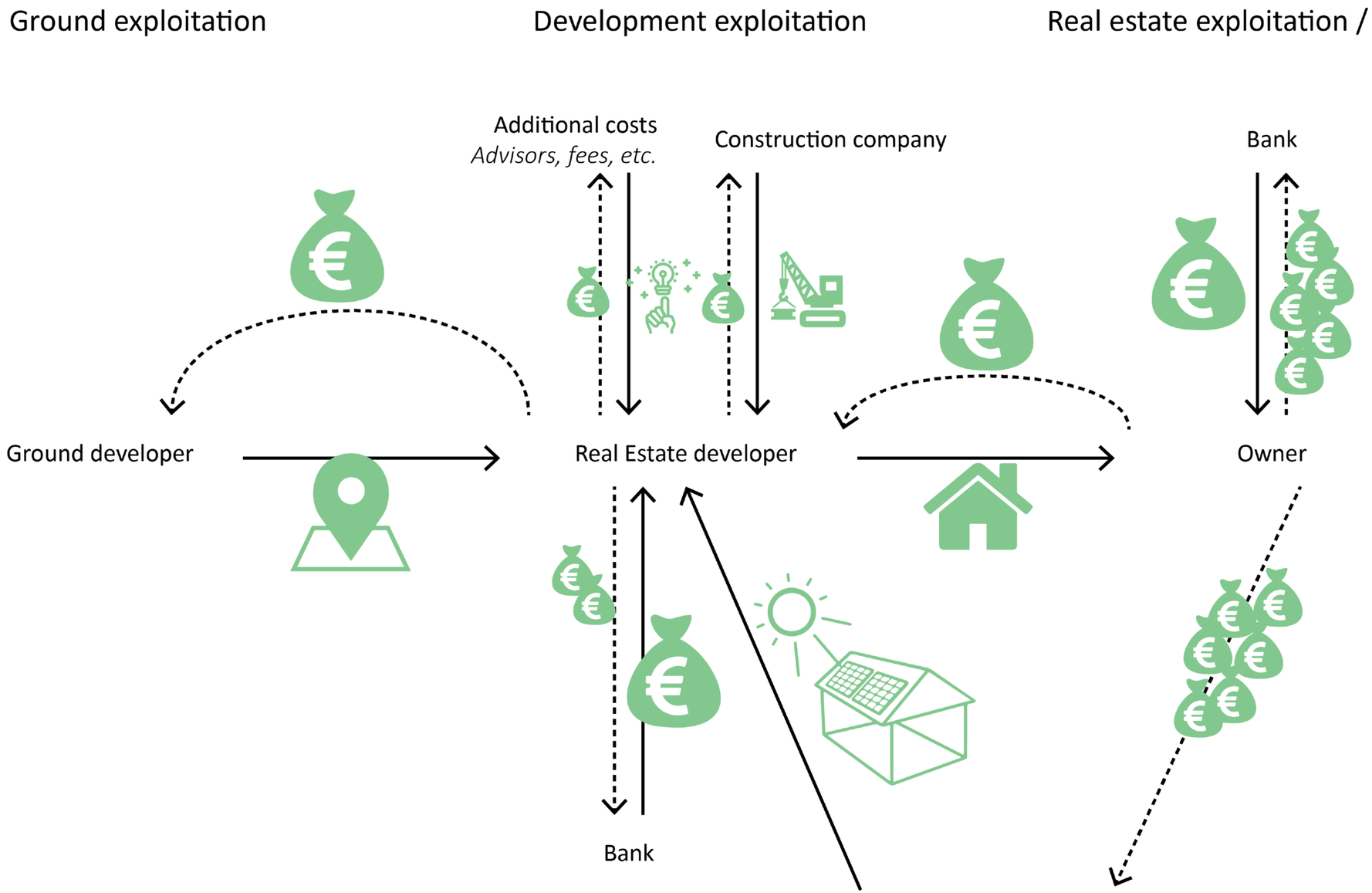
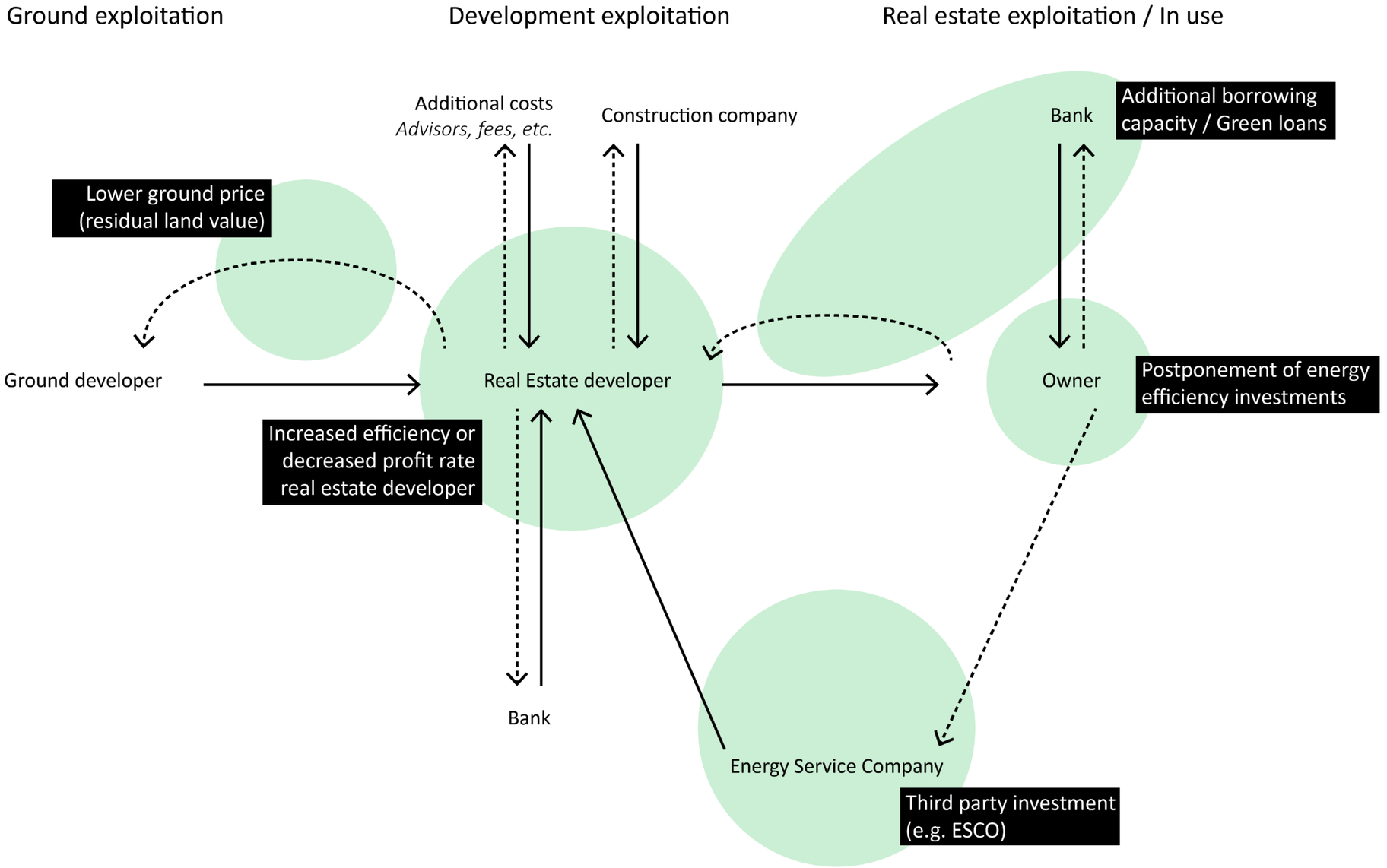


Figure based on Putman (2010) and Vlek et al (2016), Bullier and Milin (2013), Bertoldi and Boza-Kiss (2017)

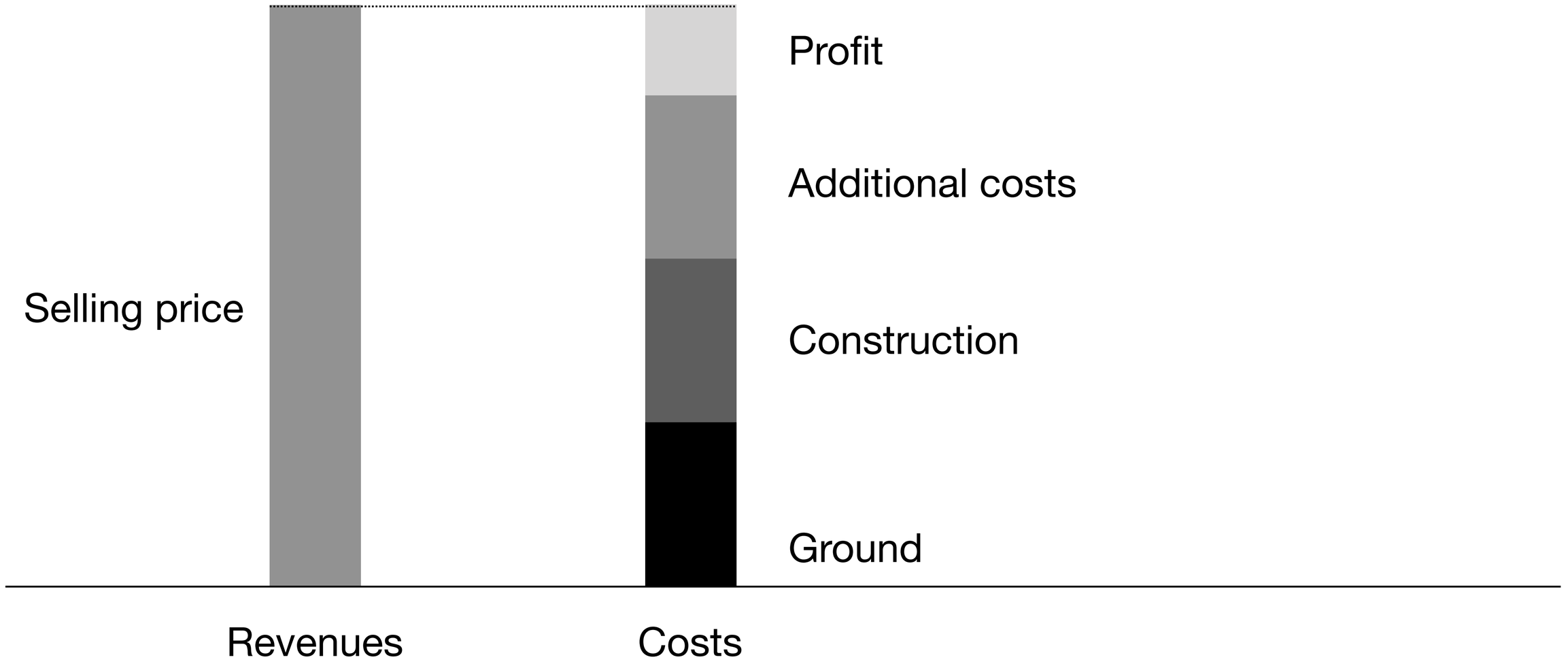
Finance



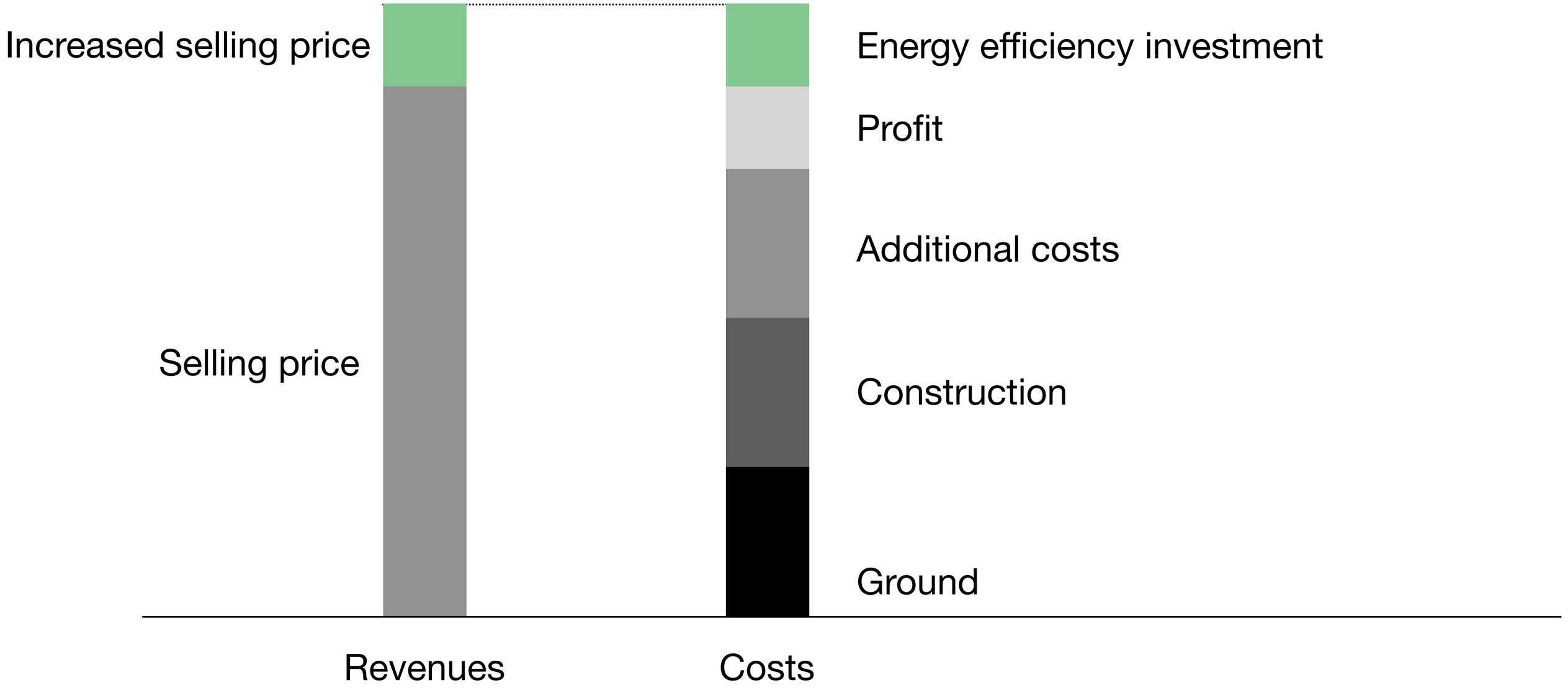
- Split-incentive (Astmarsson *et al.*, 2013; Bullier & Milin, 2013).
- Other preferences home buyers (De Vries, 2010).
- A <-> G-labelled buildings €27.000 difference (Brounen, 2015, 2017).
- Unknown extra market value A++, A++++, except for extra borrowing space (Blok, 2014, 2015, 2016).

