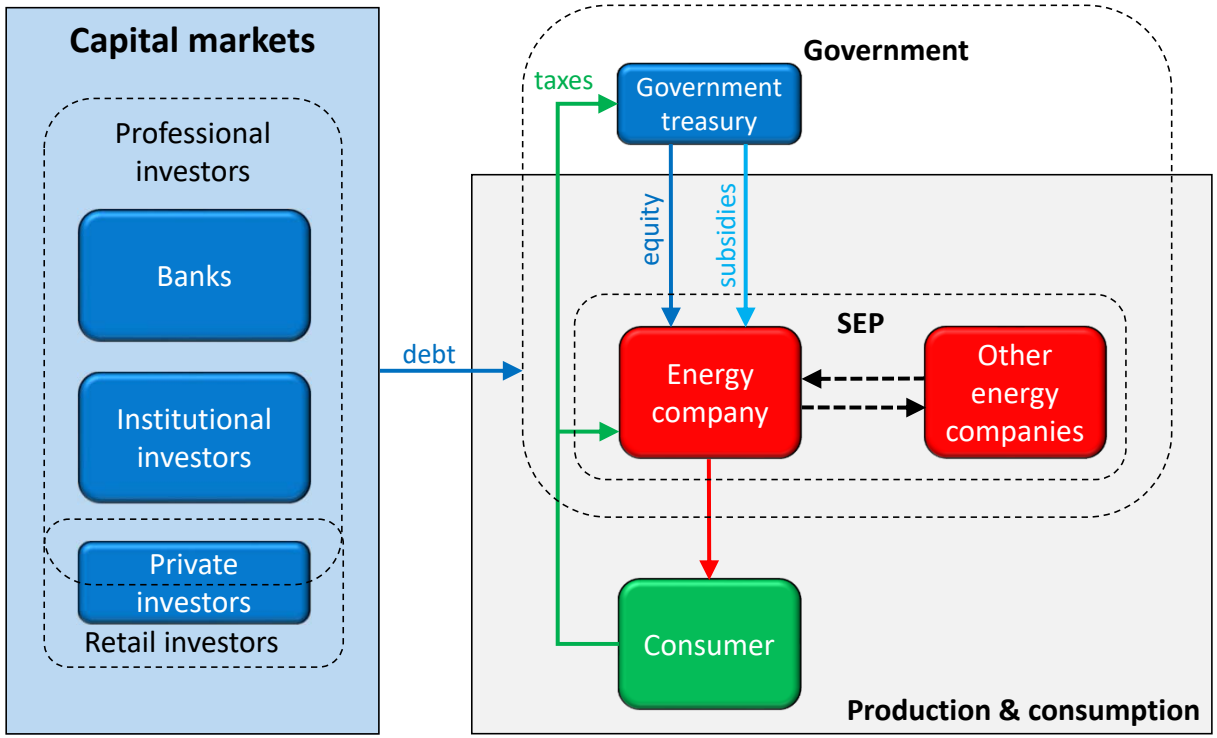
Appendix A: Typical exchanging relationships by market organization

Section A.1: organisation of the energy market in the past



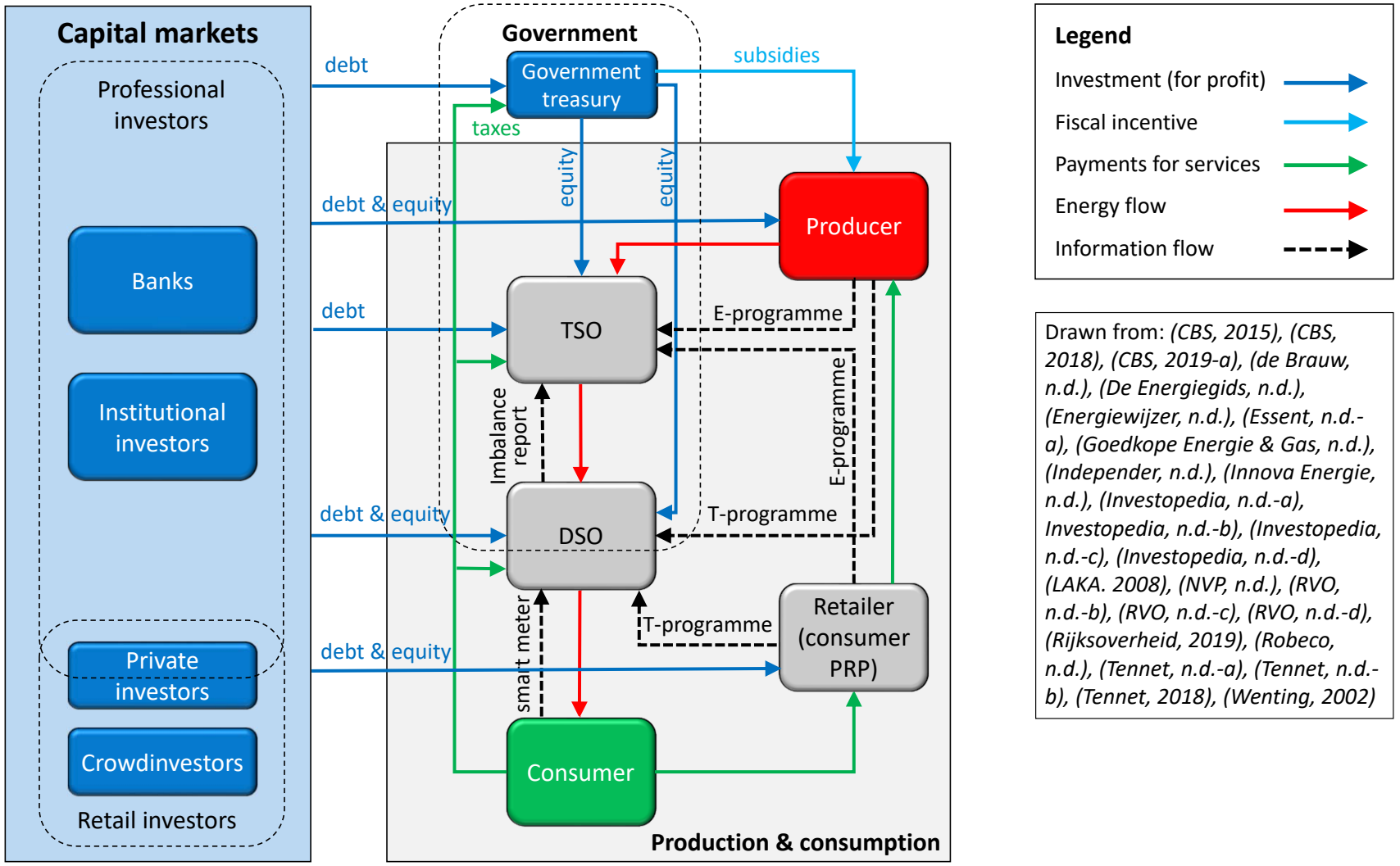
Legend

- Investment (for profit)
- Fiscal incentive
- Payments for services
- Energy flow
- Information flow

Drawn from: *(CBS, 2015), (De Energiegids, n.d.), (Energiewijzer, n.d.), (Innova Energie, n.d.), (Investopedia, n.d.-a), (Investopedia, n.d.-b), (Investopedia, n.d.-d), (LAKA. 2008), (NVP, n.d.), (Rijksoverheid, 2019), (Robeco, n.d.)*

Drawn from: (CBS, 2015), (De Energiegids, n.d.), (Energiewijzer, n.d.), (Innova Energie, n.d.), (Investopedia, n.d.-a), (Investopedia, n.d.-b), (Investopedia, n.d.-d), (LAKA. 2008), (NVP, n.d.), (Rijksoverheid, 2019), (Robeco, n.d.)

Section A.2: organisation of the energy market today – typical consumer



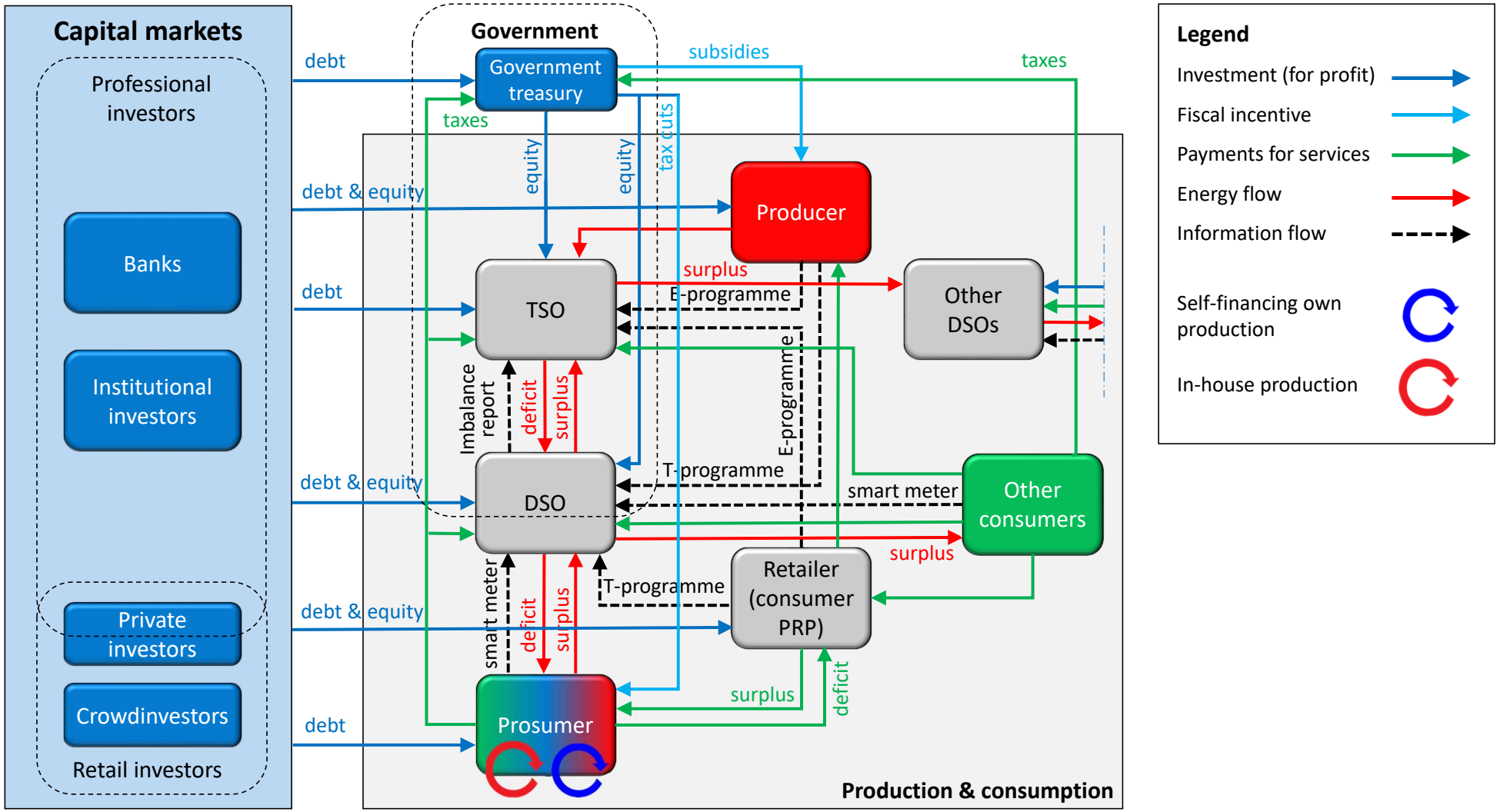
Legend

- Investment (for profit)
- Fiscal incentive
- Payments for services
- Energy flow
- Information flow