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

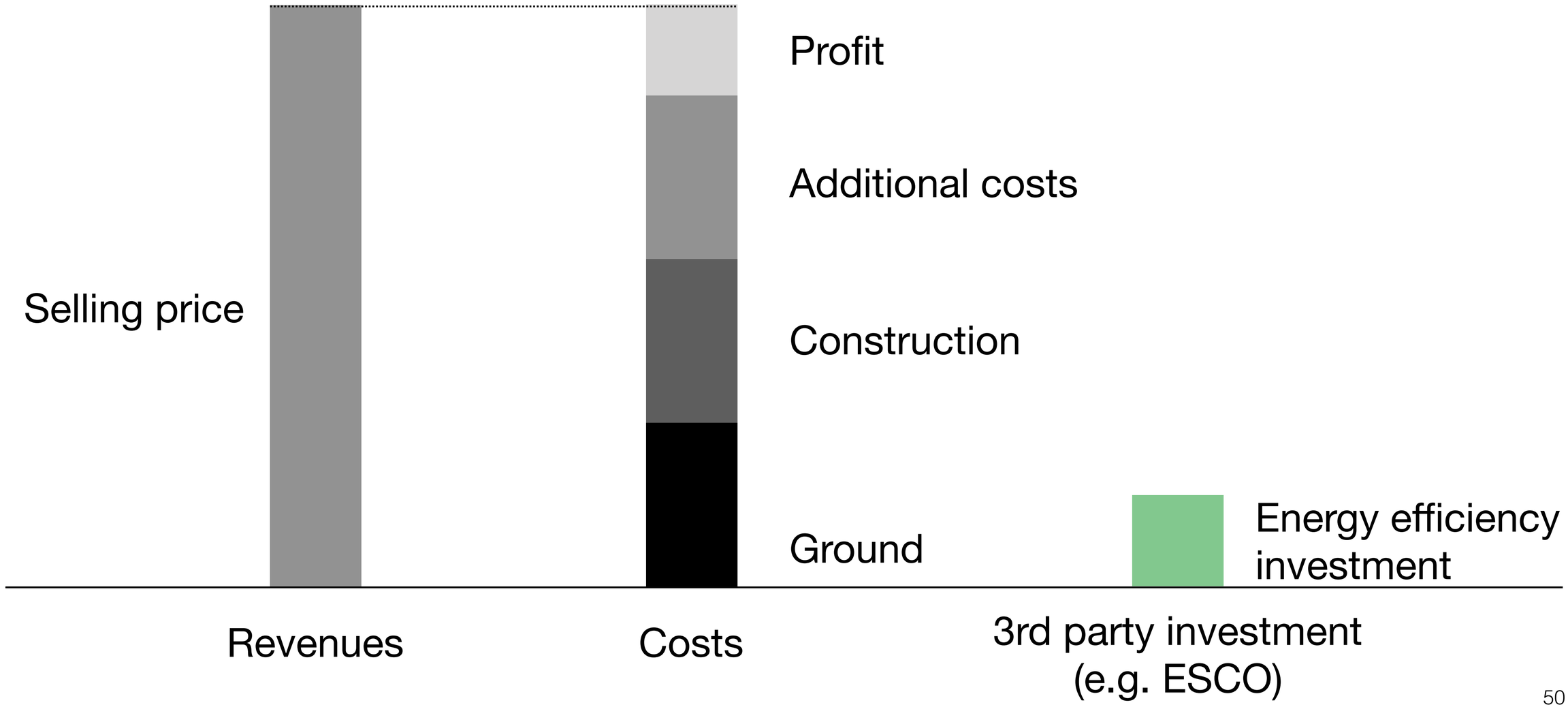
Finance


Selling price
Profit
Additional costs
Construction
Ground
Revenues
Costs

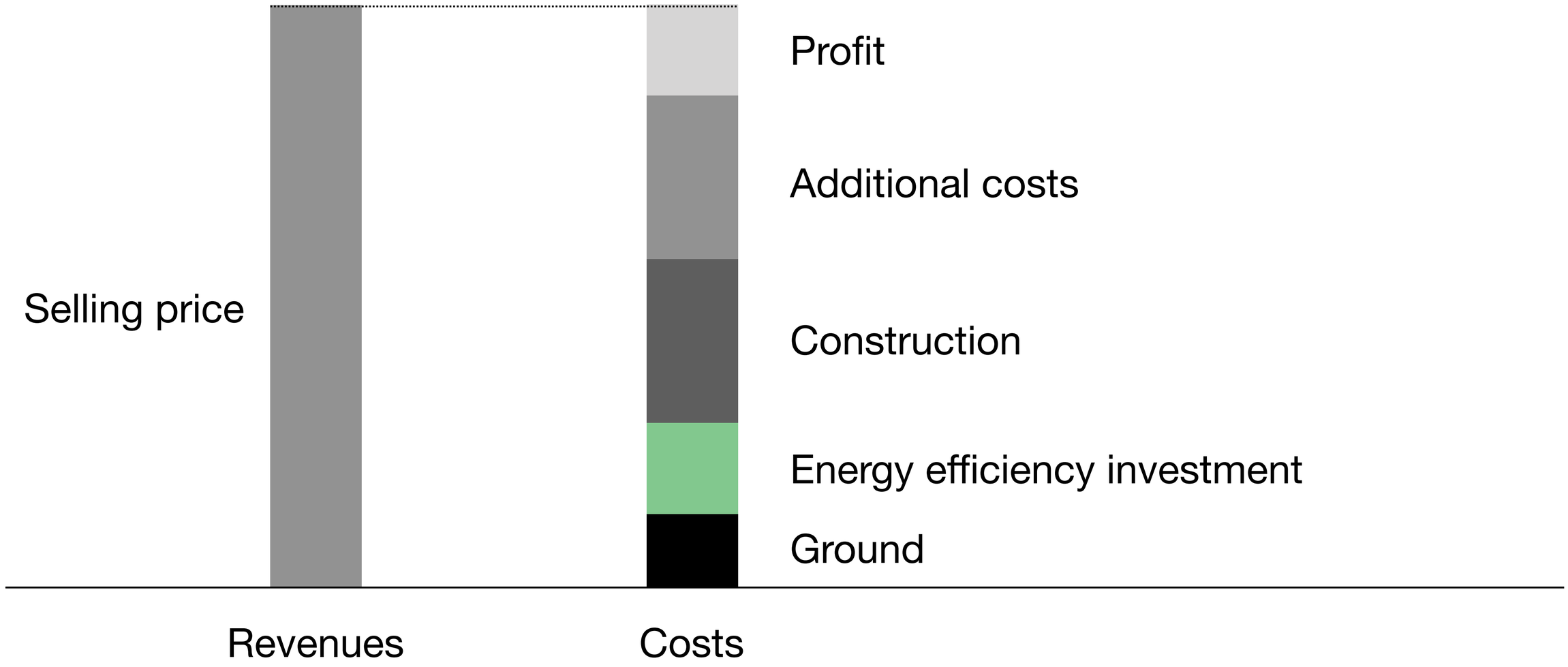
Finance


Increased selling price
Selling price
Energy efficiency investment
Profit
Additional costs
Construction
Ground
Revenues
Costs

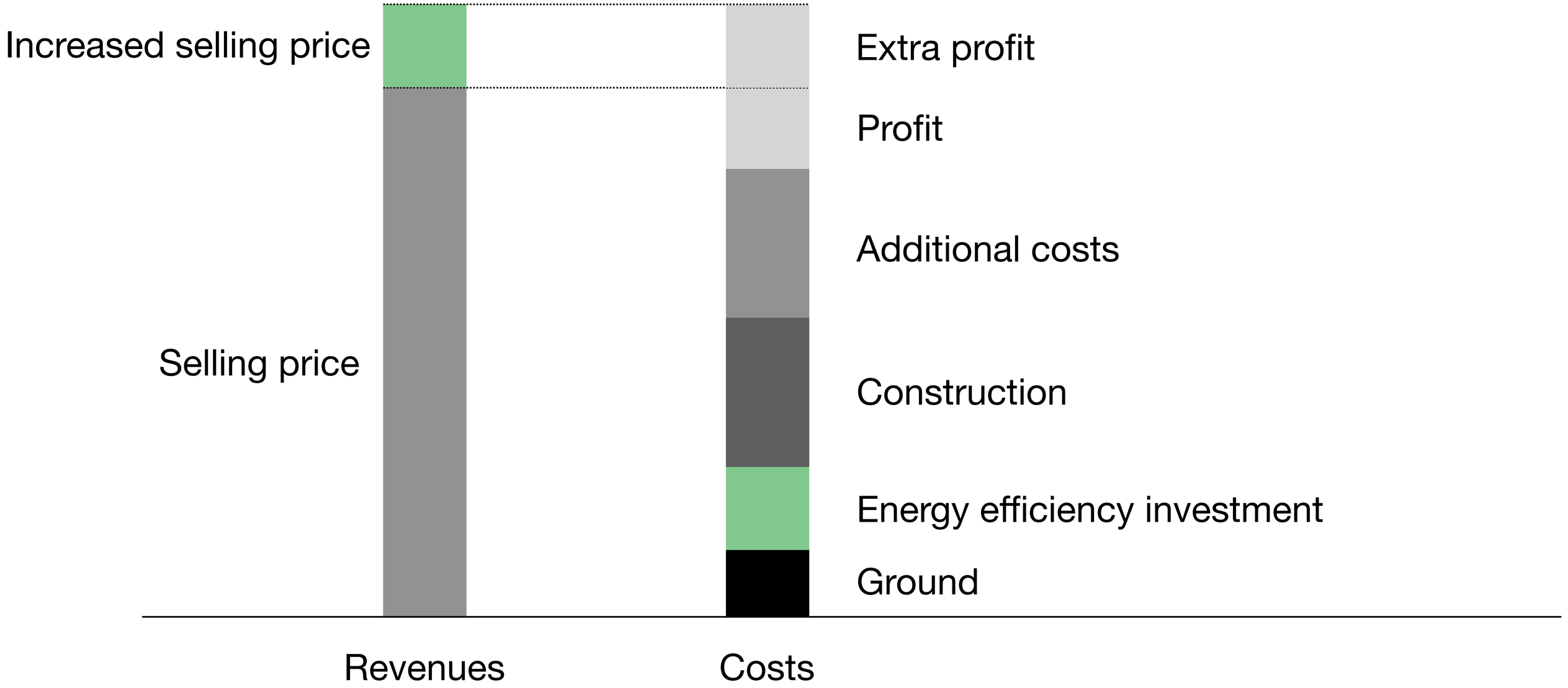
Finance


Selling price
Profit
Additional costs
Construction
Ground
Energy efficiency investment
Revenues
Costs
3rd party investment (e.g. ESCO)

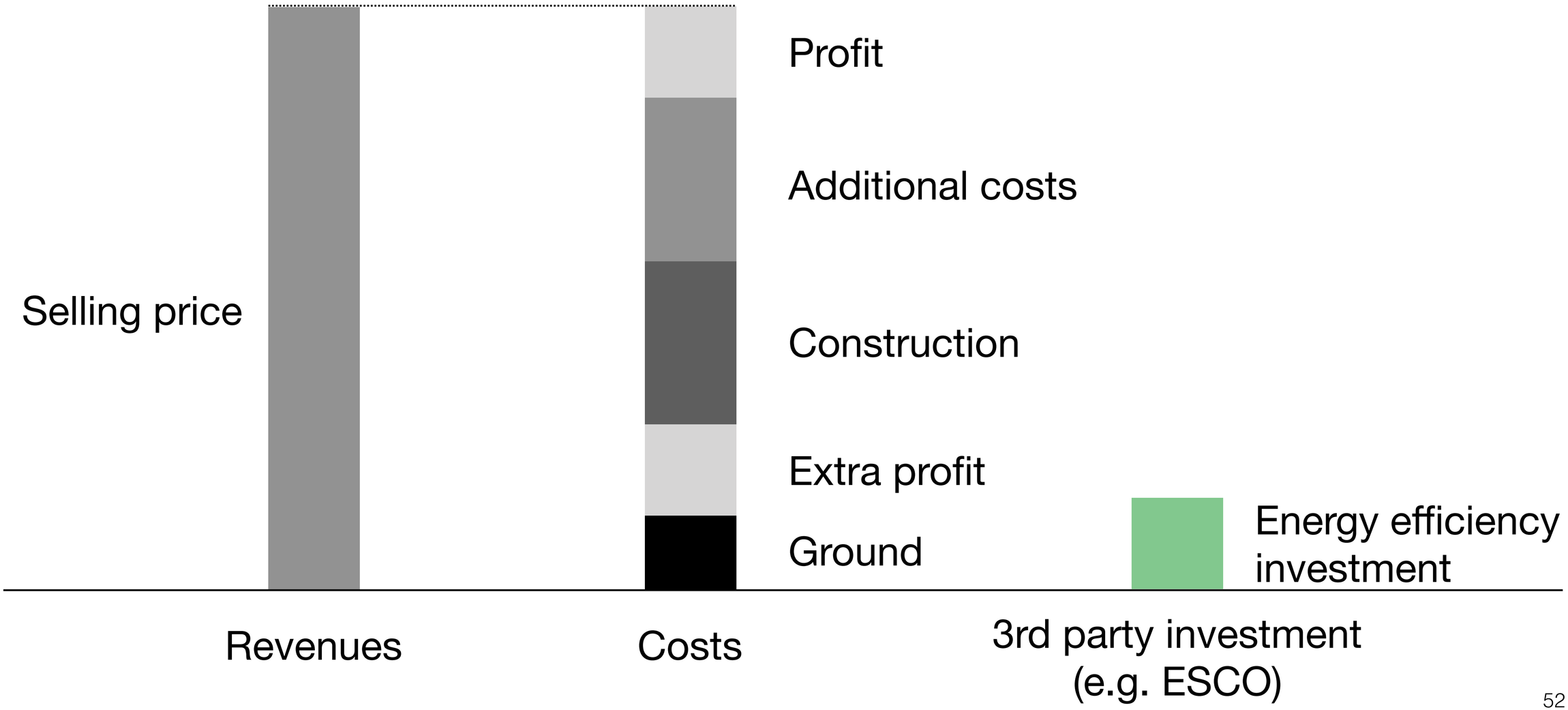
Finance


Selling price
Profit
Additional costs
Construction
Energy efficiency investment
Ground
Revenues
Costs

Finance


Increased selling price
Selling price
Extra profit
Profit
Additional costs
Construction
Energy efficiency investment
Ground
Revenues
Costs

Finance


Selling price
Profit
Additional costs
Construction
Extra profit
Ground
Energy efficiency investment
Revenues
Costs
3rd party investment (e.g. ESCO)

Part 3: Exploring case studies

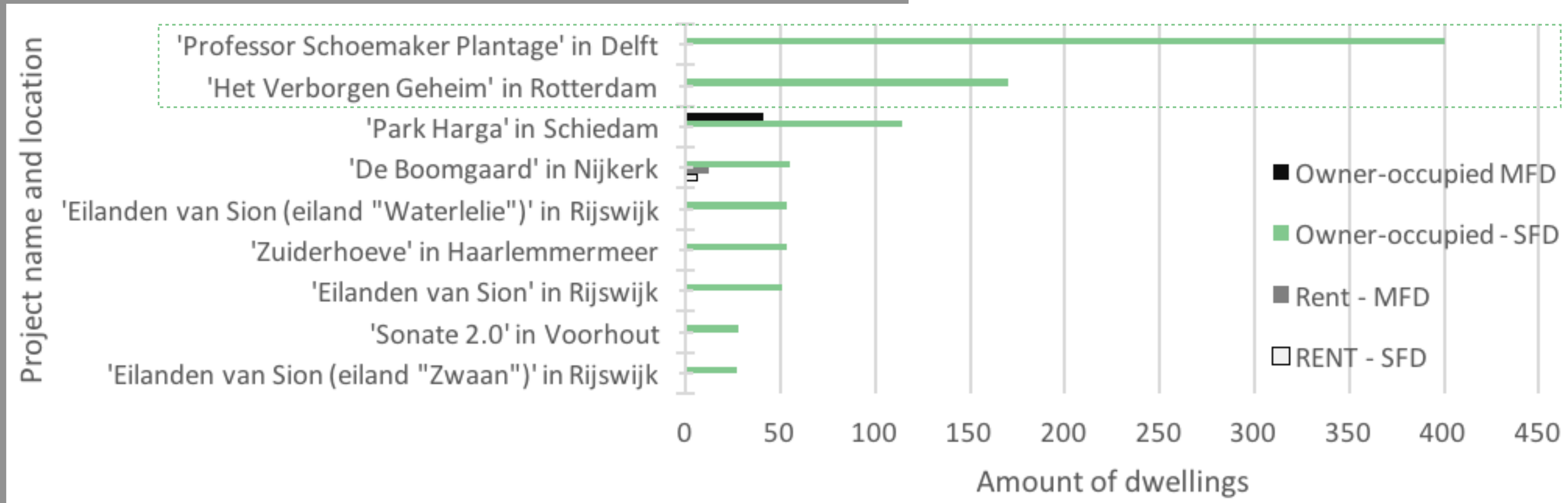
- Purposive sampling (Bryman, 2012; Kumar, 2014)
- Results

Van Omme & De Groot:
Het Verborgen Geheim, Rotterdam (in-depth)

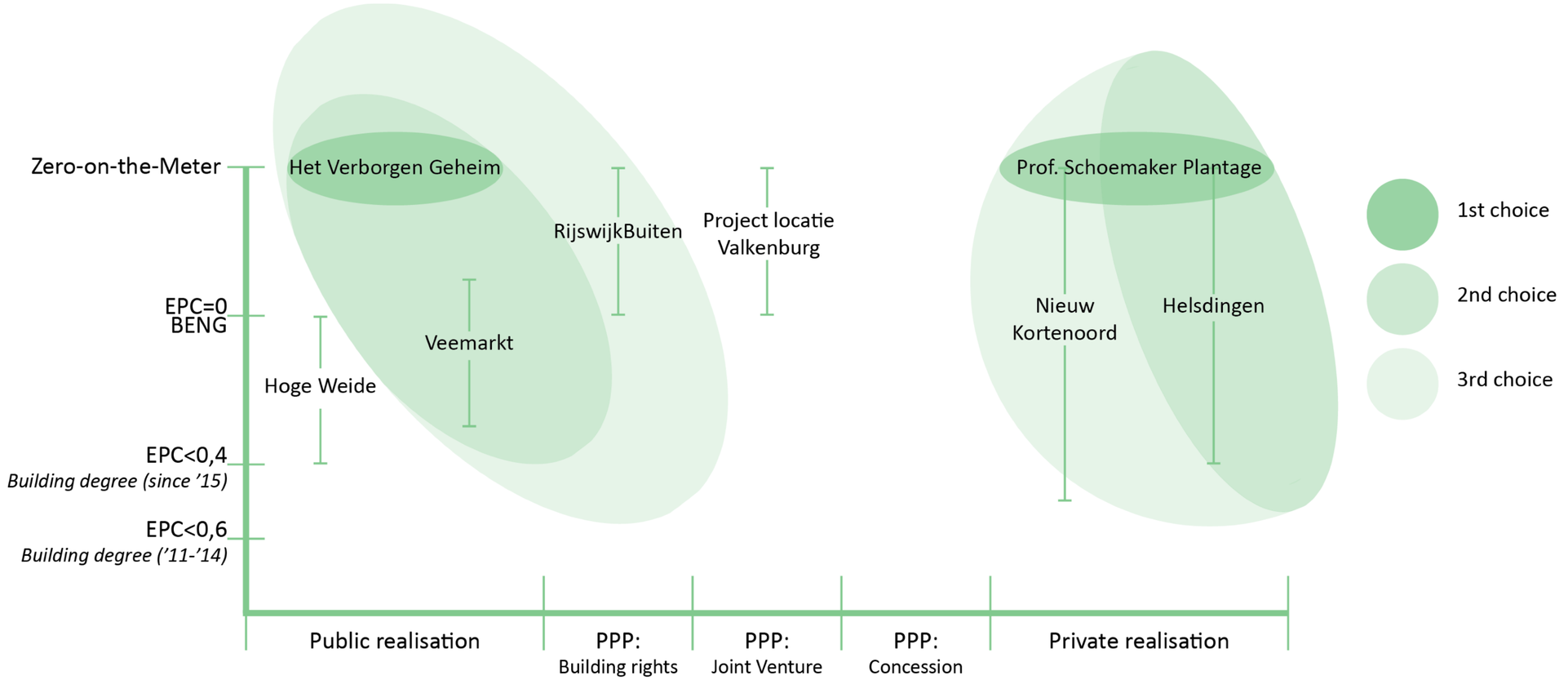
AM:
Prof. Schoemaker Plantage, Delft (explorative)

Sampling (1)

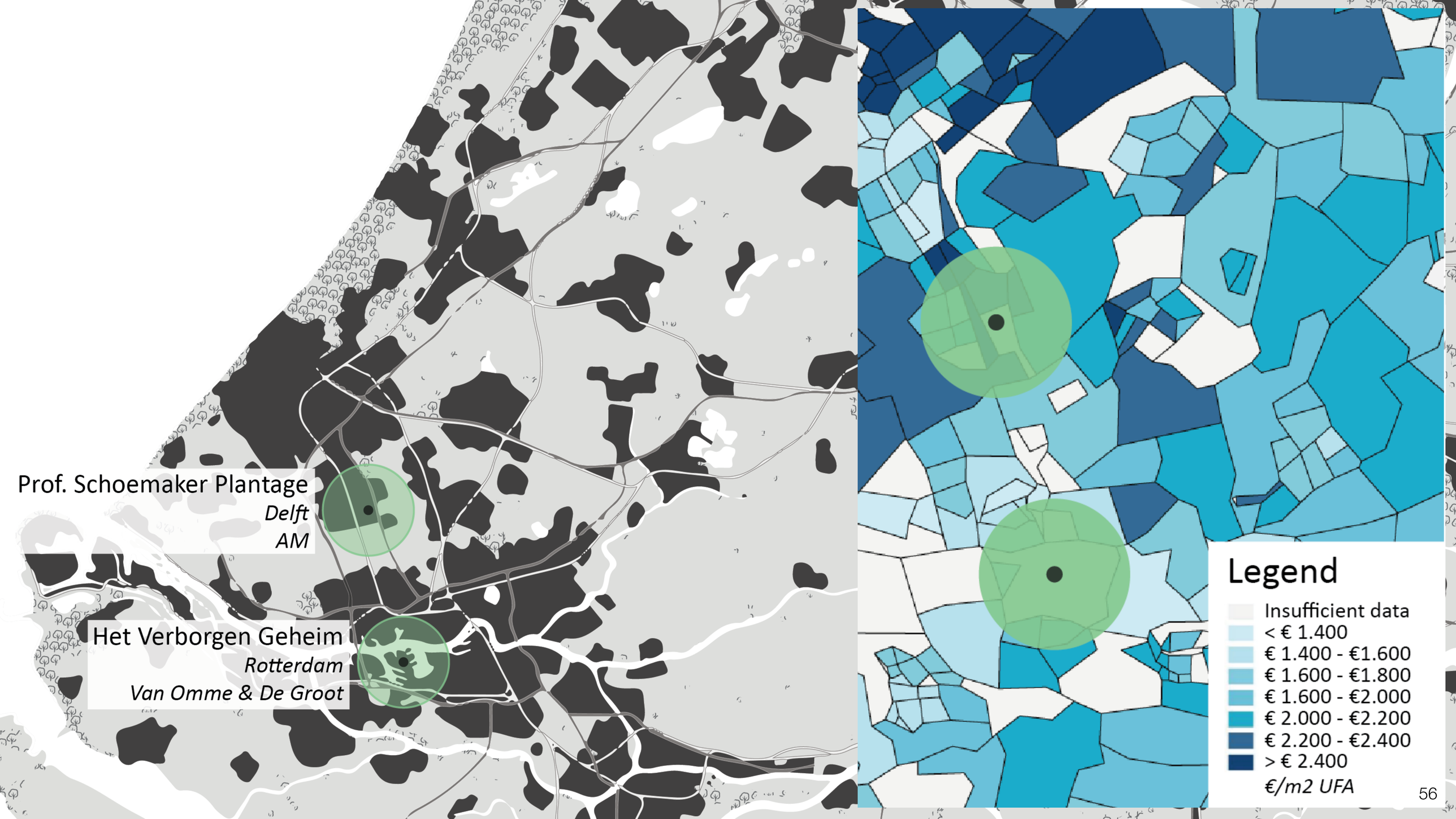
- ZEN-database
- ZEN: Follow-up program of Lente-Akkoord



Sampling (2)



- 1st choice: in-depth investigated
- 2nd choice: Desk research + semi-structured interviews
- 3rd choice: Desk research + personal communication


Prof. Schoemaker Plantage
Delft
AM
Het Verborgen Geheim
Rotterdam
Van Omme & De Groot
Legend
Insufficient data
< € 1.400
€ 1.400 - €1.600
€ 1.600 - €1.800
€ 1.600 - €2.000
€ 2.000 - €2.200
€ 2.200 - €2.400
> € 2.400
€/m2 UFA

Van Omme & De Groot:
Het Verborgen Geheim

AM: Prof. Schoemaker Plantage

Results exploring case studies

	‘Het Verborgen Geheim’	‘Prof. Schoemaker Plantage’
Partnership model	Public realization	Private realization
Incentive for real estate developer	MEAT-tender	Changing legislation Market circumstances
Organisational	Involvement of ESCo Design-and-Build contract	Design-and-Build contract
Financing	ESCo Low ground price of the municipality (€19.419 / dwelling)	Increasing selling price by additional borrowing capacity for ZOM (€ 29.000,-)
Physical	All-electric with ground source heat pump powered with PV-panels	

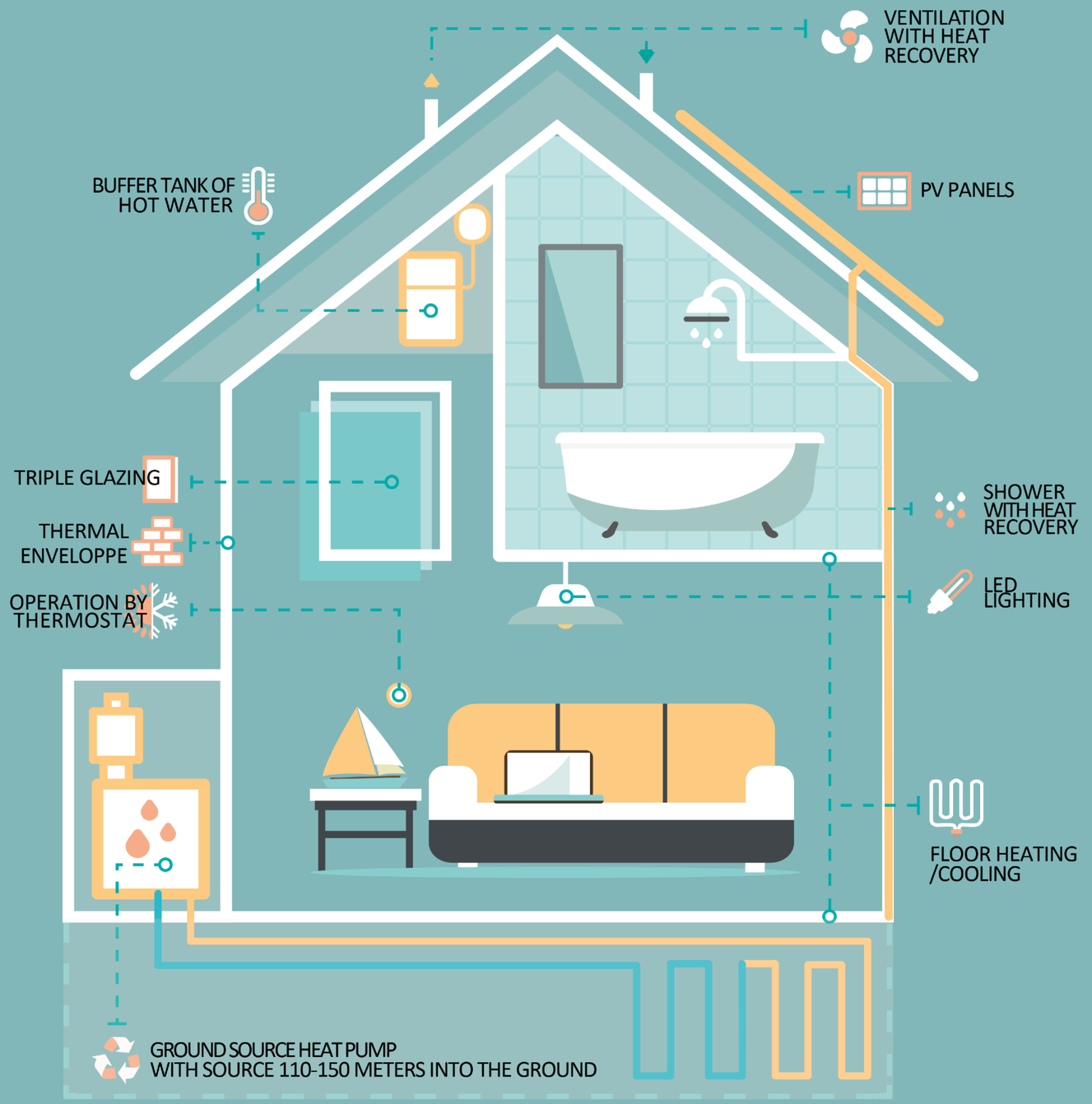


Figure based on Klimaatgarant and Het Verborgen Geheim (2016).

RijswijkBuiten, Rijswijk

Part 4: Development DST

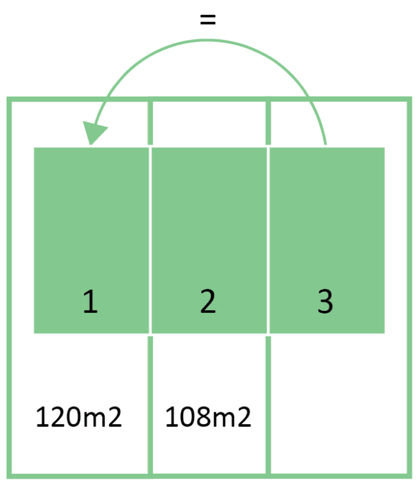
- Objective of the model
- Components
- System structure

Development of the DST

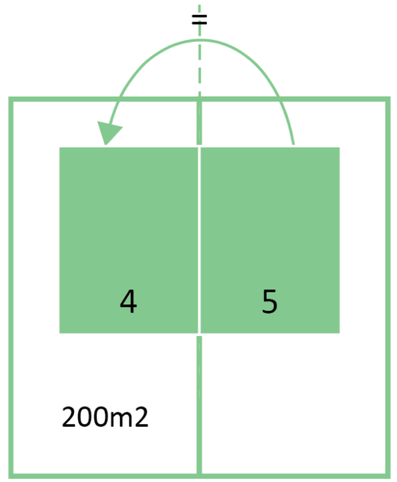
- Optimal dwelling program with related all-electric energy supply installations and financing method
- Objective function (real estate developer): Maximal profit
- Within the given constraints (such as energy legislation, density)

Top view

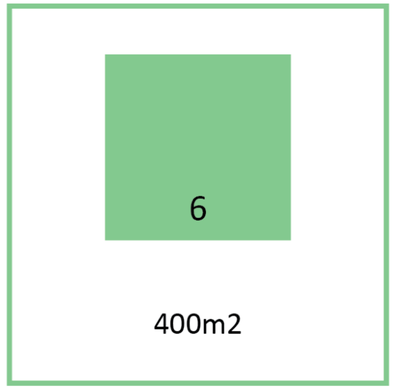
Terraced dwellings



Semi-detached dwellings



Detached dwellings

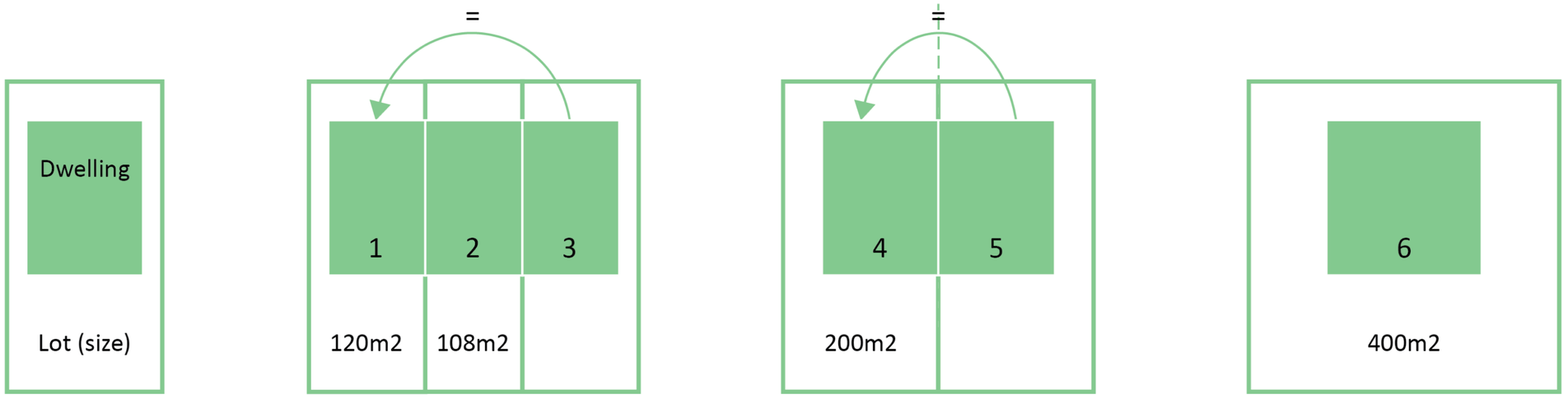


Top view

Terraced dwellings

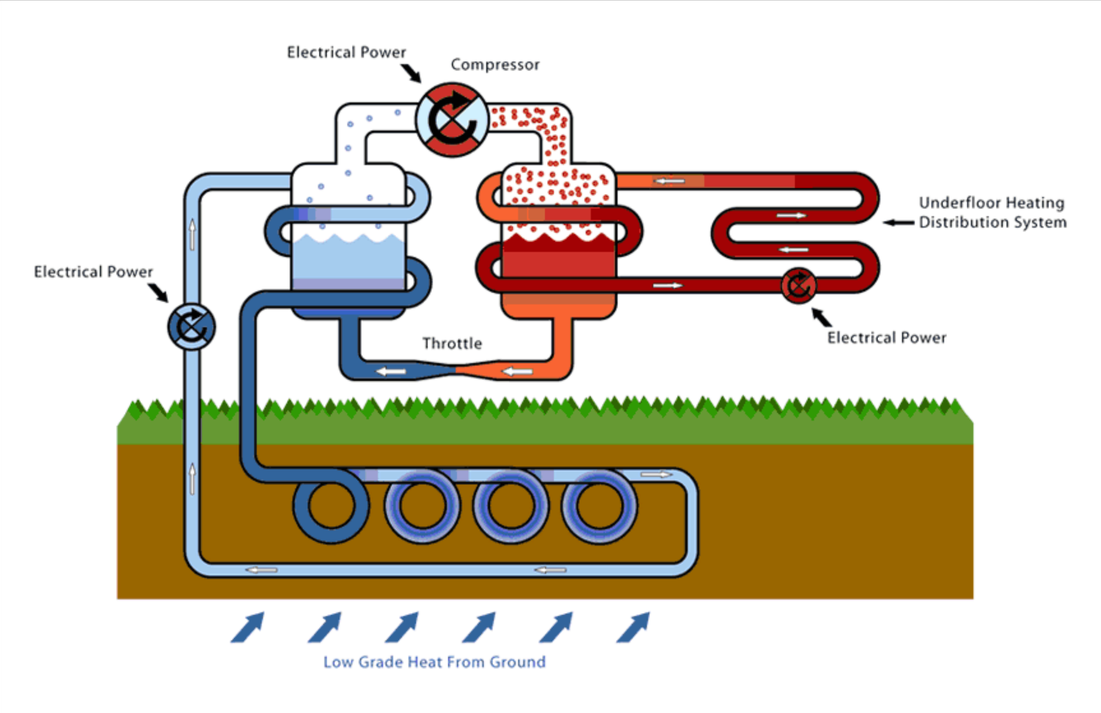
Semi-detached dwellings

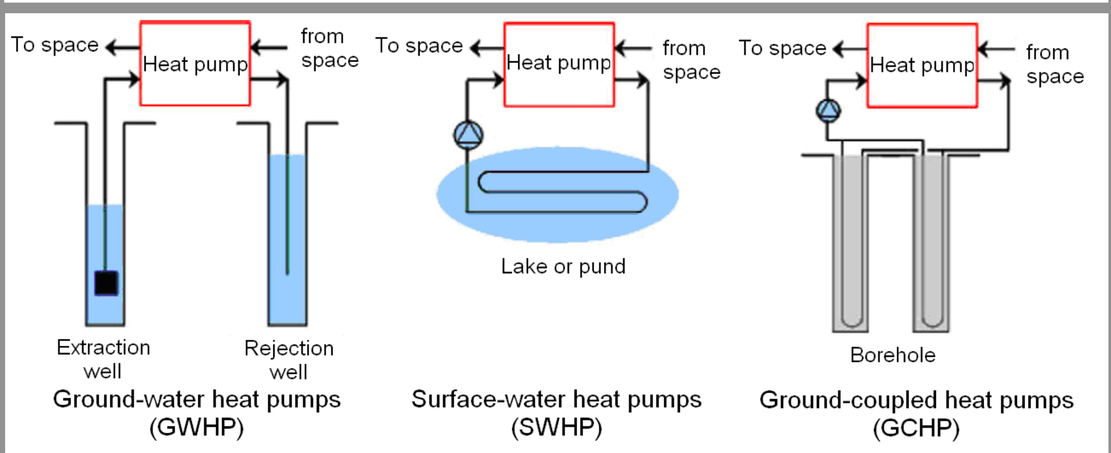
Detached dwellings



	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	 UFA: 100m2	 UFA: 150m2	 UFA: 175m2
B	 UFA: 125m2	 UFA: 125m2	 UFA: 175m2	 UFA: 200m2
C	 UFA: 150m2	 UFA: 150m2	 UFA: 200m2	 UFA: 250m2