Drawn from: *(CBS, 2015), (CBS, 2018), (CBS, 2019-a), (de Brauw, n.d.), (De Energiegids, n.d.), (Energiewijzer, n.d.), (Essent, n.d.-a), (Goedkope Energie & Gas, n.d.), (Independer, n.d.), (Innova Energie, n.d.), (Investopedia, n.d.-a), Investopedia, n.d.-b), (Investopedia, n.d.-c), (Investopedia, n.d.-d), (LAKA. 2008), (NVP, n.d.), (RVO, n.d.-b), (RVO, n.d.-c), (RVO, n.d.-d), (Rijksoverheid, 2019), (Robeco, n.d.), (Tennet, n.d.-a), (Tennet, n.d.-b), (Tennet, 2018), (Wenting, 2002)*

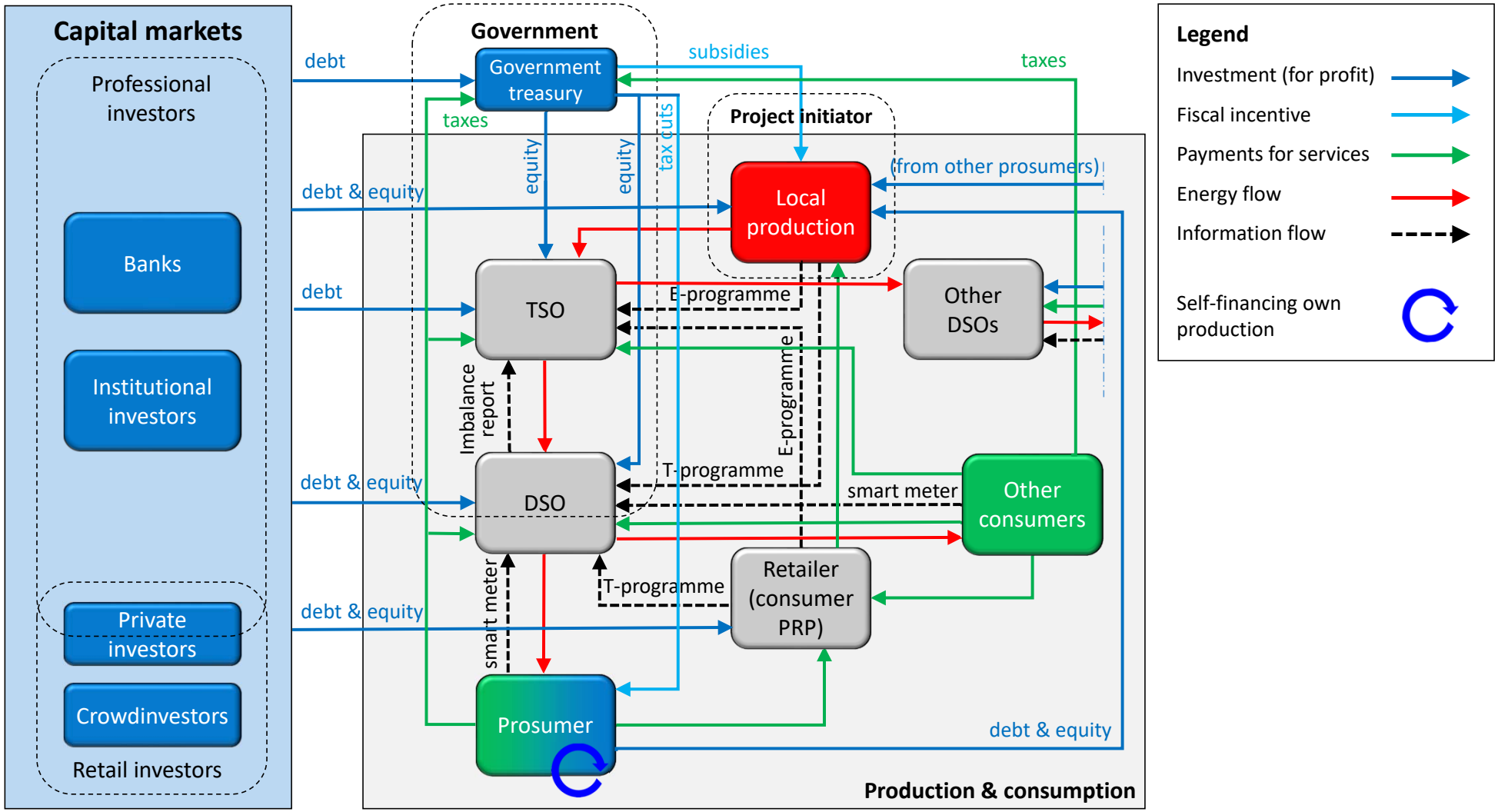
Drawn from: (CBS, 2015), (CBS, 2018), (CBS, 2019-a), (de Brauw, n.d.), (De Energiegids, n.d.), (Energiewijzer, n.d.), (Essent, n.d.-a), (Goedkope Energie & Gas, n.d.), (Independer, n.d.), (Innova Energie, n.d.), (Investopedia, n.d.-a), Investopedia, n.d.-b), (Investopedia, n.d.-c), (Investopedia, n.d.-d), (LAKA. 2008), (NVP, n.d.), (RVO, n.d.-b), (RVO, n.d.-c), (RVO, n.d.-d), (Rijksoverheid, 2019), (Robeco, n.d.), (Tennet, n.d.-a), (Tennet, n.d.-b), (Tennet, 2018), (Wenting, 2002)

Section A.3: organisation of the energy market today – prosumer (in-house production)



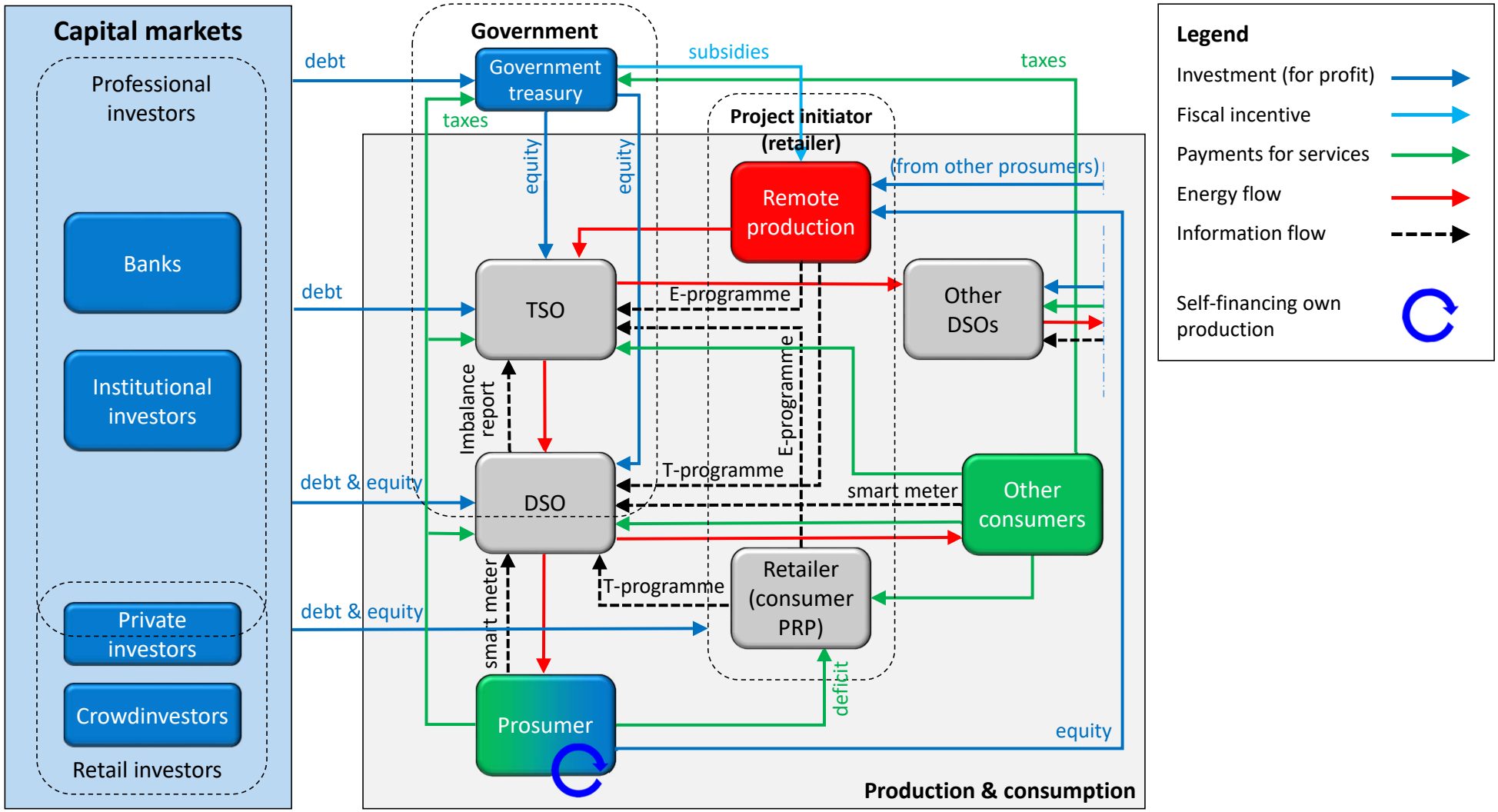
Drawn from: (CBS, 2015), (CBS, 2018), (CBS, 2019-a), (de Brauw, n.d.), (De Energiegids, n.d.), Energievergelijkers, n.d.), (Energiewijzer, n.d.), (Essent, n.d.-a), (Essent, n.d.-b), (Goedkope Energie & Gas, n.d.), (Greenchoice, n.d.), (Independer, n.d.), (Innova Energie, n.d.), (Investopedia, n.d.-a), Investopedia, n.d.-b), (Investopedia, n.d.-c), (Investopedia, n.d.-d), (LAKA. 2008), (NVP, n.d.), (RVO, n.d.-b), (RVO, n.d.-c), (RVO, n.d.-d), (Rijksoverheid, 2019), (Robeco, n.d.), (Tennet, n.d.-a), (Tennet, n.d.-b), (Tennet, 2018), (Vereniging eigen huis, n.d.), (Wenting, 2002)

Section A.4: organisation of the energy market today – prosumer (local production through cooperatives)



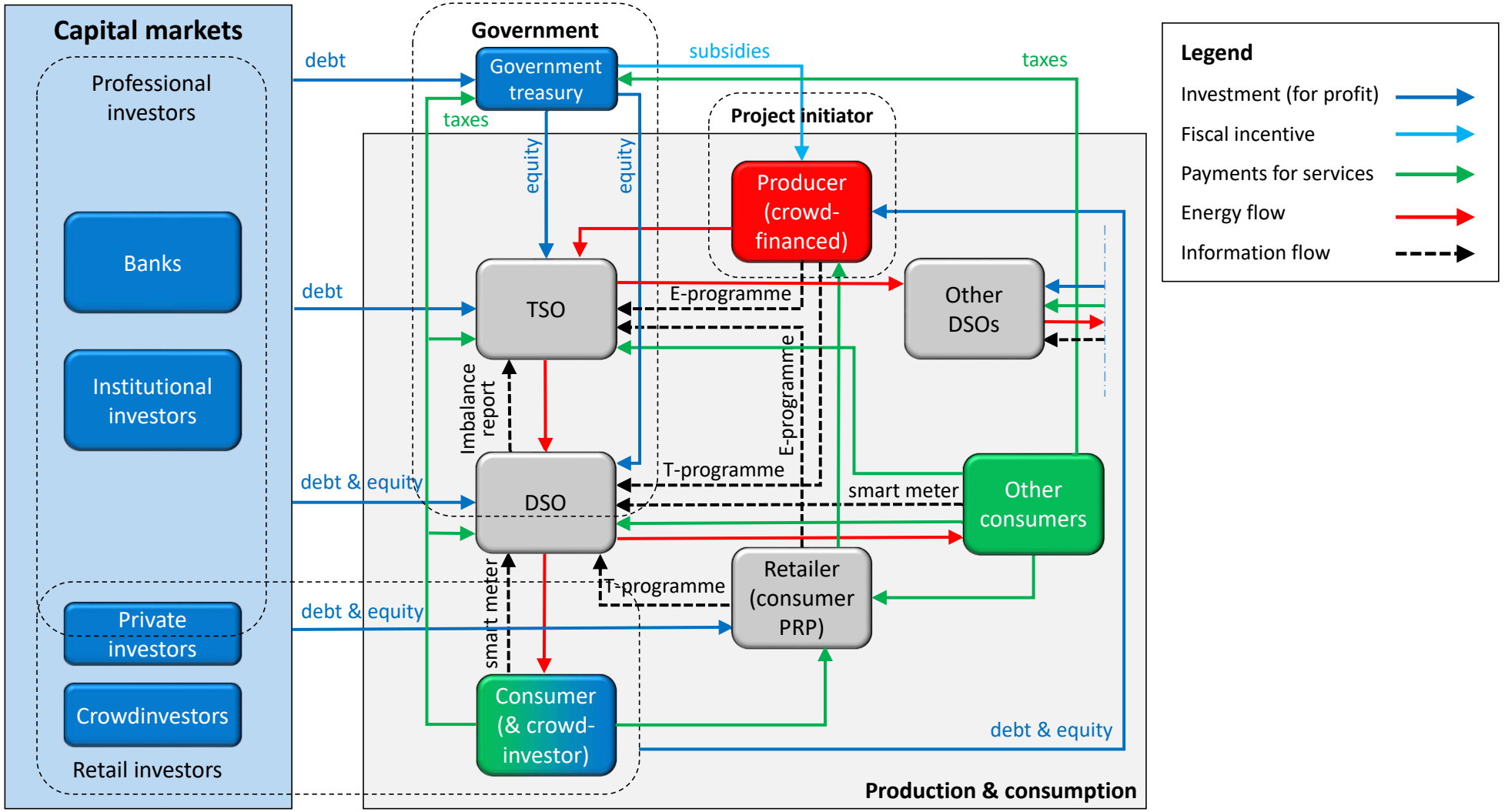
Drawn from: (CBS, 2015), (CBS, 2018), (Crowdfundingcijfers.nl, n.d.), (de Brauw, n.d.), (De Energiegids, n.d.), (Energiewijzer, n.d.), (Essent, n.d.-a), (Goedkope Energie & Gas, n.d.), (Hier opgewekt, 2016), (Hier opgewekt, n.d), (Independer, n.d.), (Innova Energie, n.d.), (Investopedia, n.d.-a), Investopedia, n.d.-b), (Investopedia, n.d.-c), (Investopedia, n.d.-d), (LAKA. 2008), (NVP, n.d.), (Overbeek, A., 2019), (Postcoderegeling, n.d.), (RVO, n.d.-b), (RVO, n.d.-c), (RVO, n.d.-d), (Rijksoverheid, 2019), (Robeco, n.d.), (Tennet, n.d.-a), (Tennet, n.d.-b), (Tennet, 2018), (Wenting, 2002)

Section A.5: organisation of the energy market today – prosumer (remote production through retailers)



Drawn from: (CBS, 2015), (CBS, 2018), (CBS, 2019-a), (de Brauw, n.d.), (De Energiegids, n.d.), (Energiewijzer, n.d.), (Essent, n.d.-a), (Goedkope Energie & Gas, n.d.), (Independer, n.d.), (Innova Energie, n.d.), (Investopedia, n.d.-a), Investopedia, n.d.-b), (Investopedia, n.d.-c), (Investopedia, n.d.-d), (LAKA. 2008), (NVP, n.d.), (RVO, n.d.-b), (RVO, n.d.-c), (RVO, n.d.-d), (Rijksoverheid, 2019), (Robeco, n.d.), (Tennet, n.d.-a), (Tennet, n.d.-b), (Tennet, 2018), (Vrij op Naam, n.d.), (Wenting, 2002)

Section A.6: organisation of the energy market today – crowdfinanced production



Drawn from: (CBS, 2015), (CBS, 2018), (CBS, 2019-a), (Crowdfundingcijfers.nl, n.d.), (de Brauw, n.d.), (De Energiegids, n.d.), (Energiewijzer, n.d.), (Essent, n.d.-a), (Goedkope Energie & Gas, n.d.), (Independer, n.d.), (Innova Energie, n.d.), (Investopedia, n.d.-a), Investopedia, n.d.-b), (Investopedia, n.d.-c), (Investopedia, n.d.-d), (LAKA. 2008), (NVP, n.d.), (RVO, n.d.-b), (RVO, n.d.-c), (RVO, n.d.-d), (Rijksoverheid, 2019), (Robeco, n.d.), (Tennet, n.d.-a), (Tennet, n.d.-b), (Tennet, 2018), (Wenting, 2002)

Appendix B: Description of key players in the Dutch renewable energy sector

Key players	Typical role	Degree of participation	Time of participation
Government	Provider of funds (subsidies) for renewable energy projects	SDE+ subsidy is 10 Billion EURO for the year 2019[15], to support renewable energy projects during a 15 year period[13]	Yearly (divided in 2 financing rounds[13])
	Provider of funds (equity) for TSOs and DSOs	Fully engaged: the government has full and majority stakes in the TSOs and DSOs respectively[11, 14]	Variable. Depends on exchanges with the dirtectives of TSOs and DSOs (these are autonomous organisations)
Capital market	Provider of funds (mosly in the form of debt[3]) for profitable ventures	According to investment preferences and opportunities	
TSO	Transmissor of energy	Fully engaged: TSOs have a monopoly on national transmission infrastructure. They settle imbalances and keep the grids stable by activating reserve capacity[37].	Constantly
DSO	Distributor of energy	Fully engaged: DSOs have a monopoly on regional distribution infrastructure. They report real consumption to TSOs[10] and provide maintenance to regional grids.	Constantly
Retailer	Retailer (often producer as well)	Retailers often act as PRPs for consumers[10] and therefore have an important role in the energy supply chain.	Constantly
Producer	Producer of energy	Producers are fully engaged in the market, as they have to plan and steer their production strategically (energy prices swing throughout the day). They provide most of the energy consumed in the market since prosumers are in the minority.	Constantly or intermittently, depending on energy source and technical set-up. However, most energy comes from stable (non-renewable) sources[3].
Consumer	Consumer of energy	Consumers participate actively only when choosing their energy retailer, but take a more passive rol thereafter. They pay a monthly advance on their estimated consumption and the final bill is settled once a year[4].	Energy is constantly drawn from the grid, but the consumer rarely engages with the market (only when choosing a retailer and the monthly deposit amount)
Prosumer (in-house production)	Investor, producer and consumer	The savings from trading energy on electronic exchanges does not offset the extra burdens of being its own PRP for small prosumers, but bigger prosumers might engage in energy trading[8]. Extant laws forcing retailers to pay reasonable feed-in tariffs[1] also incentivize small prosumers to sell their energy surplus, if any, directly and automatically to their retailers.	Variable. Depends on energy source, technical set-up and business model. However, the bigger prosumers sometimes engage in energy trading, which can take a little as 10 minutes daily[2].
Prosumers (local production through cooperatives)	Investor and consumer	Energy cooperatives: prosumers located close to each other (e.g. within the same neighbourhood) organise in cooperatives recognized as legal persons[6]. Contributions from participants are used to produce energy locally and pay for management expenses, usually in return for voting rights, shares of the profits and tax returns (settled with retailers)[7].	After becoming a member of a cooperative or investor in a project of the retailer the prosumer is not required to be actively involved in the process; however, members with voting rights might be incentived to do so.
Prosumers (remote production through retailers)	Investor and consumer	Projects of the retailer: sometimes retailers allow their customers to invest in their projects in return for shares of the production. The net consumption is settled through the energy bill[5].	After becoming an investor in a project of the retailer the prosumer is not required to be actively involved in the process. The retailer handles the production and the settlements of the energy bill.
Crowdinvestor	Investor	According to investment preferences and opportunities. The crowdinvestor is not producing or financing his/her own consumption anymore, but is merely an investor in an energy project.	Mostly during the financing rounds, but possibly throughout the project life cycle if support from and/or accountability to investors is (contractually) agreed upon.