Energy supply

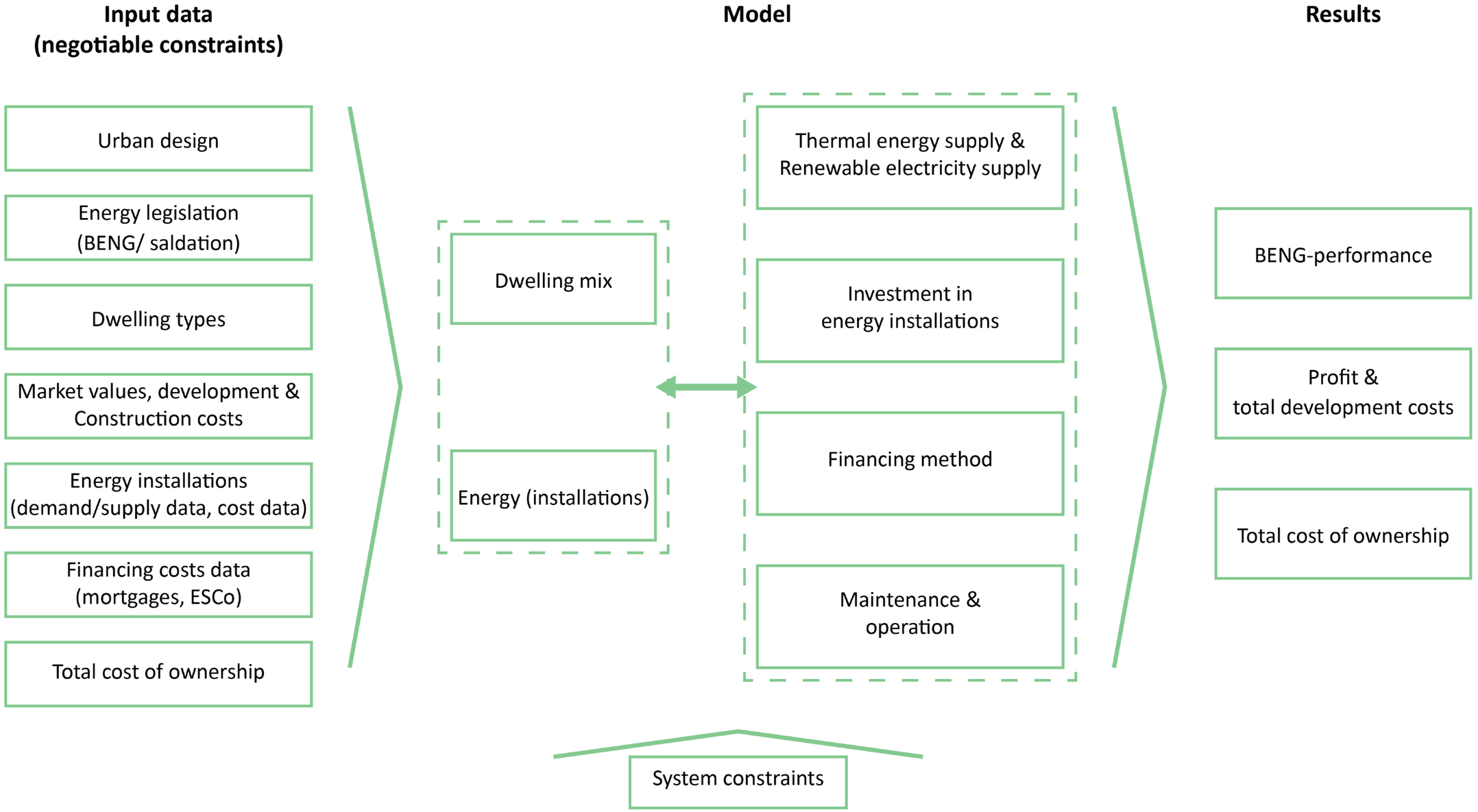




- Thermal:
  - E-boilers
  - Air Source Heat Pump (ASHP)
  - Ground Source Heat Pump (GSHP)
- Electricity
  - PV-panels
  - Wind

https://www.intechopen.com/source/html/49252/media/image23.png
http://aquasourceltd.co.uk/wp-content/uploads/2009/08/heatpumpschematic.gif

Structure of DST



De Oase (part of Veemarkt), Utrecht

Part 5: Added value DST

- Application of DST
- Expert focus group

Application to the case of Van Omme & De Groot, Rotterdam

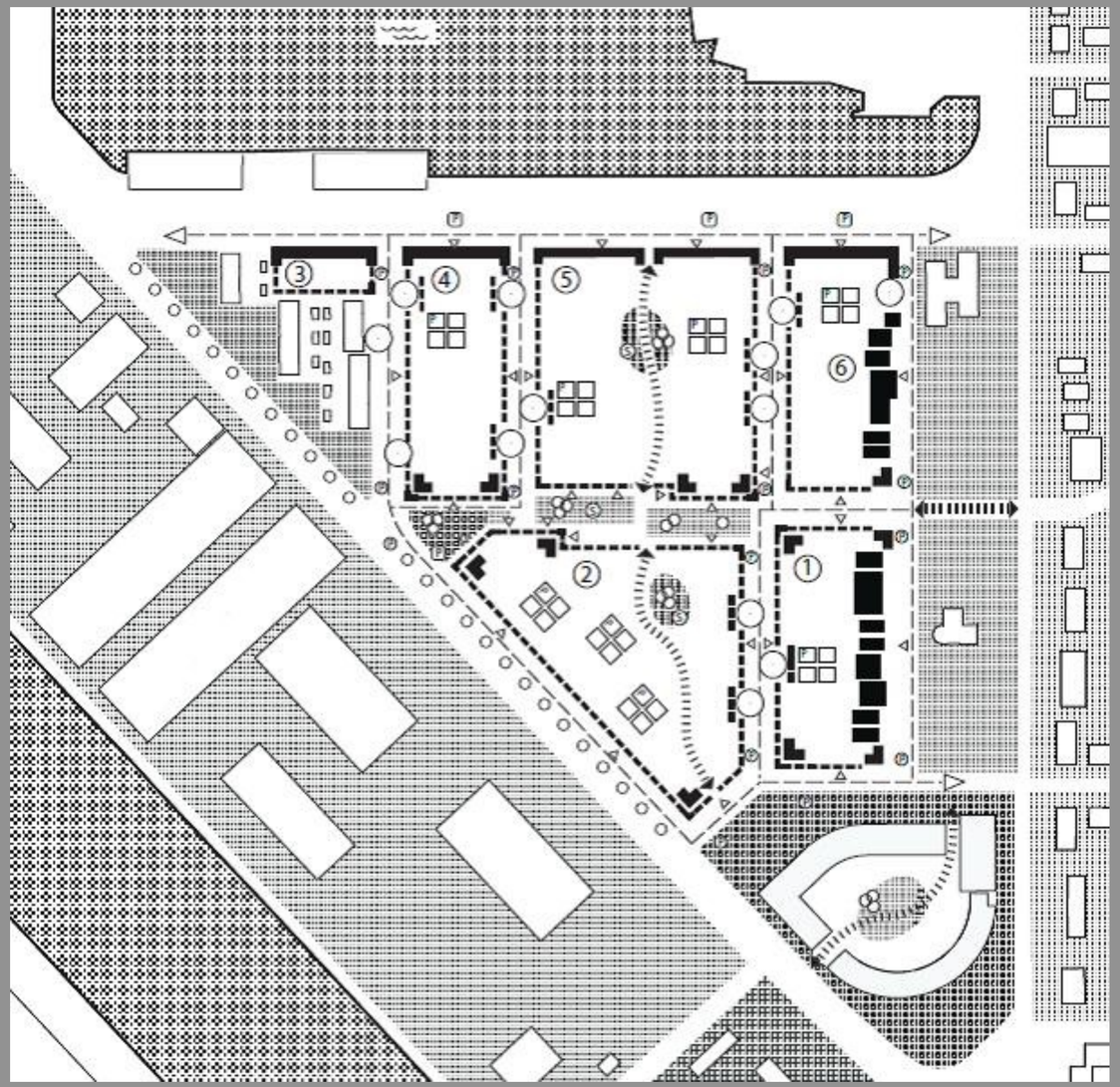
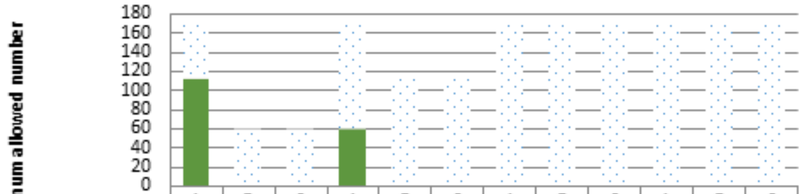


Figure of land-use plan, Gemeente Rotterdam (2013)

- 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

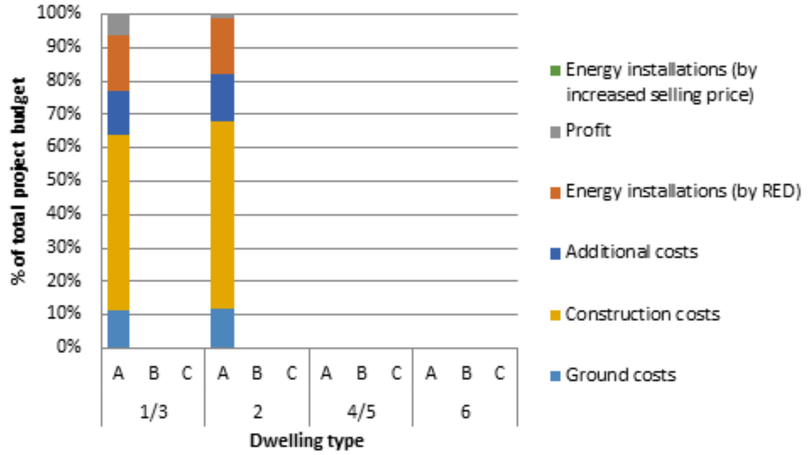
Results

Dwelling mix



	A	B	C	A	B	C	A	B	C	A	B	C
	1/3			2			4/5			6		
Remaining	58	58	58	112	112	112	170	170	170	170	170	170
ZotM: GSHP	112	0	0	58	0	0	0	0	0	0	0	0
ZotM: ASHP	0	0	0	0	0	0	0	0	0	0	0	0
ZotM: E-boilers	0	0	0	0	0	0	0	0	0	0	0	0
BENG: GSHP	0	0	0	0	0	0	0	0	0	0	0	0
BENG: ASHP	0	0	0	0	0	0	0	0	0	0	0	0
BENG: E-boilers	0	0	0	0	0	0	0	0	0	0	0	0

Breakdown of project expenses (ex. VAT)



MAX PROFIT

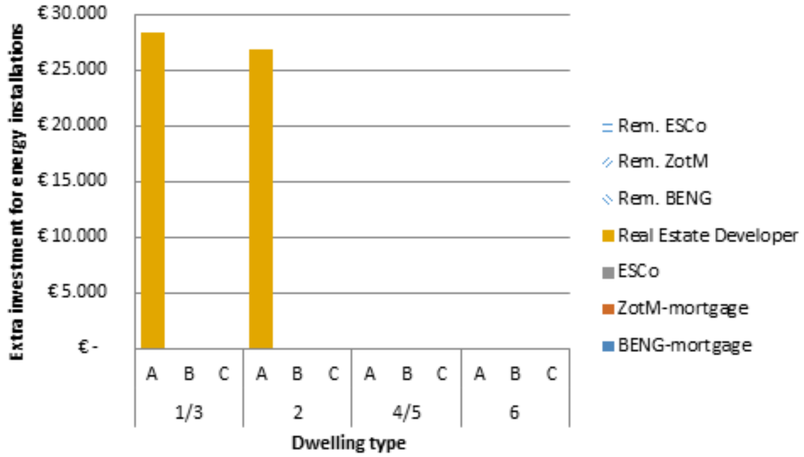
Constraints	Energy ambition:	*Zero-on-the-Meter*
	ESCo:	*Not allowed*

Urban design		% of MAX	MIN	MAX
Lot size	19704	71%	n/a	27700
Dwellings	170	100%	170	170

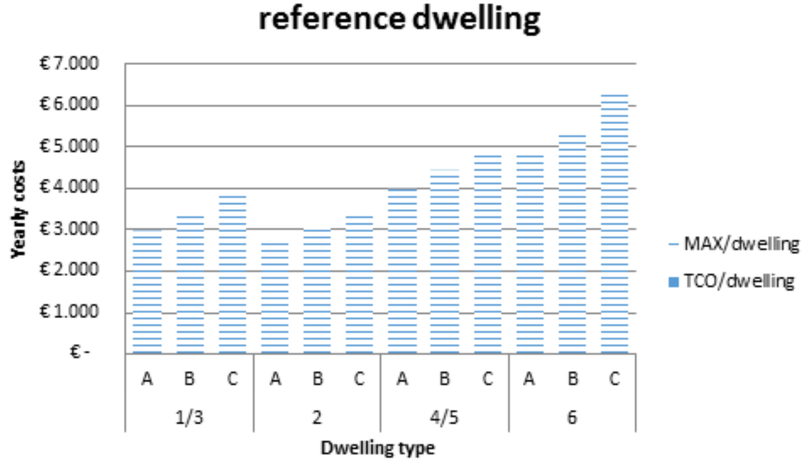
Total inv.	**€**	**(4.737.200,50)**		
Extra in selling price	€	-		
Extra inv. Esco	€	-	+	
Inv. Real estate dev.	€	(4.737.200,50)		
Profit (ex costs)	€	6.120.368,10	+	
Profit (incl costs)	€	1.383.167,60		
Construction costs	€	24.191.800,75	+	*incl energy, excl profit*
Total construction costs	€	25.574.968,35		*incl energy, incl profit*
Profit		**5,41%**		*profit / total costs*

Yearly electricity demand	**(89.525)**	kWh taken from e-grid			
Roof available	0	m2	Type1	Type2	Type3
PV-panels	5.132	m2	2346	5	2780
Wind power	-	kW			

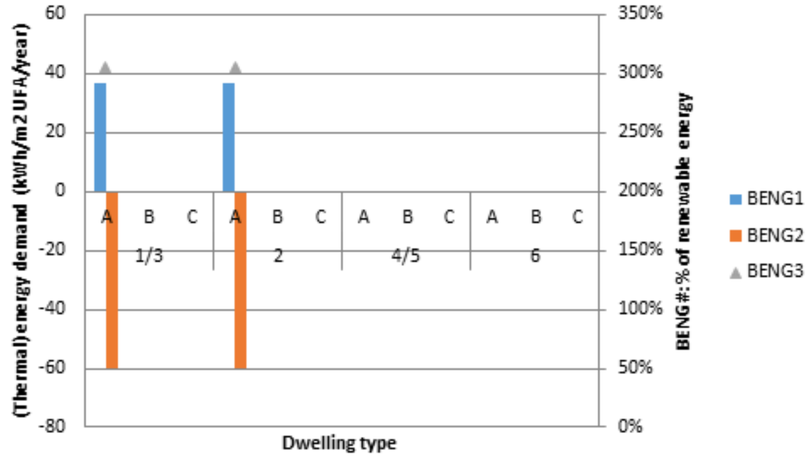
Financing mix



Total cost of ownership in relation to reference dwelling

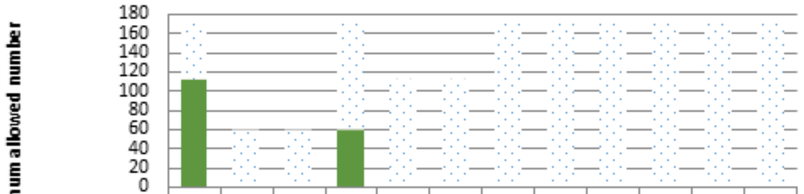


BENG-requirements



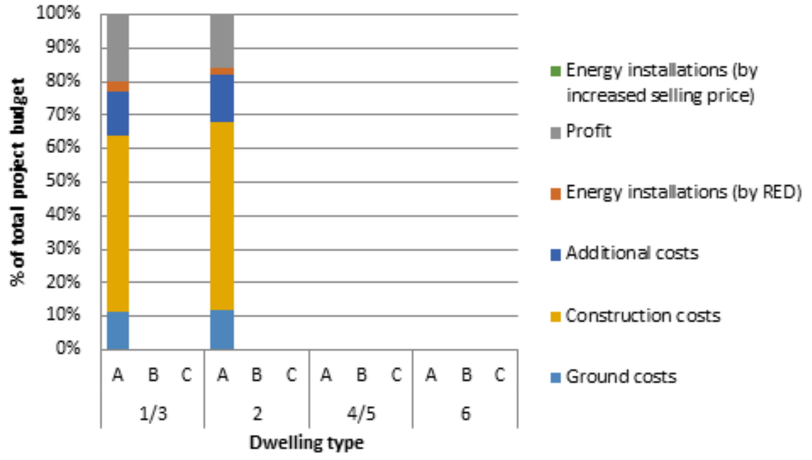
Results

Dwelling mix



	A	B	C	A	B	C	A	B	C	A	B	C
	1/3			2			4/5			6		
Remaining	58	58	58	112	112	112	170	170	170	170	170	170
ZotM: GSHP	112	0	0	58	0	0	0	0	0	0	0	0
ZotM: ASHP	0	0	0	0	0	0	0	0	0	0	0	0
ZotM: E-boilers	0	0	0	0	0	0	0	0	0	0	0	0
BENG: GSHP	0	0	0	0	0	0	0	0	0	0	0	0
BENG: ASHP	0	0	0	0	0	0	0	0	0	0	0	0
BENG: E-boilers	0	0	0	0	0	0	0	0	0	0	0	0

Breakdown of project expenses (ex. VAT)



MAX PROFIT

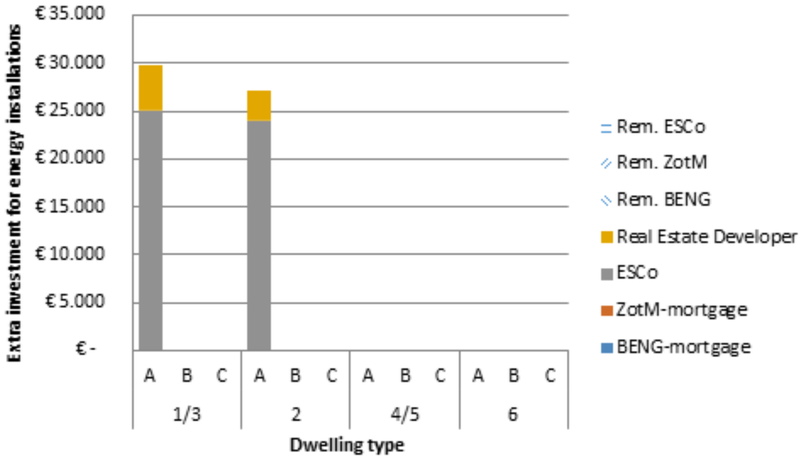
Constraints	Energy ambition:	*Zero-on-the-Meter*
	ESCo:	*Allowed*

Urban design		% of MAX	MIN	MAX
Lot size	19704	71%	n/a	27700
Dwellings	170	100%	170	170

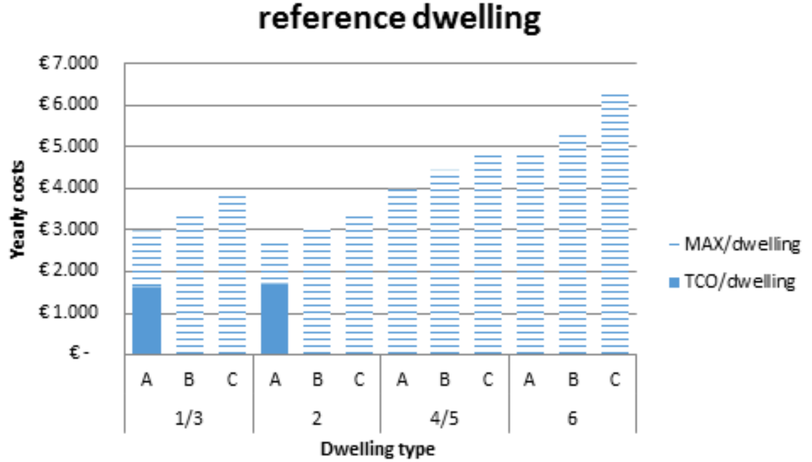
Total inv.	**€**	**(4.890.465,50)**		
Extra in selling price	€	-		
Extra inv. Esco	€	4.181.108,00	+	
Inv. Real estate dev.	€	(709.357,50)		
Profit (ex costs)	€	6.120.368,10	+	
Profit (incl costs)	€	5.411.010,60		
Construction costs	€	24.345.065,75	+	*incl energy, excl profit*
Total construction costs	€	29.756.076,35		*incl energy, incl profit*
Profit		**18,18%**		*profit / total costs*

Yearly electricity demand	**(125.531)**	kWh taken from e-grid			
Roof available	1	m2	Type1	Type2	Type3
PV-panels	5.130	m2	1	706	4424
Wind power	-	kW			

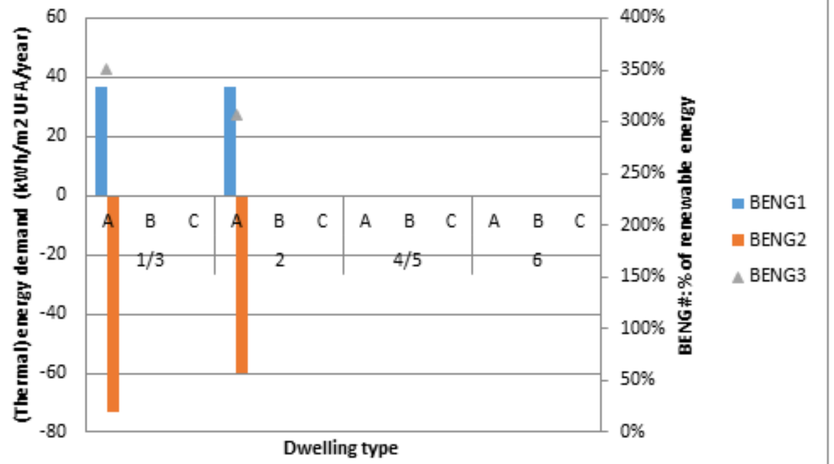
Financing mix



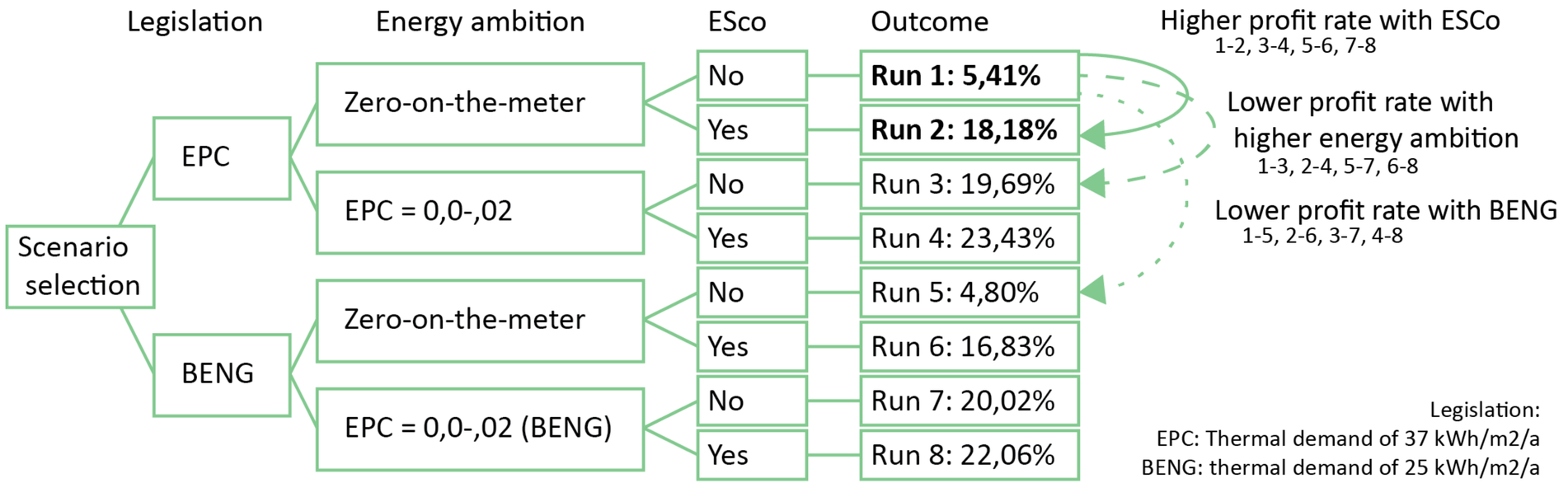
Total cost of ownership in relation to reference dwelling



BENG-requirements



Results



- Higher profit rate with ESCo
- Lower profit rate with higher energy ambition
- Lower profit rate with BENG-legislation

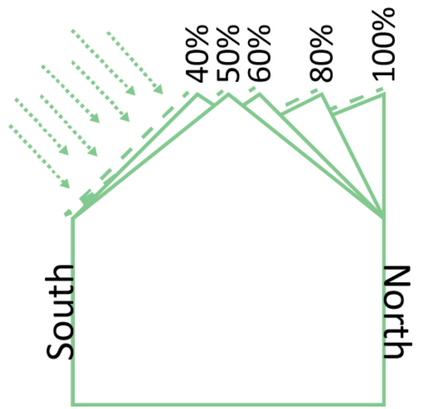
Comparison

	Real life situation	Decision Support Tool
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)	170 terraced dwellings of 100 m2 2:1 (corner : mid-terraced)
Heating installations	170 GSHP	170 GSHP
Financing	Energy installations financed by ESCo	Energy installations financed by ESCo

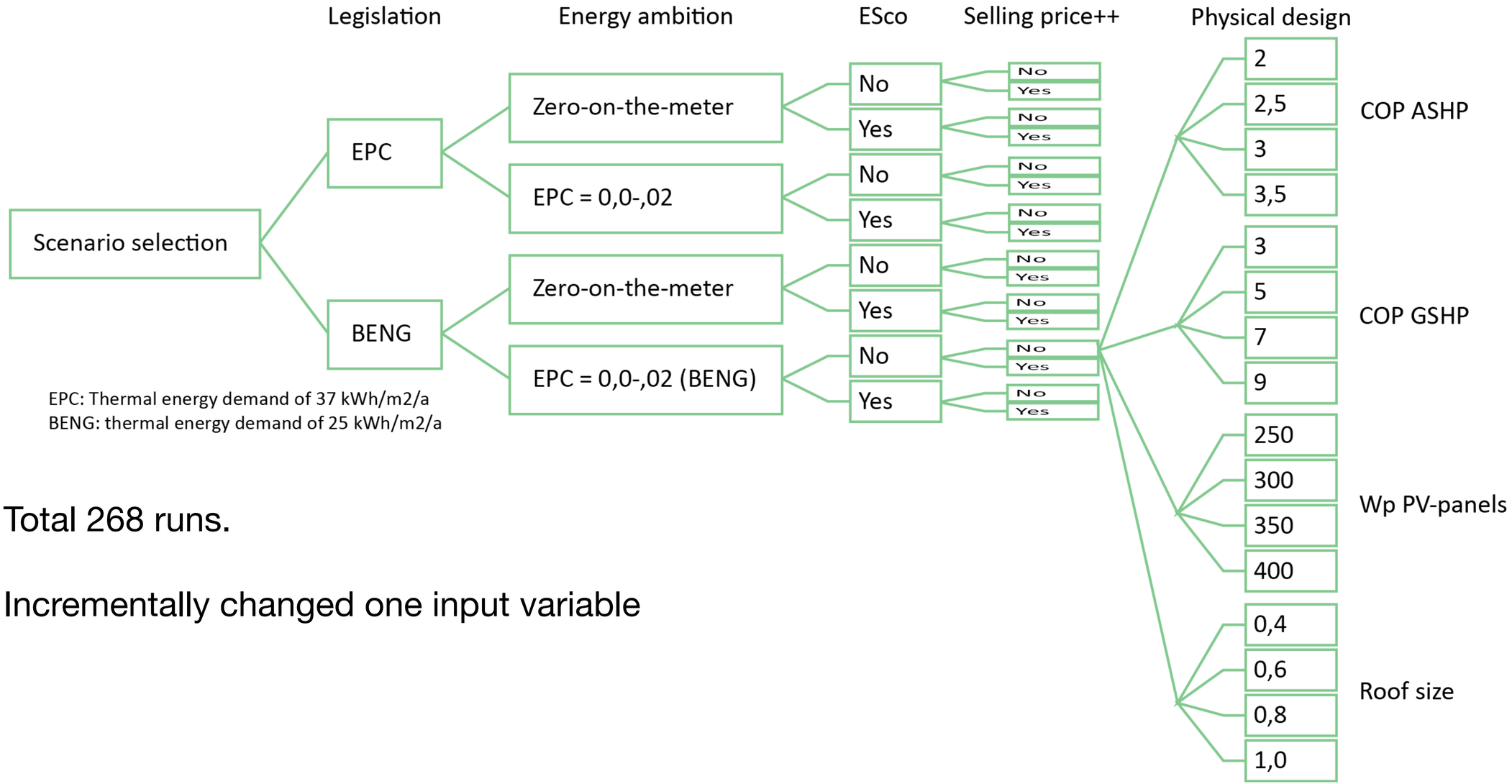
- Same installations and financing method
- Smaller dwellings

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



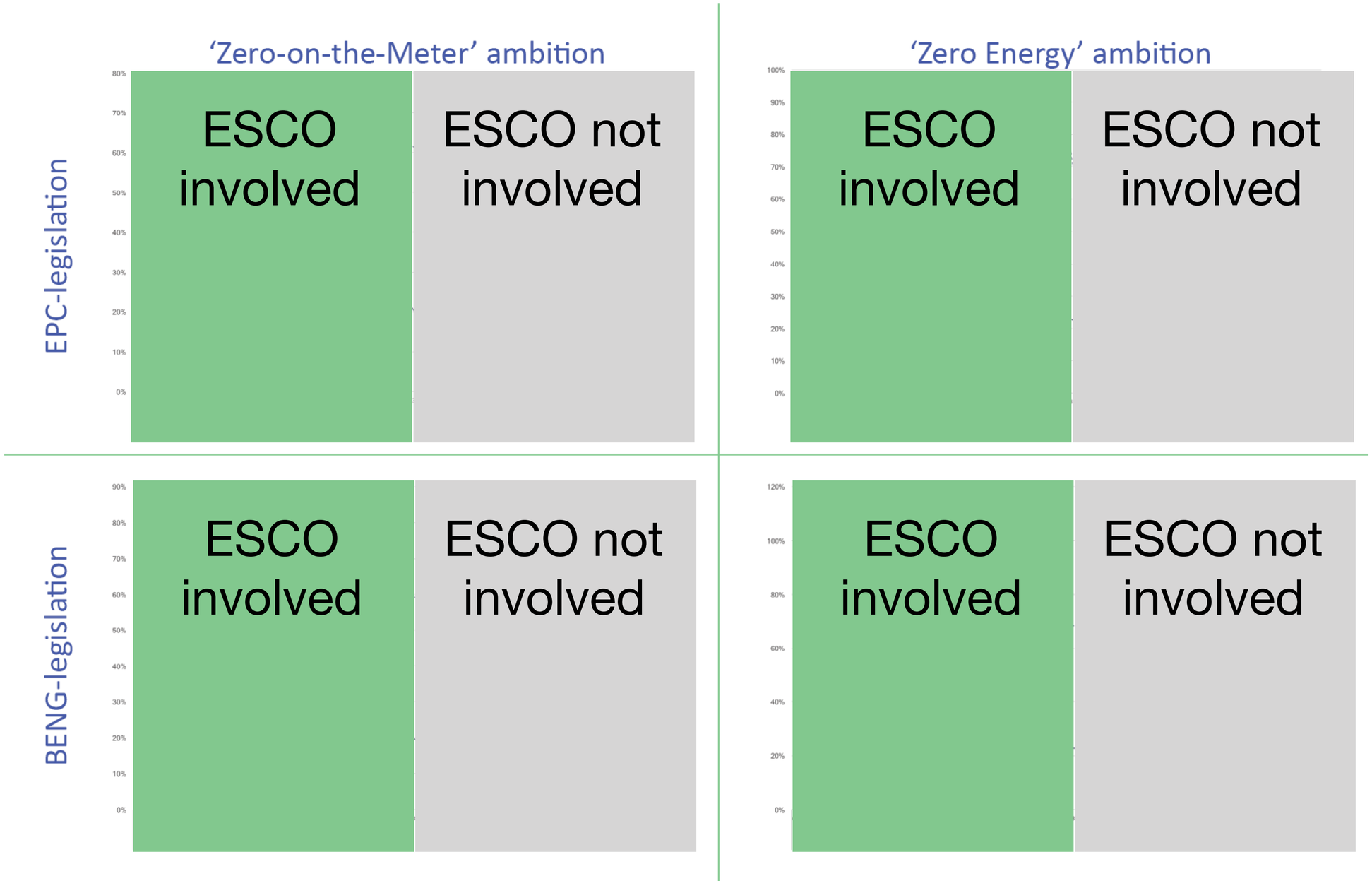
Sensitivity analysis



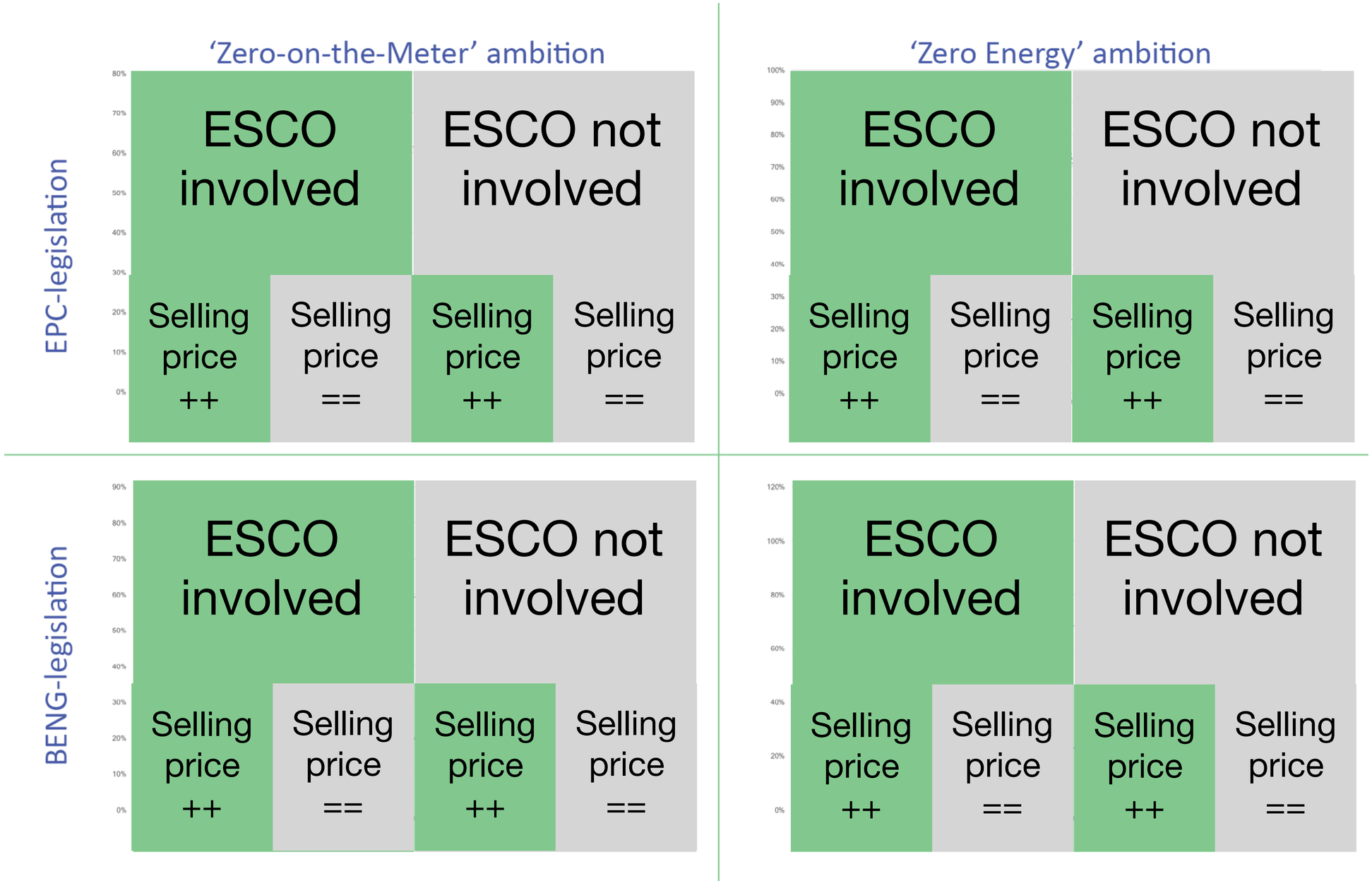
EPC: Thermal energy demand of 37 kWh/m2/a
BENG: thermal energy demand of 25 kWh/m2/a