Key players	Operating environment	Purpose/reason for participation
Government	In The Netherlands	To stimulate renewable energy production
	In The Netherlands	Because the government has full and majority stakes in the Dutch TSOs and DSOs respectively
Capital market	Worldwide	Mainly for the purpose of capital formation (driven a market logic[9]).
TSO	In The Netherlands & parts of Germany	To maintain the energy grids balanced while facilitating free market competition in energy production
DSO	In their region (within The Netherlands)	To provide reliable energy grids and facilitate access to all market parties.
Retailer	Customers are located in The Netherlands, but energy can be bought from neighbouring countries. The business models of energy retailers in neighbouring countries falls outside the scope of this research.	To provide a service in exchange for a profit.
Producer	In and around the Netherlands (related to cross-border energy trading)	To provide a product in exchange for a profit.
Consumer	In The Netherlands.	As a result of basic needs for energy.
Prosumer (in-house production)	In and around the Netherlands (related to cross-border energy trading)	To contribute to the energy transission, protect themselves against rising energy prices and save money. Also, the tax returns are a financial incentive.
Prosumers (local production through cooperatives)	In The Netherlands. By delegating production to third parties prosumers loose the capacity to engage in energy trading.	As with Prosumer (in-house production) but without the responsibility of production and levereging better locations and bigger scales.
Prosumers (remote production through retailers)	In The Netherlands. By delegating production to third parties prosumers loose the capacity to engage in energy trading.	As with Prosumer (local production) but leveraging even better locations and bigger scales
Crowdinvestor	In The Netherlands	For the purpose of capital formation and to contribute to the energy transission (driven a community logic[9]).

References

1 (Energievergelijkers, n.d.)
2 (Jules Energy, n.d.)
3 (CBS, 2019)
4 (Independer, n.d.)
5 (Vrij op Naam, n.d.)
6 (Postcoderegeling, n.d.)
7 (Overbeek, 2019)
8 (Agro Energy, 2017)
9 (Vismara, 2019)
10 (Wenting, 2002)
11 (Innova Energie, n.d.)
12 (Tennet, n.d.-b)
13 (RVO, n.d.-b)
14 (Tennet, 2018)
15 (Solar, n.d.)
16 (CBS, 2018)

Appendix C.1: cost of borrowing / issuing debt on different platforms (5 year term)

Example issue size (€):	400,000	Discount rate investors[5]	0.050
Maturity (years):	5	Discount rate issuer[6]	0.120
Inflation rate	0.02		

	Investment platforms[1]				
Platform details	**Geldvoorelkaar**	**NPEX[2]**	**Oneplanetcrowd**	**Greencrowd**	**Greenfundholland**
Type	Crowdfinancing (market leader)	Securities exchange for SMEs	Crowdfinancing	Crowdfunding (non-profit)	Crowdfinancing
Permits/exemptions	for attracting redeemable funds	for issuing tradeable securities	for attracting redeemable funds	for attracting redeemable funds	for attracting redeemable funds
Total crowdfinancedd (€)	182,906,800	79,135,982	54,139,022	9,222,795	632,800
Particularities	10 year max. lending period	For companies over 3 years old and with a working product	For companies ver 3 years old and with possitive cashflows; 10 year max. lending period	For socially responsible projects; as a tool to create awareness about the need for sustainability	For companies over 3 years old and with stable cashflows; fixed borrowing rate (4.7%); all costs borne by the issuer
Borrower/ debt issuer					
Minimum issue size (€)	25,000	500,000	100,000	-	-
Listing costs (€)	349-499	5,000	850	100	0
Issuance costs (%)	1.25%	3.00%	2.00%	3.00%, € 1,250 min.	3.00%
Administrative costs per year	0.95%, 7.9% max. (in total)	0.40%, € 10,000 min.	1.00%	€ 2 per bond[3] per year	2.30%
Transaction (trading) costs (%)	n.a	0.50%	n.a	n.a	n.a
Brokerage fees (discounted 12%)	19,197	55,048	23,269	12,951	45,164
Net cost of borrowing (excl. tax shield)	9.80%	18.76%	10.82%	8.24%	15.99%
Brokerage fees	4.80%	13.76%	5.82%	3.24%	10.99%
Investors					
Investment costs	0.00%	1.00%	0.00%	0.00%	0.00%
Administrative costs per year	0.4%, 2.8% max. (in total)	0.60%	0.8% of outstanding debt[4]	0.00%	0.00%
Transaction (trading) costs	n.a	0.50%	n.a	n.a	n.a
Brokerage fees (discounted at 5%)	6,927	16,391	8,583	0	0
Net rate of return (excl. Loan defaults)	3.27%	0.90%	2.85%	5.00%	2.82%[7]
Brokerage fees	1.73%	4.10%	2.15%	0.00%	0.00%
Total brokerage fees (indexed)	30,952	83,447	37,625	13,212	55,364

References (cost structure only)	https://www.geldvoorelkaar.nl/geld-lenen/tarieven.aspx	https://www.npex.nl/financiering/kosten	https://www.oneplanetcrowd.com/nl/s/tarieven	https://greencrowd.nl/veelgestelde-vragen/alle-vragen/	https://greenfundholland.nl/lenen/#tarieven
	https://www.geldvoorelkaar.nl/geld-investeren/tarieven.aspx	https://www.npex.nl/beleggen/kosten	https://www.oneplanetcrowd.com/nl/s/tarievenonderneming		

[1]Sample of platforms with a focus on (ar at least a separate category for) renewable energy projects

[2]NPEX is a traditional securities exchange for small and medium-sized enterprises (SMEs) and only presented as a reference for cost comparison

[3]€ 3400 bond value assumed, based on the average loan size per investor (ASN Bank, 2019)

[4]5% bond interest and linear repayment assumed, as laid out in Oneplanetcrowd's website

[5]de average expected return for crowdfunders is 6-8% (Investeerders, n.d.), but a lower (5%) return is asssumed due to the sustainable nature of the investment

[6]the equity investors are assumed to be the borrowers/ issuers of debt for the project. The expected rate of return for equity investors in the renewable energie sector is 12-15% (PBL, 2018)

[7]5% not realistic. The actual lending rate offered to investors at the time of writing this thesis was on average 2.82%

Appendix C.2: cost of borrowing / issuing debt on different platforms (15 year term)

Example issue size (€):	400,000	Discount rate investors[5]	0.050
Maturity (years):	15	Discount rate issuer[6]	0.120
Inflation rate	0.02		

	Investment platforms[1]				
Platform details	**Geldvoorelkaar**	**NPEX[2]**	**Oneplanetcrowd**	**Greencrowd**	**Greenfundholland**
Type	Crowdfinancing (market leader)	Securities exchange for SMEs	Crowdfinancing	Crowdfinancing (non-profit)	Crowdfinancing
Permits/exemptions	for attracting redeemable funds	for issuing tradeable securities	for attracting redeemable funds	for attracting redeemable funds	for attracting redeemable funds
Total crowdfinancedd (€)	182,906,800	79,135,982	54,139,022	9,222,795	632,800
Particularities	10 year max. lending period	For companies over 3 years old and with a working product	For companies ver 3 years old and with possitive cashflows; 10 year max. lending period	For socially responsible projects; as a tool to create awareness about the need for sustainability	For companies over 3 years old and with stable cashflows; fixed borrowing rate (4.7%); all costs borne by the issuer
Borrower/ debt issuer					
Minimum issue size (€)	25,000	500,000	100,000	-	-
Listing costs (€)	349-499	5,000	850	100	0
Issuance costs (%)	1.25%	3.00%	2.00%	3.00%, € 1,250 min.	3.00%
Administrative costs per year	0.95%, 7.9% max. (in total)	0.40%, € 10,000 min.	1.00%	€ 2 per bond[3] per year	2.30%
Transaction (trading) costs (%)	n.a	0.50%	n.a	n.a	n.a
Brokerage fees (discounted 12%)	24,809	87,109	36,093	13,707	74,660
Net cost of borrowing (excl. tax shield)	11.20%	26.78%	14.02%	8.43%	23.36%
Brokerage fees	6.20%	21.78%	9.02%	3.43%	18.66%
Investors					
Investment costs	0.00%	1.00%	0.00%	0.00%	0.00%
Administrative costs per year	0.4%, 2.8% max. (in total)	0.60%	0.8% of outstanding debt[4]	0.00%	0.00%
Transaction (trading) costs	n.a	0.50%	n.a	n.a	n.a
Brokerage fees (discounted at 5%)	9,258	30,911	19,713	0	0
Net rate of return (excl. Loan defaults)	2.69%	-2.73%	0.07%	5.00%	2.82%[7]
Brokerage fees	2.31%	7.73%	4.93%	0.00%	0.00%
Total brokerage fees (indexed)	44,695	184,331	90,698	15,132	130,213