- Total 268 runs.
- Incrementally changed one input variable

Effect on finance



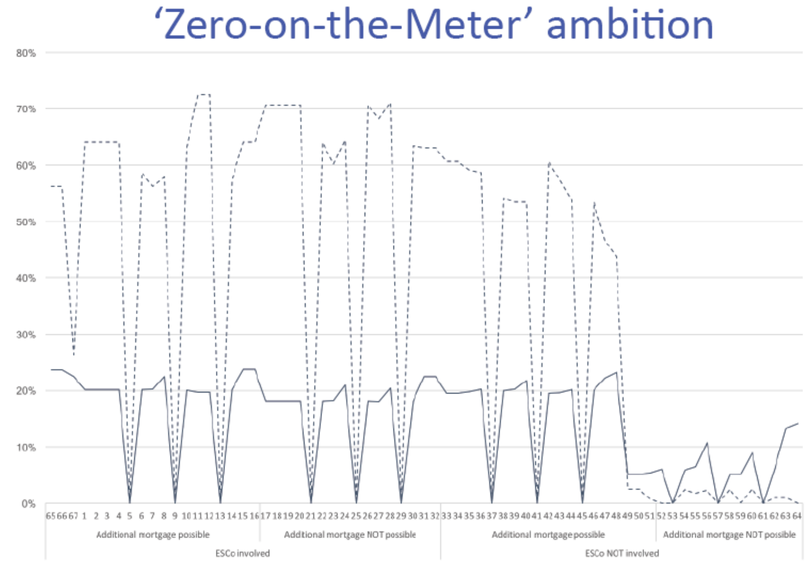
Effect on finance

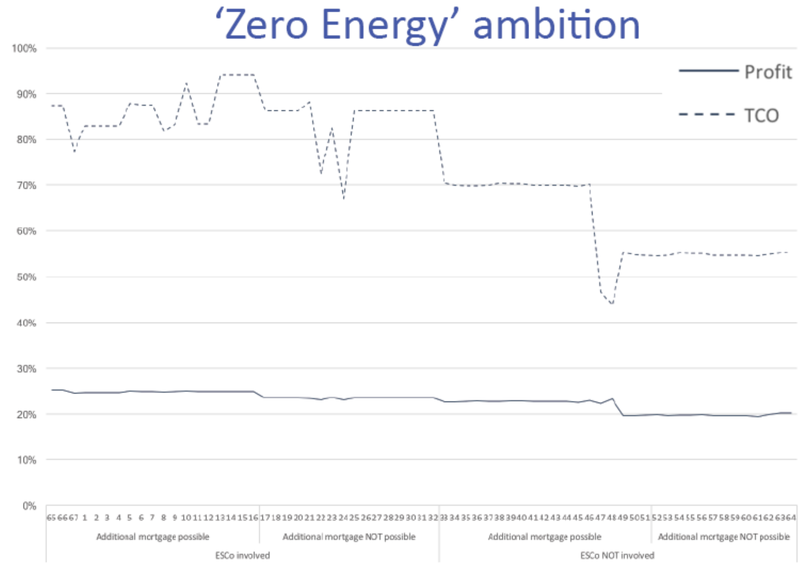


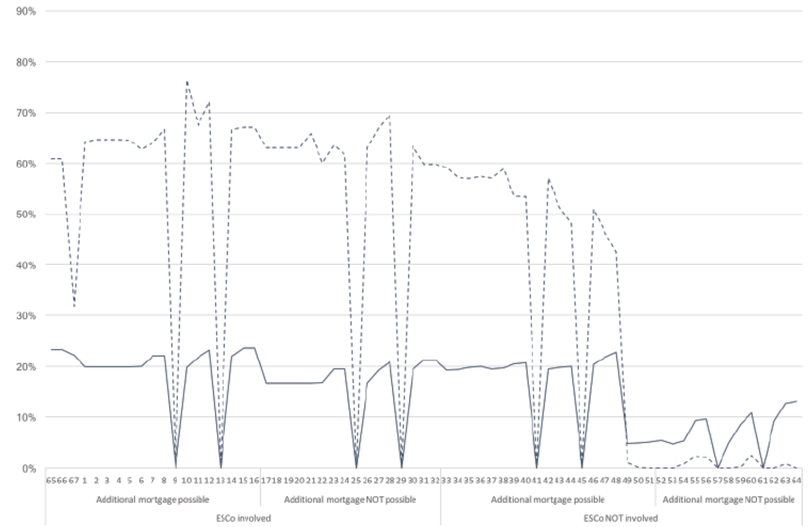
Effect on finance

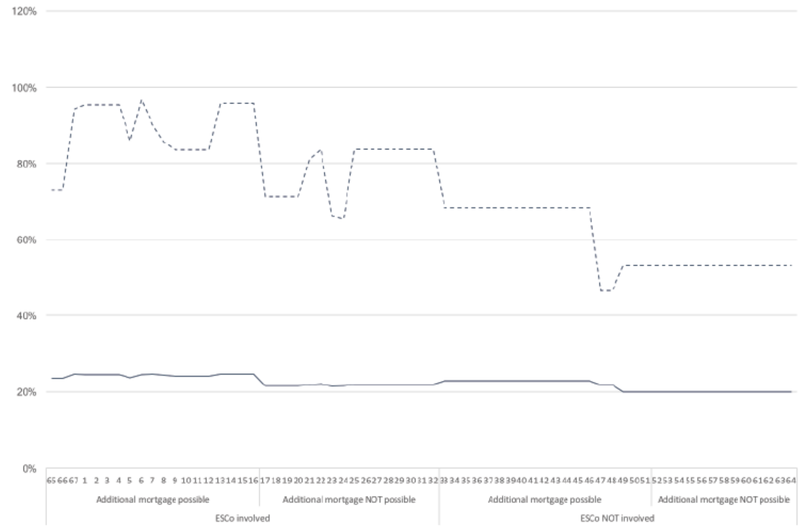
EPC-legislation

BENG-legislation









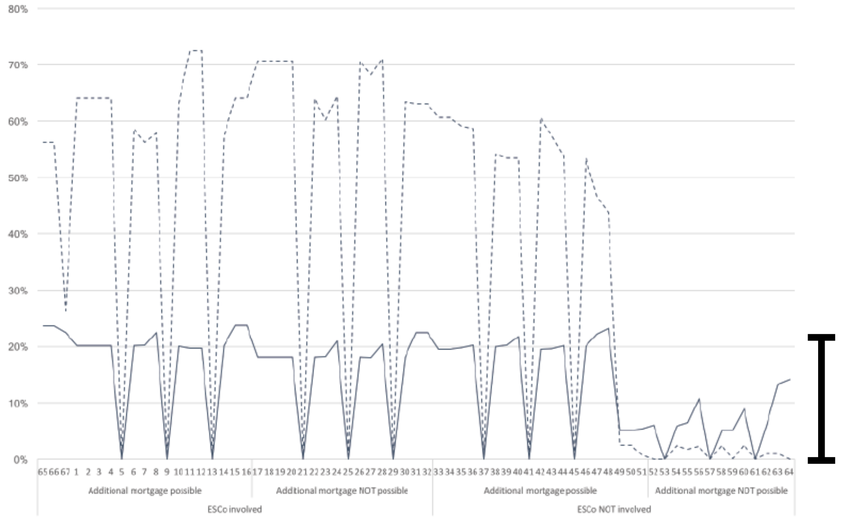
- Increased effect of decisions in higher energy ambition