References (cost structure only)	https://www.geldvoorelkaar.nl/geld-lenen/tarieven.aspx	https://www.npex.nl/financiering/kosten	https://www.oneplanetcrowd.com/nl/s/tarieven	https://greencrowd.nl/veelgestelde-vragen/alle-vragen/	https://greenfundholland.nl/lenen/#tarieven
	https://www.geldvoorelkaar.nl/geld-investeren/tarieven.aspx	https://www.npex.nl/beleggen/kosten	https://www.oneplanetcrowd.com/nl/s/tarievenonderneming		

[1]Sample of platforms with a focus on (ar at least a separate category for) renewable energy projects

[2]NPEX is a traditional securities exchange for small and medium-sized enterprises (SMEs) and only presented as a reference for cost comparison

[3]€ 3400 bond value assumed, based on the average loan size per investor (ASN Bank, 2019)

[4]5% bond interest and linear repayment assumed, as laid out in Oneplanetcrowd's website

[5]de average expected return for crowdfunders is 6-8% (Investeerders, n.d.), but a lower (5%) return is asssumed due to the sustainable nature of the investment

[6]the equity investors are assumed to be the borrowers/ issuers of debt for the project. The expected rate of return for equity investors in the renewable energie sector is 12-15% (PBL, 2018)

[7]5% not realistic. The actual lending rate offered to investors at the time of writing this thesis was on average 2.82%

Appendix D: Interview protocol

1.1. Purpose

These interviews constitute the pilot study (preliminary research) that supplements the theoretical analysis in the formulation of design requirements (the theoretical research perspective), which was used to confront reference smart contract applications (the research object) in order to produce an improved implementation of crowdfinancing. The purpose of the interviews is to find out on empirical grounds, from the perspective of relevant market parties, whether crowdfinancing is a promising alternative method to finance renewable energy projects and what the success criteria are for that process.

1.2. Interview participants

The reasoning behind the selection of interview participants is laid out in section 4.2 of the thesis report. They are again mentioned here for the purpose of clarity and the related letter (see below) will be used in this appendix to refer to their individual answers to the questions.

M: Initiator of Municipality projects

B: Initiator of Big projects

S: Initiator of Small projects

C: Consultant

P: Crowdfinancing Platform

1.3. Interview questions

Questions 1-3 are meant primarily for older interviewees (above 40 years old), since they were at least in their 20's when the re-structuring of the energy market of the late 1990's took place. English numbers (1-2-3-…) identify the main questions, while roman numbers (I-II-III-…) identify sub-questions that deal with specific domains of the main questions. However, unexpected responses sometimes took the conversation towards another direction, for which no questions were prepared –

in that case questions were asked ad hoc in order to achieve a deeper understanding of the interviewees' statements; these additional questions are identified with "EXTRA" in front of them.

The expected responses to the sub-questions are included whenever possible (in red), as derived from the theoretical analysis of this thesis (see chapters 3-5)

1.3.1. Evolution of the energy market (before and after privatization)

The energy market underwent structural changes in the 1990's that resulted in the liberalization and privatization of the supply of energy, while maintenance and operation of the connecting infrastructure (the national transmission system and regional distribution systems) remained in the hands of the state.

1. How would you describe the changes in the organization of the energy market due to the re-structuring of the 1990's, in terms of the roles of the different parties involved and the exchanging relationships between them?

The organisation of the energy market before the re-structuring was based on an all-encompassing top-down approach where all matters related to energy – from technology advancement to environmental effects – were dependent upon government action. All energy companies were government-owned and had a monopoly on the supply of energy, since they owned the connecting infrastructure and were the producers and the retailers as well. These companies worked together in the SEP to jointly steer the production of electricity and the construction of new power plants (LAKA, 2008).

The re-structuring of the energy market allowed public bodies to keep oversight of the market and arguably safeguard public interests by maintaining control of the connecting infrastructure, given its inherent characteristic of natural monopoly, while creating a level playing field for the private sector to innovate and compete in the production and retail domains. This liberalized market economy allowed more parties to be involved in different stages of the energy supply chain and new roles to emerge.

M: I did not notice any changes as a consumer, besides paying for energy to a different party.

C: The distribution and production of energy cannot not be done by the same party anymore. Producers sell energy to consumers and network operators facilitate the transport of the energy.

I Who have been the producers of energy before and after the re-structuring?

Starting in 1895 the existing power plants in the Netherlands were taken over by the municipalities and started fusing together throughout the twentieth century into regional and provincial energy companies, which were all directly or indirectly controlled by municipalities and provinces (CBS, 2015). These energy companies were the sole producers in the region they operated and this process of centralization continued until only 4 energy companies remained in 1988 (LAKA, 2008).

After the re-structuring all energy in the Netherlands has been produced by the private sector, either by retailers themselves or by dedicated producers from the Netherlands and neighboring countries that sell their production directly to retailers or on international electronic exchanges. Production and retail of energy are not done necessarily by the same parties anymore – the third biggest energy retailer of the Netherlands does not produce any energy but acquires it from the market (Goedkope Energie & Gas, n.d.) – and energy is traded on international exchanges, since many neighbouring countries are connected to the same international energy grids.

C: I am not aware of who were the producers before the re-structuring, but now you have a lot of producers. Essent, Eneco, Vattenfall are among the biggest producers, while there are many small producers (especially the renewable energy producers) that sell their production to the biggest producers, as these are often also the energy retailers.

II What changes do you perceive in the role of the consumers?

Before the re-structuring consumers could not choose the source or provider of their energy and the prices thereof were imposed upon them (De Energiegids, n.d.). They had no direct influence on the energy market. However, after the 1990's customers can switch between retailers of energy, thereby having a direct influence on the market by switching to their preferred retailer; as a result, the biggest retailers have been consistently losing their share of the market, while the smaller retailers have gained the most amount of new customers (Pricewise, 2016).

Additionally, the introduction of subsidies and new market rules (e.g. feed-in tariffs) for renewables stimulated decentralized generation by the consumers themselves, as their own production is deducted from their consumption (Essent, n.d.b), while also being rewarded for overproduction (Energievergelijkers, n.d.). This effectively made them *prosumers* – a new paradigm where consumers are producers and consumers at the same time. Prosumers started with in-house production, but are now organizing in energy cooperatives for joint remote production in order to

leverage better locations and bigger scales of production (Postcoderegeling. n.d.). Additionally, consumers are now also investing in renewable energy projects initiated by third parties through varying crowdfinancing models, either for their own consumption or merely as investors.

III Have new roles emerged?

The liberalisation and privatisation of the energy market have changed the rules of the game, since any legal person with a physical connection to the energy grids (e.g. electricity, gas, district heating) can be responsible for the management of that connection, for the supply and/or consumption of energy, while all market parties in the Netherlands are free to buy or sell energy among each other (Tennet, n.d.) and on international exchanges. As a result, new roles have emerged such as prosumers, energy cooperatives (Postcoderegeling. n.d.), re-sellers of energy (Wenting, 2002), and (prosumers) traders of energy (Jules Energy, n.d.).

IV Wat forms of financing have been used before and after the re-structuring to raise funds for energy projects?

Since the energy companies were state-owned until the beginning of the 21st century, it is assumed that their projects were funded with public funds – financed through taxation or issuance of government bonds (publicly traded debt securities). The latter is commonly done by the government to raise funds from capital markets when public budgets are not sufficient to cover government spending.

However, after the privatization of production and retail the funds for companies and projects within these domains are sourced from capital markets in the form of debt and/or equity. Debt-based financing is the main method of providing funds for companies in the Netherlands (Financieringsmonitor, 2018), which is achieved by taking bank loans or issuing corporate bonds (publicly traded debt securities) to capital markets; while equity-based financing entails selling company shares, either through an exchange in case of publicly traded companies or directly to investors in case of non-listed companies.

C: I am not aware of the forms of financing before the re-structuring. Currently most projects are financed for 70-80% with bank debt [in Dutch: *vreemd vermogen*] with a duration equal to the SDE-subsidy, while the remaining 20-30% is financed with private equity [in Dutch: *eigen vermogen*]. If funds are raised through crowdfinancing, this is often in the form of bonds.

V Who have been the investors with those forms of financing?

Although public budgets are ultimately formed by raising taxes, the direct profits obtained from investments made with these funds do not flow back to the public but to government bodies, thereby making the latter the investors. On the other hand, the issuance of government debt implies that capital markets loan money to the government to support its spending by buying debt securities (Investopedia, n.d.-b), thereby making the holders of the securities creditors of the government and therefore indirectly also debt-based investors in government activities.

With regards to the private sector, debt-based financing constitutes the bulk of the financing market: banks are the main investors with 63% of all yearly investments in the form of loans, a mix of investors from the entirety of the capital markets provide 33% by buying corporate bonds and private investors provide 5% through private loans.

In turn, although equity investments (provided primarily by investment firms and private investors) have been increasing and are again on par with pre-crisis levels , they still only make up 0.9% of the financing market (Financieringsmonitor, 2018).

C: For the bigger projects the big energy companies provide the required 20-30% private equity from their balance sheet and for smaller initiatives the municipalities sometimes provide part of the funds, but often it is energy cooperatives who raise funds through crowdfinancing. There are however some examples of bigger projects, such as wind parks, where the funds are also obtained through crowdfinancing.

2. Where do you see yourself now in the energy market, what is your current role?
3. In your opinion, was the re-structuring of the energy market beneficial? And if so, to whom?

The state-owned energy companies mentioned earlier were considered slow, inefficient and lacking transparency (Energy Watch, n.d) and the SEP could not cope with developments in the energy market: starting in the 1990s the private sector was allowed to produce electricity from their wasted thermal energy by means of combined heat and power plants and feed it into the electricity grid, while the SEP continued to build redundant power plants (Follow the Money, n.d.). The re-structuring of the market removed these inefficiencies by allowing the market to organically match supply and demand, thereby stimulating the private sector to innovate and improve services in order to stay competitive. This was ultimately beneficial to the consumers, as they now can “vote with their dollars” on the future of the energy market, not just by choosing their preferred retailers but also by self-organizing or investing in initiatives for renewable generation that have indiscriminate access to the energy grids.

1.3.2. Energy transition

The use of fossil fuels has had a negative impact on the environment, for which reason we have decided to transition to renewable sources of energy in order to reduce carbon emissions.