Effect on finance

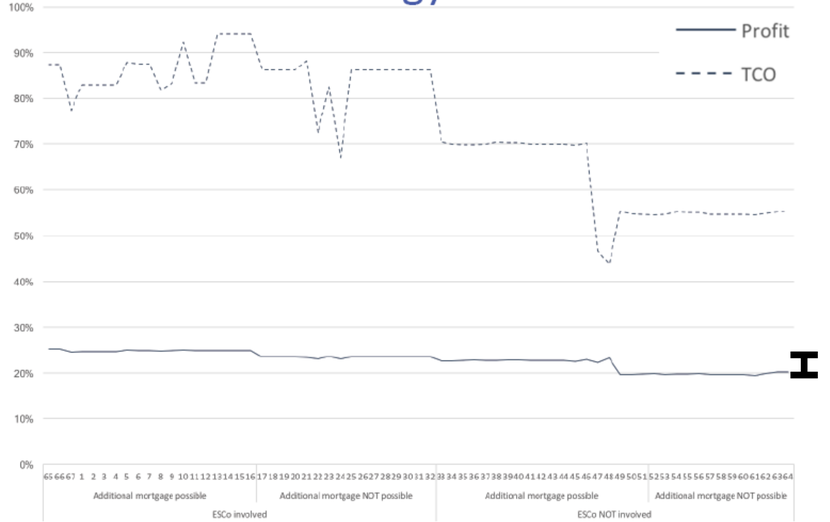
EPC-legislation

BENG-legislation

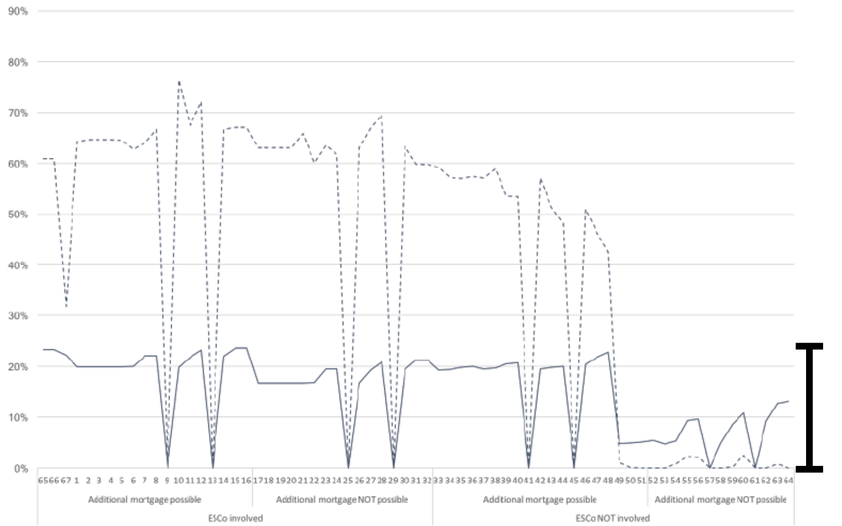
‘Zero-on-the-Meter’ ambition

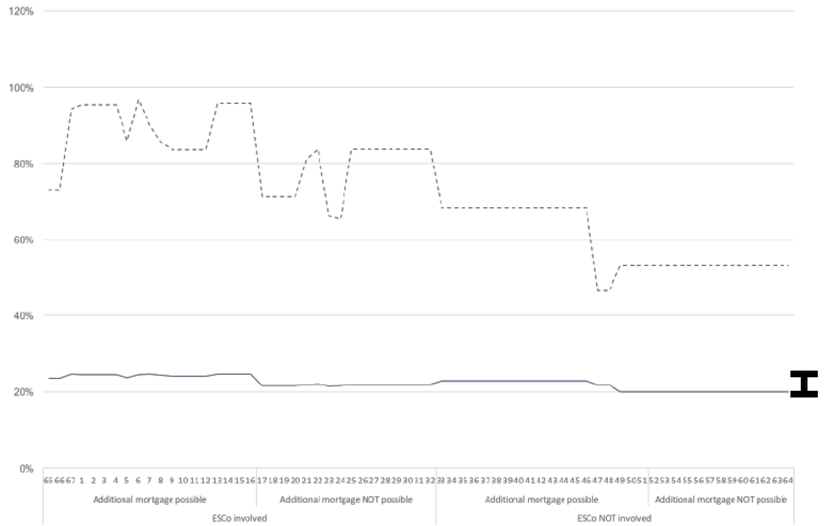


‘Zero Energy’ ambition

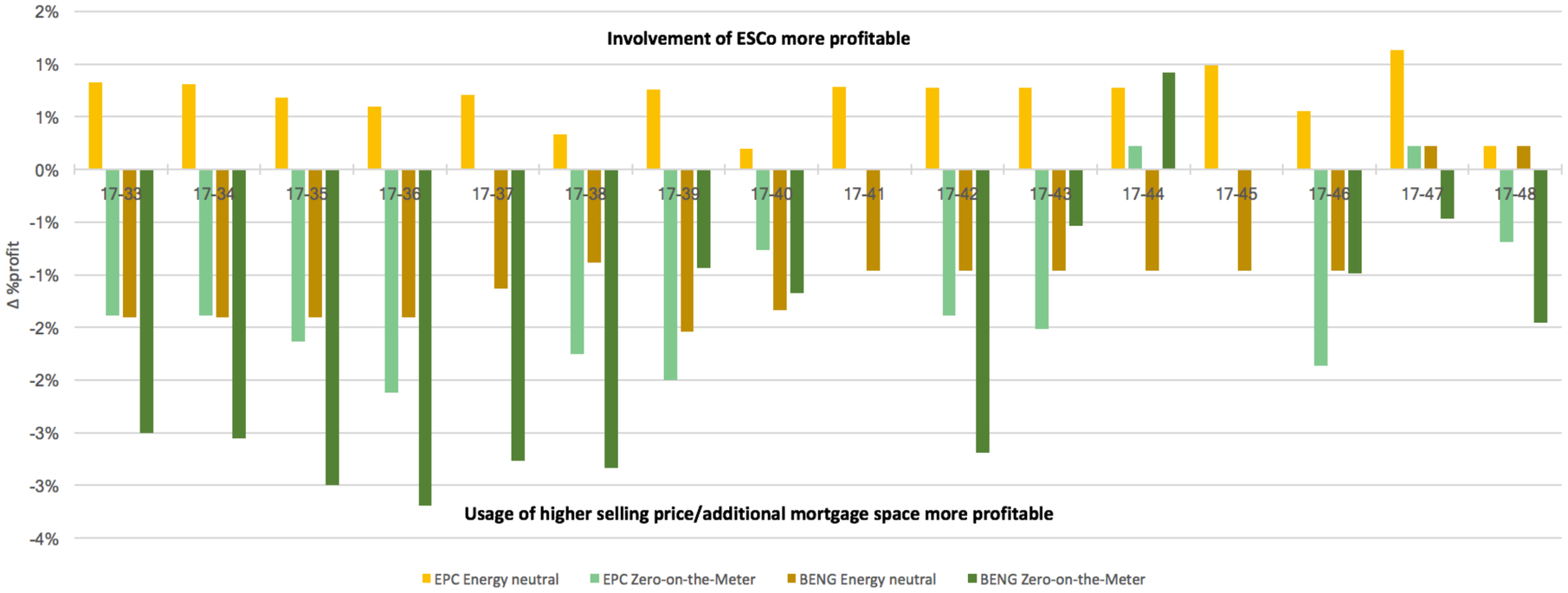


- Increased effect of decisions in higher energy ambition



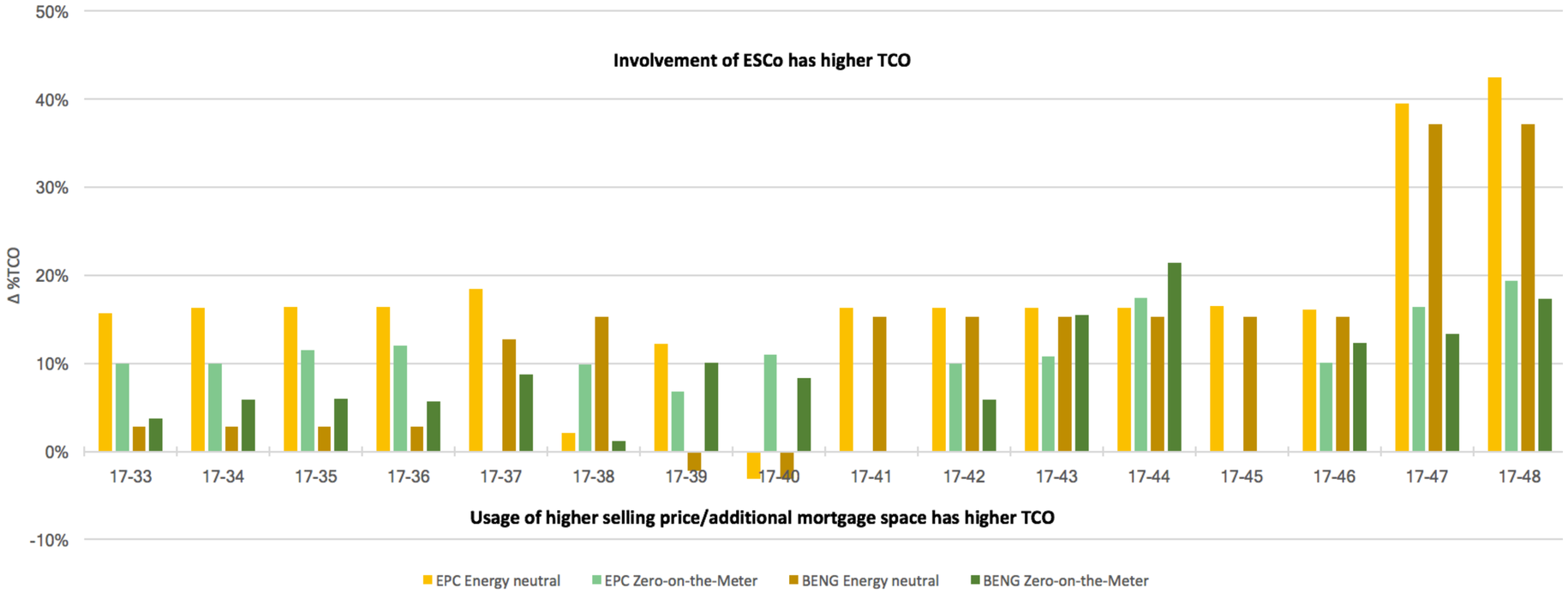


ESCo vs.
additional borrowing capacity



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

ESCo vs.
additional borrowing capacity

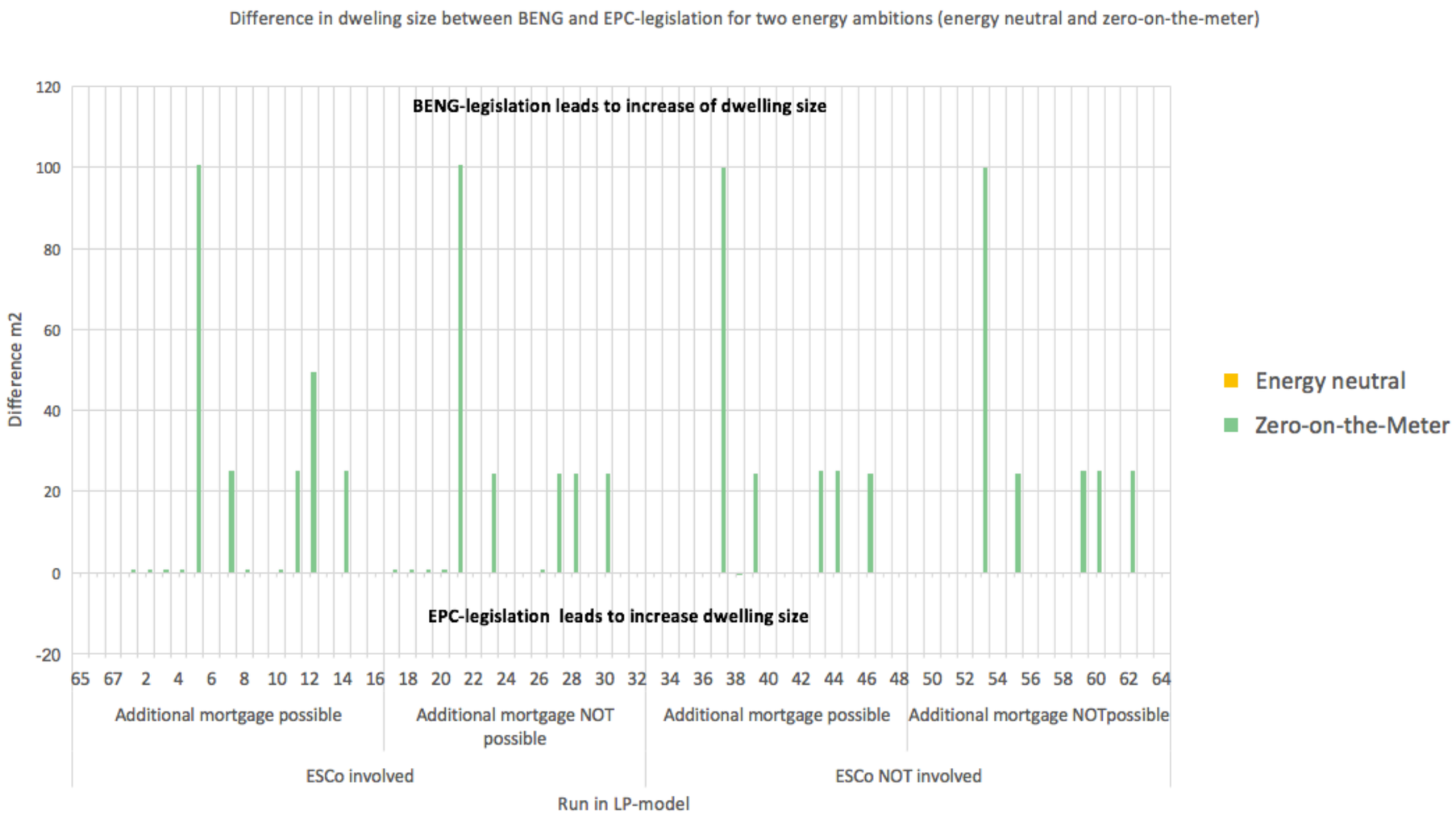


- Increased effect of decisions in higher energy ambition
- Increased selling price often more profitable.
- Increased selling price often lower TCOs.

Effect on installations and dwelling type

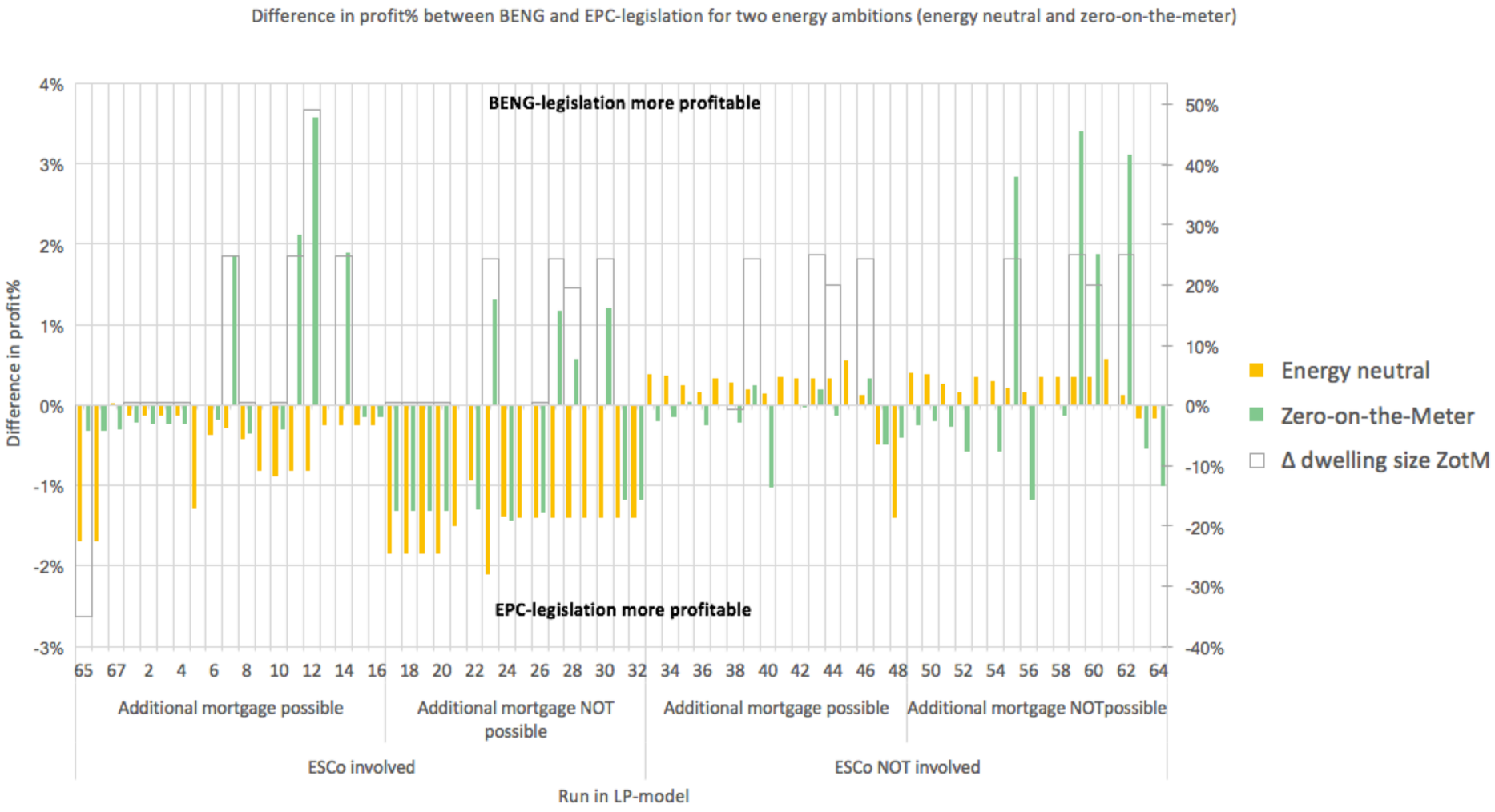
- Increased effect of decisions in higher energy ambition
- Increased selling price often more profitable.
- Increased selling price often lower TCOs.
- Efficiencies and financing method influences optimal energy installations

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

Legislation - profit



- 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

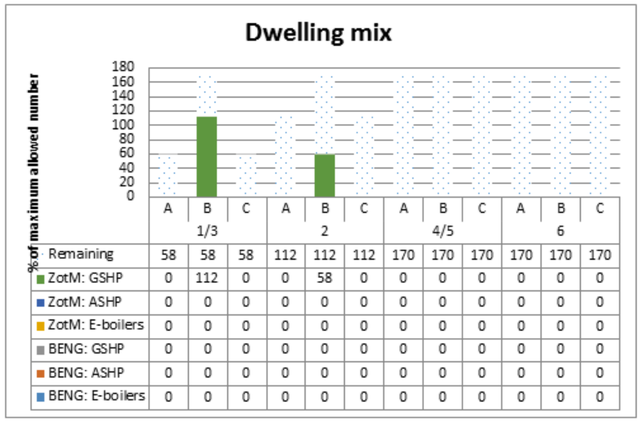
Round 2

- Dwelling size 1st run was lower (100m2)

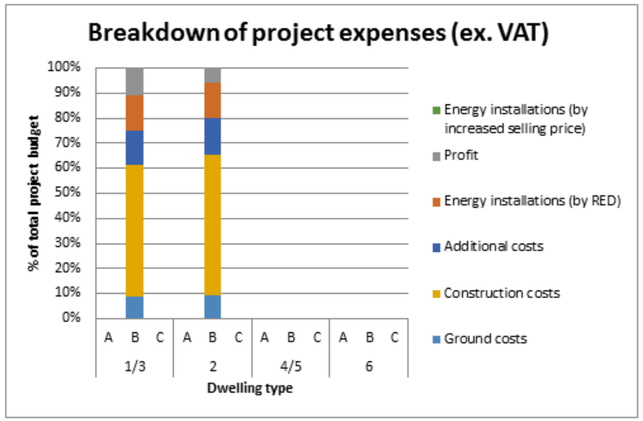
- New input:
  - COP GSHP
  - PV-panel

Results round 2

- Excluding ESCo: 10,15% profit



	A	B	C	A	B	C	A	B	C	A	B	C
	1/3			2			4/5			6		
Remaining	58	58	58	112	112	112	170	170	170	170	170	170
ZotM: GSHP	0	112	0	0	58	0	0	0	0	0	0	0
ZotM: ASHP	0	0	0	0	0	0	0	0	0	0	0	0
ZotM: E-boilers	0	0	0	0	0	0	0	0	0	0	0	0
BENG: GSHP	0	0	0	0	0	0	0	0	0	0	0	0
BENG: ASHP	0	0	0	0	0	0	0	0	0	0	0	0
BENG: E-boilers	0	0	0	0	0	0	0	0	0	0	0	0



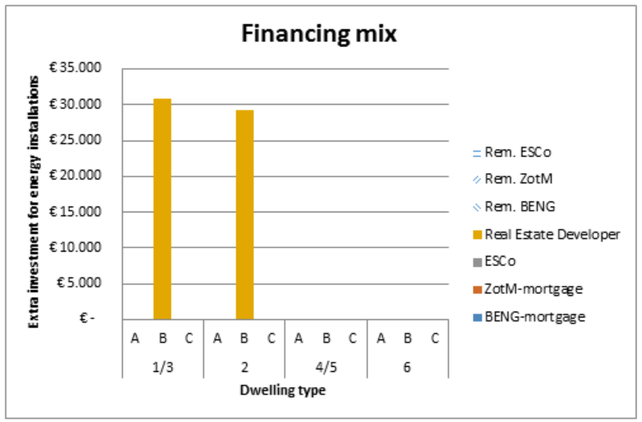
MAX PROFIT

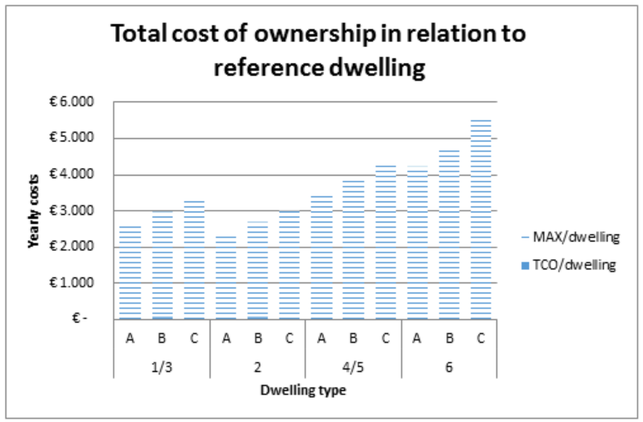
Constraints	Energy ambition:	*Zero-on-the-Meter*
	ESCo:	*Not allowed*

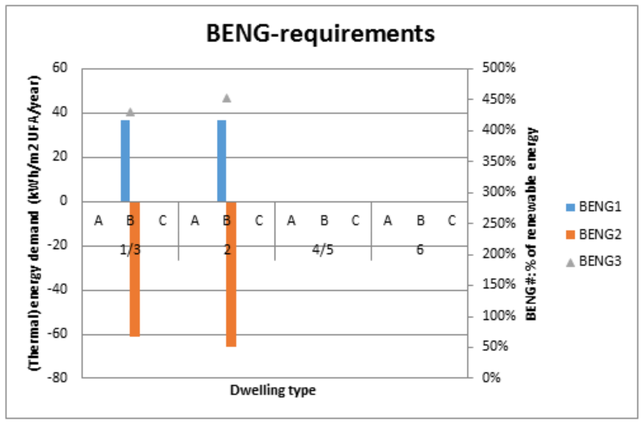
Urban design		% of MAX	MIN	MAX
Lot size	19704	71%	n/a	27700
Dwellings	170	100%	170	170

Total inv.	**€**	**(5.146.477,50)**		
Extra in selling price	€	-		
Extra inv. Esco	€	-	+	
Inv. Real estate dev.	€	(5.146.477,50)		
Profit (ex costs)	€	8.475.767,62	+	
Profit (incl costs)	€	3.329.290,12		
Construction costs	€	29.464.727,81	+	*incl energy, excl profit*
Total construction costs	€	32.794.017,93		*incl energy, incl profit*
Profit		**10,15%**		*profit / total costs*

Yearly electricity demand	**(100.129)**	kWh taken from e-grid			
Roof available	3	m2	Type1	Type2	Type3
PV-panels	5.129	m2	3368	0	1761
Wind power	-	kW			

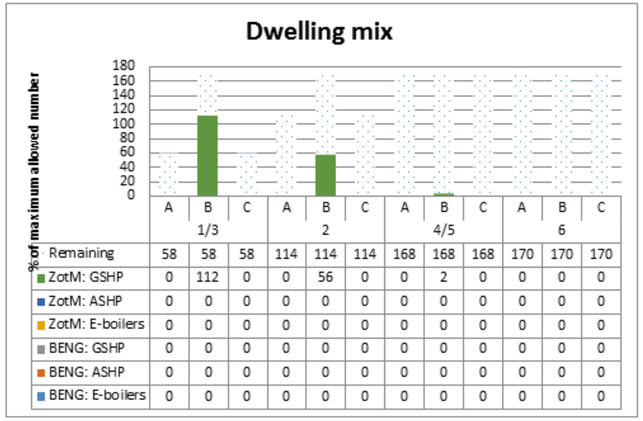




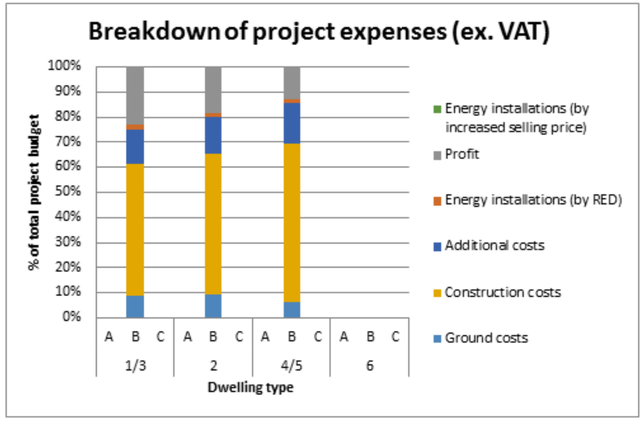


Results round 2

- Including ESCo; 20,70% profit
  - Profit: additional



	A	B	C	A	B	C	A	B	C	A	B	C
	1/3			2			4/5			6		
Remaining	58	58	58	114	114	114	168	168	168	170	170	170
ZotM: GSHP	0	112	0	0	56	0	0	2	0	0	0	0
ZotM: ASHP	0	0	0	0	0	0	0	0	0	0	0	0
ZotM: E-boilers	0	0	0	0	0	0	0	0	0	0	0	0
BENG: GSHP	0	0	0	0	0	0	0	0	0	0	0	0
BENG: ASHP	0	0	0	0	0	0	0	0	0	0	0	0
BENG: E-boilers	0	0	0	0	0	0	0	0	0	0	0	0



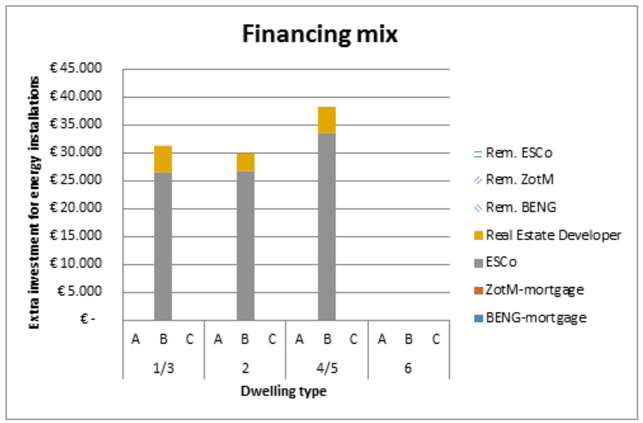
MAX PROFIT

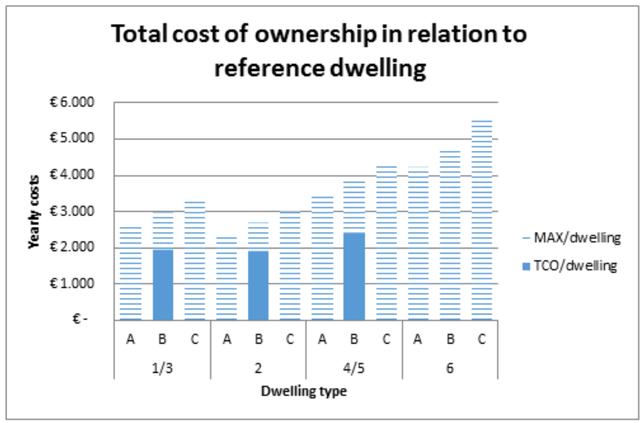
Constraints	Energy ambition:	*Zero-on-the-Meter*
	ESCo:	*Allowed*

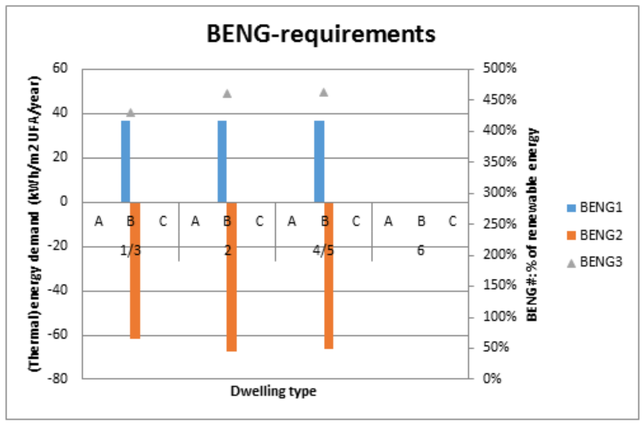
Urban design		% of MAX	MIN	MAX
Lot size	19888	72%	n/a	27700
Dwellings	170	100%	170	170

Total inv.	€	**(5.241.097,35)**		
Extra in selling price	€	-		
Extra inv. Esco	€	4.528.601,10	+	
Inv. Real estate dev.	€	(712.496,25)		
Profit (ex costs)	€	8.481.258,74	+	
Profit (incl costs)	€	7.768.762,49		
Construction costs	€	29.758.815,23	+	*incl energy, excl profit*
Total construction costs	€	37.527.577,71		*incl energy, incl profit*
Profit		**20,70%**		*profit / total costs*

Yearly electricity demand	**(106.980)**	kWh taken from e-grid			
Roof available	75	m2	Type1	Type2	Type3
PV-panels	5.080	m2	5080	0	0
Wind power	-	kW			







Comparison round 2

	Real life situation	Round 2 with ESCo
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

RijswijkBuiten, Rijswijk

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.