1. What major changes do you perceive in the energy market due to the energy transition?

Since professional investors are primarily driven by profit generation (Vismara, 2019), in order to stimulate the energy transition the Dutch government had to incentivize the private sector to invest in renewable energy. To that end, different forms of subsidies and tax exemptions were introduced to remove the unprofitable component of investments in renewables and accelerate innovation and adoption. These measures have caused controversy in the political arena, but meanwhile technological advances have made investments in renewables evermore competitive (e.g. solar panels are 5 times cheaper today than 15 years ago, when subsidies for solar panels in households were introduced [GreenHome, 2019]). As a result, different models of "prosuming" started to arise and energy retailers are evermore focused on offering green energy, arguably as a reflection of the values and preferences of their consumer base.

B: The producers of non-renewable energy (e.g. gas and coal-fired, but also nuclear power plants) have increasingly more difficulties to stay profitable. Therefore, the government will probably have to sponsor those producers in the future, because they will eventually become unprofitable due to the raising costs of production.

Additionally, everybody is looking to connect with the consumer, which constitute the real value because retail of energy alone is not profitable enough. By example, retailers continually link other products to energy retail in order to attract the consumer.

Extra: How come that the costs of production are rising for non-renewable energy production?

B: Sustainable energy has preference in the energy market due to regulation. Therefore, as the market share of sustainable energy increases, it is harder for energy produced from non-renewable sources to be sold on the market.

I How has production been affected due to the use of renewables?

Most renewable energy produced in the Netherlands is intermittent (e.g. solar and wind energy). This problematic characteristic of renewables can be solved with overcapacity or storage (Duurzaam

Bedrijfsleven, 2012), but so far renewables only provide 7.41% of the country's energy consumption (CBS, 2019) and no large scale storage solution has been implemented yet. The fluctuations in the energy grids are currently being mitigated by the collective effort of all countries connected to the international electricity grids, which all hold reserve capacity in stand-by to compensate for deviations in the frequency of the electrical power system (Tennet, n.d.-b). However, it is uncertain if this approach will be enough (and financially feasible) to deal with a drastic increase of production from renewables.

B: Energy production and retail used to be done by ONE company, but in recent years those roles have been separated – also due to regulation – and production has become more difficult.

S: People in general want the transition to happen and think that solar and wind power is the way to get there, but in my opinion this is not realistic. There's a lot of "green washing" going on, as companies advertise the use of green energy while behind the scenes a lot less green activity is taking place (e.g. green certificates).

C: Coal-fired power stations currently provide the base load for the electrical grid, but they will be closed. Offshore wind will probably take over the base load production, possibly also in combination with nuclear power (if that discussion is started). On the other hand, there's a lot of on-shore wind and solar scattered across the country, which produce high peaks in the supply of electricity and are already causing problems for the regional distribution network operators. This energy will have to be stored in either batteries or hydrogen. I expect the decentralization of production to continue, but in bigger scales, due to less incentives through subsidies for the really small projects (most energy cooperatives fall in this category).

Extra: why do you think this green washing is taking place?

B: I think that politicians are pushing their agendas towards sustainable goals by means of regulation and companies are just trying to act within the constraints of such regulation. Loopholes in the laws and lobbying by multinationals are causing that in the end not much is really happening with regards to renewables.

II Who is taking the initiative to produce renewable energy?

Initiatives for small-medium production have been taking by consumers (in the capacity of prosumers), either individually or through energy cooperatives. Medium-big projects have been carried out by energy retailers, municipalities, entrepreneurial companies and basically any market party whose proposal meets the conditions to receive subsidies (Rijksdienst voor Ondernemend Nederland, n.d.). It is expected that soon, if not already, production without subsidies will be possible (de Brauw, n.d.) and therefore more projects can be undertaken.

M: Right now everybody can be a potential project initiator and production can take place for the purposes of retail, but also for private consumption.

B: In general it is the Dutch retailers and international investment firms (e.g. from Germany, the UK and Spain) that are starting projects in the Netherlands. The latter are coming here because the energy market in the Netherlands is relatively less developed and there are thus more opportunities. Project developers and energy cooperatives are also taking the initiative, but the latter to a lesser degree.

C: The biggest projects are being started by the big energy retailers, but the legacy (gas & oil) energy companies are starting to come into the sector. Additionally, the small projects are mostly being undertaken by energy cooperatives.

P: Cooperatives, utilities and specialized developers.

III Wat forms of financing are being used for these initiatives?

Varying forms of financing are being used for these initiatives, which depend on specific project characteristics, the desired capital structure (often highly leveraged) and the possibility to secure bank loans. The initiatives of individual prosumers (in-house production) are usually financed through the provision of their own private equity and/or acquiring loans from sustainable funds, provided that the applicant is credit worthy (Vereniging eigen huis, n.d.). However, small-medium projects of groups of prosumers (remote production) have difficulties acquiring loans (e.g. energy cooperatives are having trouble receiving bank loans due to the lack of standardization in their business models and/or the relative small size of their projects [Hier opgewekt, 2016]) and have therefore relied primarily in their own private equity and varying models of crowdfinancing. Additionally, producers of energy have started to finance their projects through crowdfinancing campaigns: some retailers allow their customers to settle their consumption with investments in shares of the production through the energy bill (e.g. with Vrijopnaam) and other producers pay out revenues/rents to investors directly (e.g. with Solar Greenpoint).

On other hand, bigger projects are more likely to be approved for bank loans (Hier opgewekt, 2016). But although banks are the main players in debt-based financing, their investments have been decreasing steadily after the financial crisis due to risk and liquidity requirements. As a result, the bigger companies and the larger SMEs are increasingly opting for corporate bonds, while the smaller SMEs are turning to alternative financing such as private equity and crowdfinancing (Financieringsmonitor, 2018).

Further, the government contributions to renewable energy projects in the form of subsidies are financed by means of taxation (e.g. a charge to the energy bill named Duurzame Energie Opslag [Essent, n.d.-a]) or issuance of government bonds (e.g. a 20-year Sovereign Green Bond [Rijksoverheid, 2019])(Richardson, 2014).

M: Most of the funds (up to 80-90%) are normally obtained through bank financing, but the other 10-20% comes from private equity.

B: For low-risk investments bank loans are being used, which can provide up to 90% of the required funds. The other 10% is provided by private equity.

S: There are almost no sources of funding for the development of new technologies. The companies and institutions that provide this kind of financing are too slow to make decisions (e.g. regarding what small companies to finance) or simply too focused on profitmaking.

C: As answered in section 1.3.1. However, many municipalities find it important that local inhabitants can also profit financially from energy projects in their surroundings, which might be enforced in different ways:

- That projects are partly financed by the locals as well (crowdfinancing)
- That locals are directly compensated financially by the project initiators
- That a share of the revenues is transferred to a development fund of the municipality

P: Project financing is the most common form, especially now that interest rates are low, but some projects might choose balance sheet financing for governance reasons. The small projects don't get project financing.

Extra: why are small projects not getting financing?

P: Banks don't look at small projects. The sub – 1 million (sometimes sub- 500k) segment is often not well organized or willing to work within the constraints put there by the banks; these constraints are in my opinion not that unreasonable.

IV Who are the investors in these initiatives?

Prosumers invest in their production, but the capital structure of the initiative can also include debt. In case of in-house production loans can be acquired from banks and government institutions by putting the underlying asset as collateral, while banks also provide funds (and support during negotiations) for the biggest projects as long as they have feasible business proposals (Vereniging eigen huis, n.d.). But with alternative forms of financing debt and/or equity is issued on capital markets, which consists of a mix of investors with varying degrees of risk aversion: starting with low-risk institutional investors and ending with high-risk crowdinvestors.

M: Banks provide the loans most of the time, but municipalities provide the private equity for their projects as well, sometimes also in combination with crowdfinancing.

B: Loans in low-risk investments are provided by banks, while the rest of the funds are provided by the project initiators themselves (e.g. project developers). Pension funds are also involved in the market, but they only invest in exploitation (e.g. they buy wind and solar parks after they have been built) due to the increased risks of development.

C: As answered in section 1.3.1

V What do you think that motivates these investors to participate?

While professional investors typically apply a market logic and are primarily driven by financial rewards, small investors in equity crowdfinancing are found to be sensitive also to a community logic and thus consider the non-monetary attributes of a project as well, such as the attention to community advancement and the potential to "bettering the world" (Vismara, 2019).

M: Banks are driven by profitmaking, but municipalities are not. So a municipality initiates a project for the benefit of society and if profits are made in the process, they are reinvested in the community.

B: Banks and pension funds are merely motivated by financial gain: the former invests only in low-risk project development, while the latter invest in low-risk project exploitation

2. Can the transition to renewables be achieved in the current state of the energy market?

For the energy sector in the Netherlands, which as of 2018 produces only 7.41% from renewable sources (CBS, 2019), meeting the commitments made in the 1990 Paris Agreement would require annual investments of over € 10 billion EURO starting in 2020, while achieving a fully sustainable energy supply by 2030 would cost € 9 billion EURO extra each year (van der Geest, 2017). Investment needs to be ramped up considerably.

M: The current state of the market cannot facilitate the transition. By example, new technologies need to be developed that don't require as much space, but we cannot wait until those technologies arrive. We need to invest now, with the technologies that are available, and after the projects' lifecycles end we reassess what is possible with the future technologies.

B: The biggest challenge with regards to the transition is a social one. 70-80% of the population perceives the energy transition as a threat, because they "cannot afford" the increased energy prices or the investments necessary for their own homes (e.g. investments in insulation, solar panels, water pumps). This high percentage of the population has to be involved in the transition and support it, in order to make the necessary funds available.

I Are the sources of funding mentioned enough to meet the necessary investment?

It can be argued that there is enough money in the economy to finance the energy transition, but to do this would be foolish in my opinion. Instead I base my judgement on the investment preferences of the investors.

Bank loans are not enough because of risk and liquidity requirements that make investments in illiquid and relatively risky infrastructure unfeasible. Additionally, loans from institutional investors would require comprehensive business models and a pipeline of projects to reduce risks and justify the high entry costs caused by the development of sector-specific expertise (van der Geest, 2017); but the energy transition also requires innovation and therefore investments in different alternatives, which cannot be restricted a-priori by deterministic long-term decisions such as pipelines of specific projects. Additionally, the switch towards corporate bonds is only feasible for big, low-risk investments (Financieringsmonitor, 2018) and is therefore not an option for small-medium projects in decentralized energy production.