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Business case optimisation for the development of energy neutral residential neighbourhoods

It is commercially possible to develop ZOM-neighbourhoods

Thank you for your attention.

Business case optimisation for the development of energy neutral residential neighbourhoods

Marco Vogelzang

P5 Presentation
November 10, 2017

Mentor team:
Y. (Yawei) Chen
Urban Development Management

R. (Ruud) Binnekamp
Real Estate Management, Design and Decision Systems

R.J. (Reinout) Kleinhans
External examiner, OTB

TU Delft
Faculty of Architecture and the Built Environment
MSc Management in the Built Environment

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).

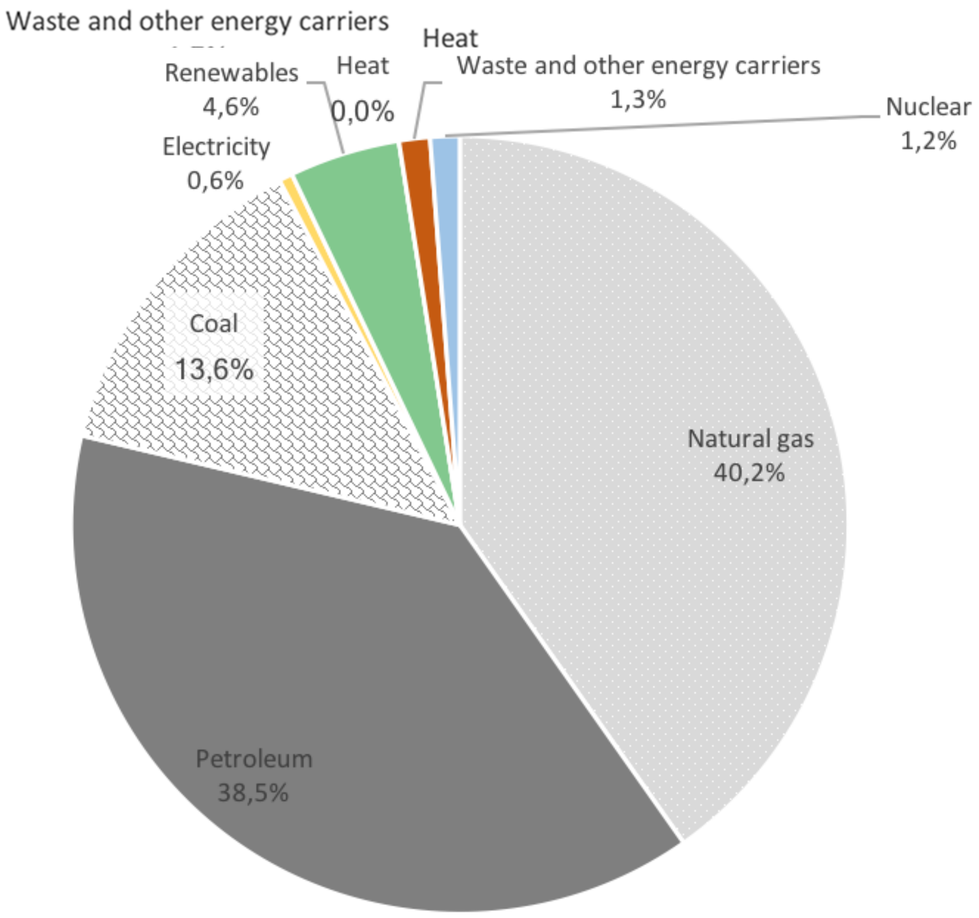
Recommendations

- 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).

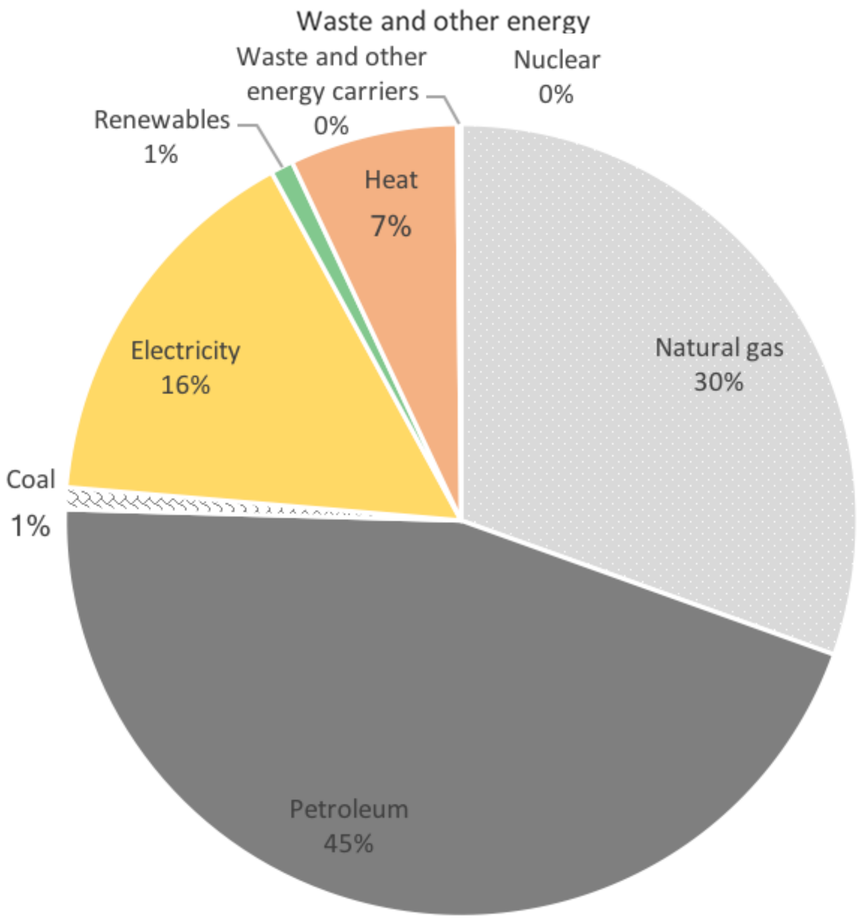
Recommendations

- 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



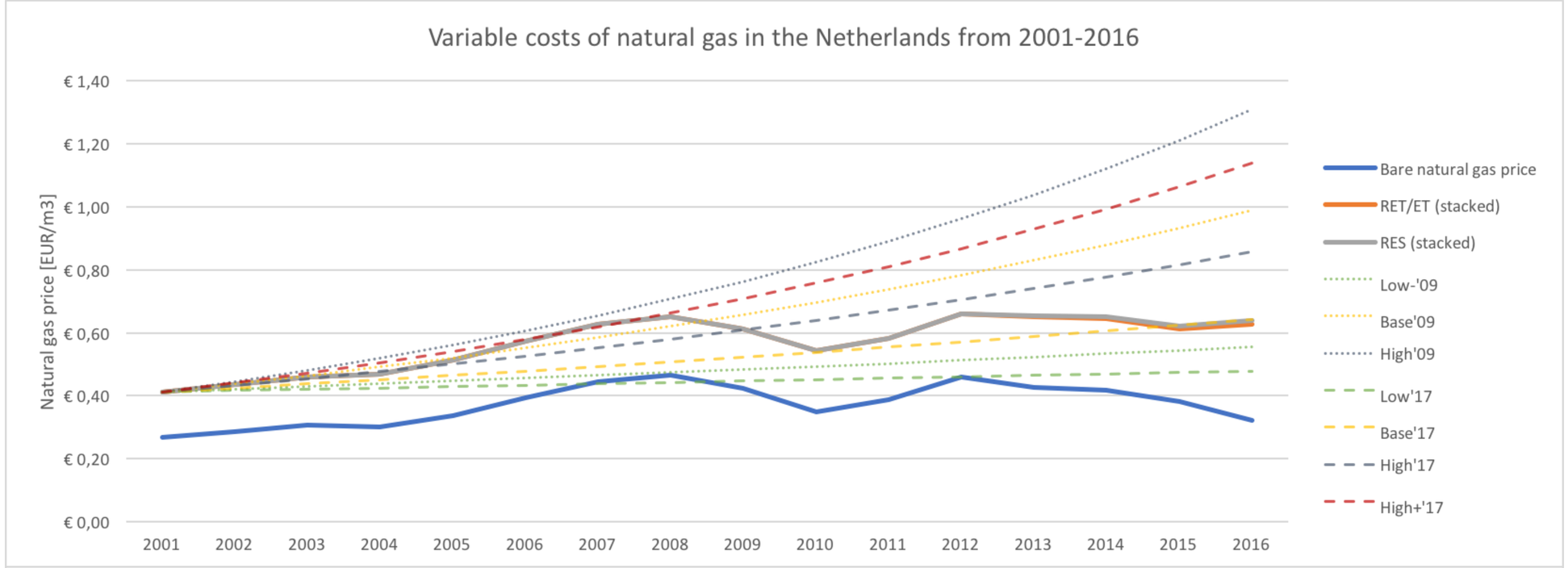
Primary energy usage
2016



Final energy usage
2016

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

Figures based on CBS (2017)



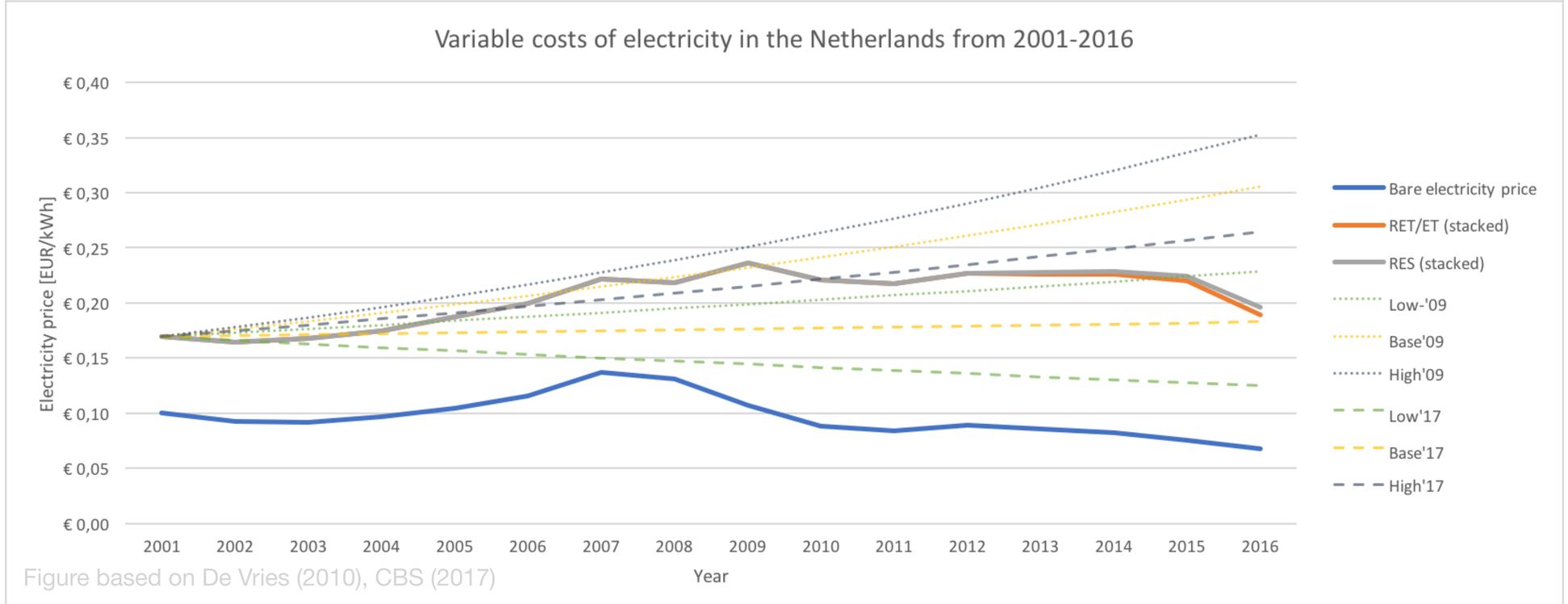


Figure based on De Vries (2010), CBS (2017)

Growth in usage of heat pumps

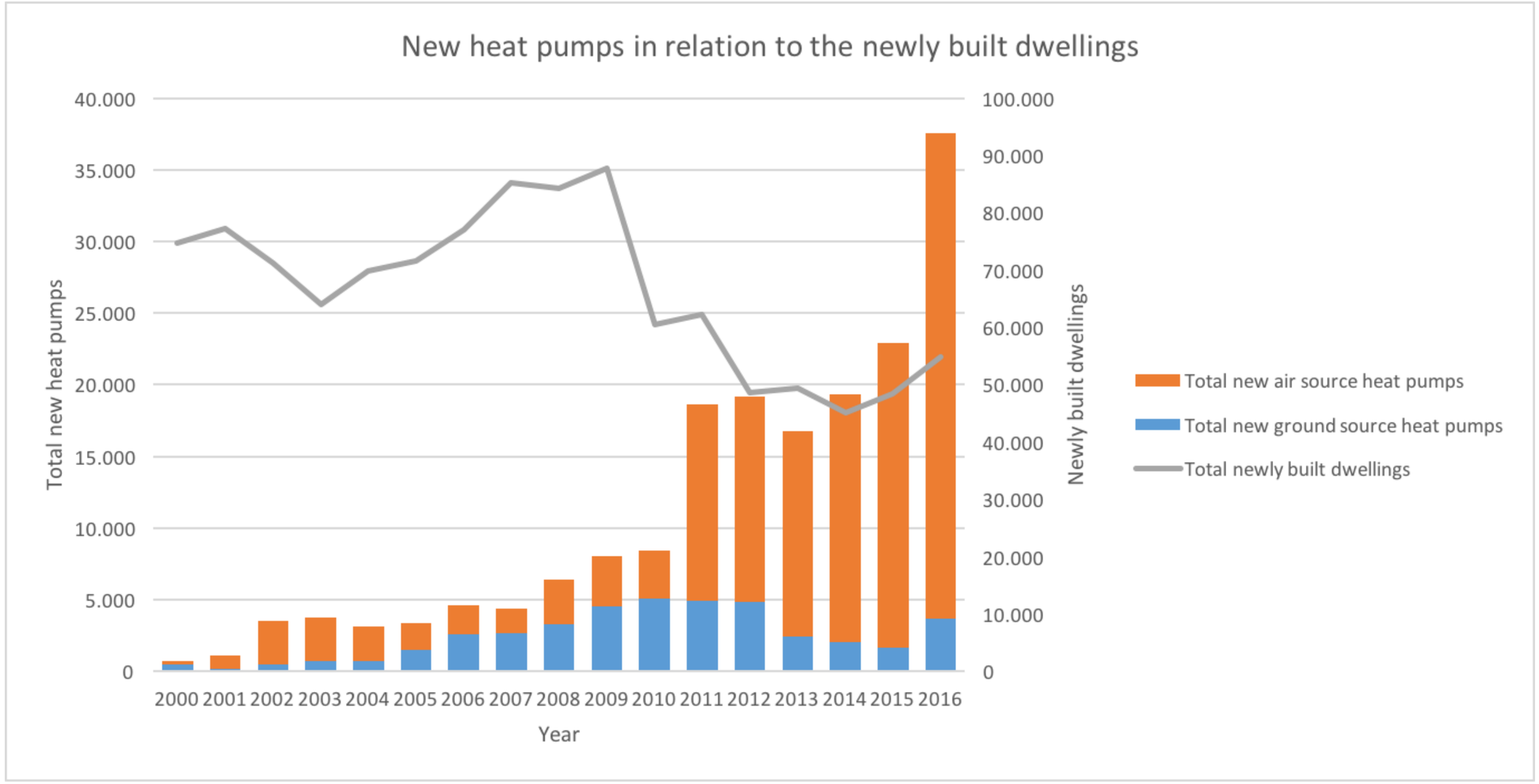


Figure based on Van de Griendt (2016) & CBS, 2017