M: I think that the transition can be achieved by reinvesting the profits from the projects that are realized now.

B: Large scale investments in big projects of energy production are taking place by banks. Where ever there is physical space made available by provinces and municipalities, projects are being developed constantly.

C: Yes. Right now I am working on a renewable energy project that will be partly financed by BNG bank, which is actually a public bank, and a municipality. I expect the public sector to be more involved in projects like this in the future.

P: There is more than enough money in the market right now. The limitations on projects being realized is actually not about financing. The financing market is relatively well established for the bigger projects, which produce the most energy anyway.

Extra: What is the use case of crowdfinancing then?

P:Crowdfinancing cannot compete with bank rates, but it can be useful in a number of situations:

- for subordinated loans (to achieve the total private capital required to receive a bank loan)
- for small projects that cannot access project financing
- for SPVs of bundled projects (e.g. solar panel leasing) which require flexibility in the funding process
- for the improvement of the built environment – banks don't like the transformation of buildings

II If yes, what is holding back investment?

B: With regards to small projects, the investment required for each project is too small to justify the efforts of the bank. Therefore, bank loans are only made available for these projects if they are bundled together (e.g with Zonnepanelendelen); however, loans for bundled projects result in relatively high rents compared to simpler loans).

S: The big energy companies, which are the ones paying for all the lobbying, are too big and too slow to bring about the necessary change required to drive the transition.

P: The barriers are actually permits and subsidy systems, as projects are always fighting in the courts to get permits. There was a project on the N33 that took 17 years to get a permit – there is no business model you can plan for 17 years of fighting about permits. The smaller projects do have trouble getting bank loans, but I don't think that they do a lot for the energy transition.

Extra: and subsidies, what's the problem with that?

P: The subsidies are somewhat complex and pretty much geared towards older technologies, i.e. wind and solar. There's not much room for innovation in terms of subsidies for newer technologies, such as tidal energy, batteries; they are not easily accepted within the current subsidy programme, the SDE+.

III If not, where should the funding come from instead? And why?

The trends are showing organic adoption of crowdfinancing in the energy sector, supported by favourable policy and regulation, where individuals combine efforts and financial resources to produce clean energy. These developments highlight a push towards renewables fuelled by the crowd – according to HIER opgewekt there are 389 initiatives for local energy production active at the time of writing this thesis. Nevertheless, these efforts need to be increased considerably in order to close the investment gap in the energy infrastructure sector.

I argue that the transition can only be achieved by investors with a community logic, which are driven by more than just capital formation and consider the non-monetary characteristics of their investments as well. The crowd fits this description and has already shown its capacity and willingness to produce, self-organise and invest in renewables (e.g. Solease raised 1 million EURO for a solar energy project within 8 minutes (AD, 2018).

B: The consumers (households) who are willing to improve their own homes have doubts about what to do because there are no simple forms of financing available. Ideally the government should make the funds easily accessible to these consumers.

IV Are there other challenges to be overcome in order to achieve the transition to renewables?

The matter of overcapacity vs storage still remains ambiguous and dependent upon further technological advancements.

B: Another challenge with regards to the transition is a technical one. Production of energy from solar and wind generates huge spikes of energy that need to be stored for later use. However, this has not become a problem yet and you need a problem first in order to solve it.

S: We need stable sources of energy to keep the economy going. Renewable sources can satisfy part of our energy needs, but we can't rely entirely on them.

1.3.3. Outlook for the future

Regardless of the specific route that we take as a society, transitioning towards clean energy will require the energy market to go through another re-structuring in order to adjust to renewables.

1. In your vision of a perfect world, where all our energy is sourced from renewables, how would the energy market be organized?

M: New economic models would have to be adopted in order to involve the community and allow them to profit from projects as well. Namely, technology advancements and automatization are continuously reducing the workforce, so in the future society will have to find new ways to share the benefits of development among the population.

B: The transition will cost us a lot of money and is therefore something that we should do together. But it also offers many opportunities, in terms of employment, technological development and possibilities to export the acquired knowledge to other countries in the future, to help others with their energy transition.

In the best scenario the government would make (cheap) financing easy and accessible to the consumer for investments in the improvement of the built environment. On the other hand, the these improvements could be financed as well by putting the buildings as collateral and attaching the loans to the value of the buildings themselves (not to the borrower, as it is done now) – in case the buildings were to be sold, the loans would be sold with the buildings as well.

S: There's a need for new companies, technologies and movements to disrupt the current situation, so that a new balance can be created. But since the world is currently dominated by banks and multinationals, only their collapse would allow the necessary radical changes to take place.

I Who would be the producers of energy?

M: Every community would produce their own energy in order to avoid being vulnerable to outside factors. To this end, local production through smaller grids would be preferable, i.e. decentralized production.

B: If all energy would come from renewables, we would get a mix of techniques for the production and storage of energy, as some locations are better than others for specific applications.

S: The initiatives to develop new technologies and find solutions to the problems of the transition need to come from the people, from entrepreneurs with new ideas and ambitions that are willing to take the next step themselves.

C: I believe that The Netherlands should invest in nuclear energy in order to have a solid backbone for the production of energy. This is the best fit for The Netherlands due to its high density population, since nuclear energy can produce high volumes of clean energy in relatively little space. Additionally, an artificial island on the sea could be used to produce hydrogen or place nuclear reactors. Offshore will become big either way.

II What would be the role of the consumers?

B: The population in general would be more supportive of sustainable energy projects, which would be beneficial for the bigger projects.

S: Consumers would team up to produce energy locally. In the process they would gain experience that could help them brand themselves online and transfer/sell their expertize to others.

C: For consumers it has to be easy to participate in renewable energy projects. A good example is the energy retailer Greenchoice, with whom the consumers can buy a share in the production of renewable energy.

III Would new roles emerge?

IV Where do you see yourself in that future organization of the energy market, would be your role?

V Wat forms of financing would be used for energy projects?

B: I think that bank loans are the best form of financing because it is the cheapest form and also because banks, unlike private equity, do not make investment decisions based on emotion and are therefore a more stable provider of funds. However, banks only make low-risk investments – risky investments must come from other sources.

C: The same as we currently have.

VI Who would be the investors with these forms of financing?

M: Everyone would be able to invest. Namely, if energy is locally produced for everybody, then everybody should be able to invest in the production of energy. Thus, energy would be for the people and by the people.

B: Banks would be the main investors.

C: The same as we currently have: for the big projects banks would provide 70-80% and the biggest energy producers would provide the rest. However, due to current political developments I expect municipalities to invest more themselves through the creation of funds; since these are public funds, the citizens would be investing in projects indirectly and also profiting from the returns made by the municipalities, which would be made available for other community projects.

2. In that vision of the perfect future, do you see potential in crowdfinancing as a form of financing for energy projects? And why?

M: Yes, crowdfinancing would be a good way to let people profit as well from energy projects in their community.

B**:** Crowdfinancing would only be an option for a start-up or project developer to finance risky projects that could otherwise not secure funding from other sources, because crowdfinancing is too expensive – the required return for the investor is too high compared to bank loans. However, if a group of people wanted to become developers themselves, such as with energy cooperatives, then crowdfinancing would be a good option. Projects could be better supported by local inhabitants, assuming that they are also investors, as NIMBY movements often oppose sustainable projects. Additionally, if the project initiator is not able to provide the required equity for a project, crowdfinancing could be a good alternative source of funds.

C: Yes. Municipalities would require projects to allow the local inhabitants to participate financially in the projects. Crowdfinancing would be used as a way of participation and not because of an unavailability of funds.

3. If yes, how would you organize the crowdfinancing process? Can you name success criteria?

M: Crowdinvestors should be involved in the project as well, since they identify with the project and are not just driven by profitmaking. The government should keep oversight of the process and project initiators should provide guarantees to their investors.

C: Project financing through crowdfinancing would be done in the form of bonds. Investors would get a fixed rate of return, but have no ownership of the project.

P: I think that these criteria should be met:

- People do not invest in the crowdfinancing platform, but in the offerings placed on the platform. The success of the platform is thus very much related to the success of the offerings on it.
- Crowdfinancing is a high volume business, since the margins are low. So cost-efficiency is really important.
- Compliance with regulation is also very important, because the space is getting more and more regulated by the day.

Extra: Can you elaborate more on the constraints put up by regulation?

P: The bottleneck in the crowdfinancing process is related to KYC regulation. By example, it is difficult to open a bank account for receiving funds from crowdfinancing, as the receiving bank would have to know where that money is coming from and that "no funny business" is going on.

Extra: but if you sell products online you also get payments from many people, so how is that any different?

P: Yes, but the KYC problem is compounded if you work in the securities industry, as it is subject to more regulation. Whether right or wrong, a big distinction is made between the sale of a ball for 1 million EUROS than selling bonds for that same amount.

I When we refer to "the crowd", what specific group of people do you see as potential investors?

S: Investors that share the same vision as the project initiator and are thus willing to support the project.

II Should investors from abroad be allowed to participate? And if so, under what conditions?

M: Yes, as long as you know who you are doing business with.

C: International investors could be allowed, but that depends on how the crowdfinancing process is organized (e.g. through a website in English).

P: Investments from abroad ca be a problem because of regulatory constraints. Right now our platform only accepts investments from within the EU or people from certain geographies, but investing from a US or Chinese bank account is not possible. This also applies to project initiators, since we have to perform KYC on our customers and the burden of proof is on us, not on the regulator. We are also not allowed to promote our services in other countries, unless we apply for permits in those jurisdictions; so international investors would have to find us themselves.

III What kind of rights do you think the investors should have?

S: That would be situation specific, since every situation and company is different.

IV What kind of obligations do you think the investors should have?

S: As little as possible. The process should be easily accessible to all.

V Should investors be involved in project development? And if so, to what degree?

S: Yes. I find it important that project initiators build a community first, by means of building trust with supporters through transparency and interaction, so that potential investors become supporters of the project before actually investing in it.

VI What kind of information should be disclosed to investors?

S: The process should be as open as possible, but I can imagine that some information should not be made public to avoid losing competitive advantage in the market.

C: If using the same model for several projects I would be prepared to "open the books" the first time, i.e. disclose the business case, mention the pros and cons, etc., in order to gain trust among investors. For the following projects I would disclose less information.

4. If not, let's entertain the following scenario: imagine that the success of raising funds through a crowdfinancing campaign would be guaranteed for your project, would you be open to use crowdfinancing to finance your project? And if so, under what conditions? [*go back to question 3*]

B: I would still not use crowdfinancing (as a source of debt) so easily because of the increased costs of borrowing from the crowd. Additionally, the biggest developers provide the equity investment required for a project from their own corporate funds, so there is no present need for equity investments either.

5. Is there anything else you would like to add?

P: The lack of liquidity is not necessarily a barrier to investing. People understand that private equity is not liquid and just accept that. Some even like it, because it is not correlated to price movements on an exchange.

Extra: In my analysis of the energy market I noticed that with smaller projects the investment costs per kWh are relatively higher than with the bigger projects. Is this related to the higher costs of capital?

P: I don't think that's the problem. Smaller initiatives simply often don't have investable projects, or the funding to develop investable projects.

Extra: In order to address to inherent trust problem of crowdfinancing - especially with international investors -, there is a possibility to lock the project funds in a smart contract on the blockchain (in escrow), which would give investors more control over the project funds during its development. What is your opinion on this approach?

C: A risk that I notice with such a financing mechanism is that it could become a medium for speculation, as investors withdraw funds from the contract because another contract/investment is more profitable. So, if it is too easy to withdraw funds from the contract, it would be too high of a risk for a project to utilize such a financing mechanism.

Appendix E: Potential of crowdfinancing for the current types of energy projects

Type of project	Bank loans accessible	Current form of financing (P= primary; S=secondary; L=limited)	Financing gap (yes/no)	Reason for gap	Potential of crowdfinancing
Prosumer (in-house production and building improvement)	Yes[1]	P: prosumer's equity; S: asset-backet loans[1]; L: loans from sustainable funds[40]	Yes	Many buildings are rented out[7], so the owner is often not the one paying for the energy bill. Additionally, no simple forms of financing are available for prosumers (households)[2]	Could be used to finance multiple prosumers, if organized through one single project initiator (bundling of projects)
Prosumers (local production through cooperatives)	Mostly no[4]	P: prosumer's equity (small scale crowdfinancing)[3]; S: alternative financing*	Yes	The projects are too small/risky for bank loans and/or due to a lack of standardization of their business models[4]	Is a good match for projects that are already initiated by the crowd
Prosumers (remote production through retailers)	Yes	P: crowdfinancing	No***		Not evident
Small projects	Mostly no[4]	Alternative financing	Yes	The projects are too small/risky for bank loans and/or lack standardization of their business models[4]	Is already being used but the scale could be increased
Medium projects	Sometimes, depending on risk profile	Mix of bank loans**, corporate bonds and alternative financing	Yes	The projects are too risky for bank loans[6]. Corporate bonds are too expensive to issue[5]	Is already being used but the scale could be increased
Big projects	Mostly yes, but decreasing[3]	P: bank loans; S: corporate bonds	No, but corporate bonds are increasing[3]		Can be used to increase support from local inhabitants and acquire the private equity required by the bank (at least 10% of the total investment sum)[2]

*e.g. private equity, crowdfinancing, equipment lease

**the probability to receive a bank loan is positively correlated with project size, but negatively correlated with risk

***enegy retailers have access to bank loans, but seem to utilize crowdfunding in order to attract consumers

References

1 (Vereniging eigen huis, n.d.)
2 (Lodders, 2019)
3 (Overbeek, 2019)
4 (Hier opgewekt, 2016)
5 (CBS, 2018)
6 (Van der Geest, 2017)
7 (Compendium voor de Leefomgeving, 2018)

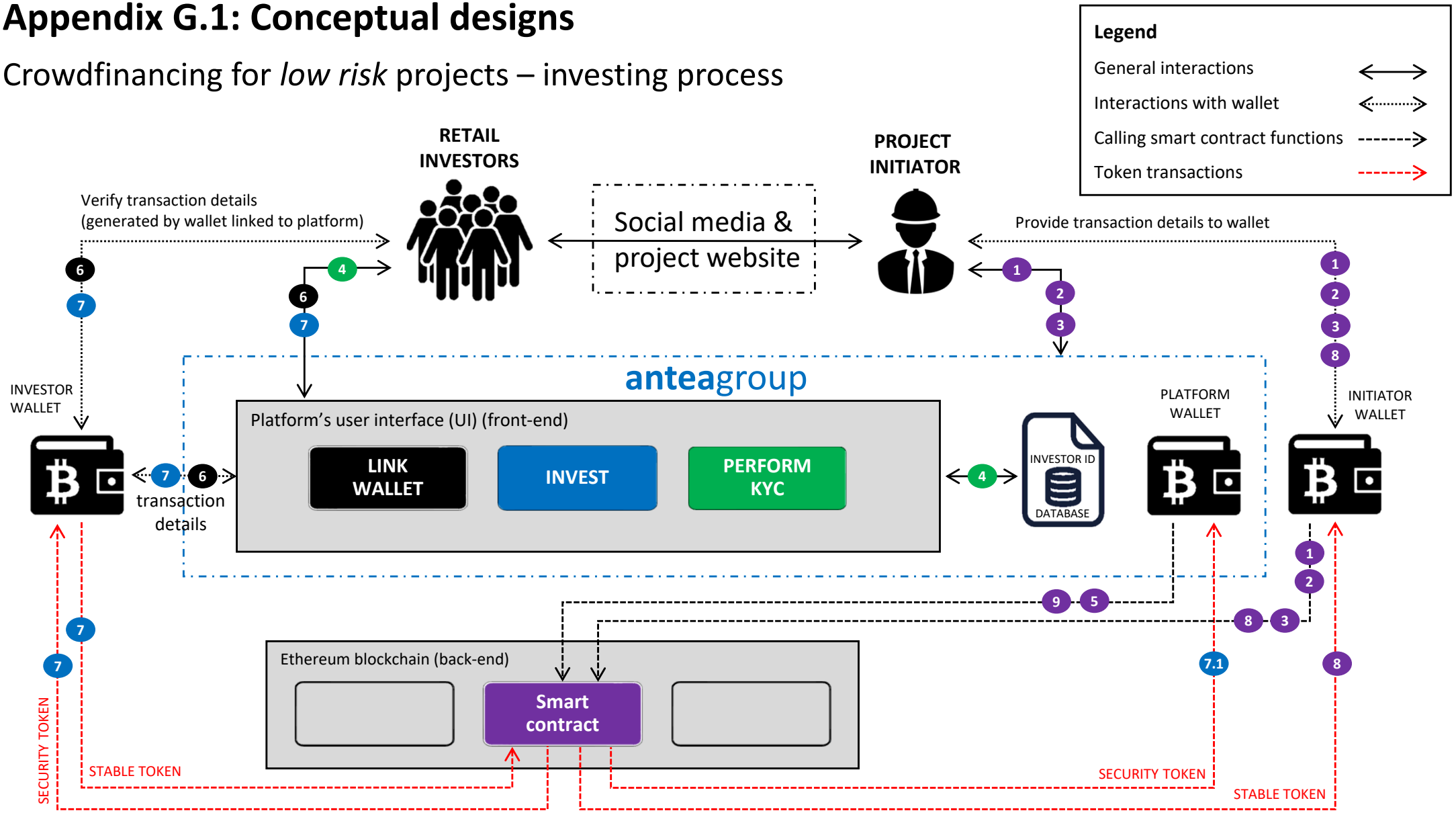
Appendix F: Stakeholder analysis

Stakeholder	Interests	Problem perceptions	Functional (F) / Performance (P) requirements
1. Project initiators (projects below € 1 million)	Contributing to the energy transition by producing renewable energy, but more so in case of energy cooperatives, which are driven by a community logic (Vismara, 2019)	Low share of energy production from renewables (CBS, 2019-a)	
	Capital formation	Bank financing is not available for small projects and project bundling is difficult (Hier opgewekt, 2016)	
	Cost efficiency	High brokerage fees on existing crowdfinancing platforms (see appendix C)	P: Low brokerage fees relative to existing crowdfinancing platforms
	Independence from third parties	Bankruptcy of the platform could undermine the project	F: Project initiator can assume the responsibilities of the platform or outsource to another party
1.1 Prosumers	Becoming energy independent	Costs of energy expected to keep increasing (ECN, 2017)	
		Grey energy (from fossil fuels) is often masked as “green” by means of Green Tradeable Certificates” (Milieu Centraal, n.d.)	
2. Project initiator (projects above € 1 million)	Contributing to the energy transition by producing renewable energy	Low share of energy production from renewables (CBS, 2019-a)	
	Capital formation	Required interest rates for crowdinvestors too high relative to bank financing	P: Low interest rates relative to bank financing
	Cost efficiency	If bank financing unavailable/insufficient: high brokerage fees on existing crowdfinancing platforms (see appendix C)	P: Low brokerage fees relative to existing crowdfinancing platforms
	Reduction of project risks (related to delays in / obstruction of project development)	Big projects are sometimes opposed by the surrounding communities	F: Local inhabitants are given priority to invest
	Independence from third parties	Bankruptcy of the platform could undermine the project	F: Project initiator can assume the responsibilities of the platform or outsource to another party
2.1 Municipalities	Allowing local residents to profit (financially) from energy projects	Local inhabitants are directly affected by the downsides of project development and exploitation, but don’t benefit from the generation of profits	F: Local inhabitants are given priority to invest
	Becoming energy independent	Costs of energy expected to keep increasing (ECN, 2017)	
		Grey energy (from fossil fuels) is often masked as “green” by means of Green Tradeable Certificates” (Milieu Centraal, n.d.)	

3. Crowdinvestors	Contributing to the energy transition by investing in renewable energy (driven by a community logic [Vismara, 2019])	Low share of energy production from renewables (CBS, 2019-a)	
	Capital formation (as a goal on itself or as a hedge against inflation)	Reduced value of bank savings due to interest rates (ECB, n.d.) being lower than inflation rates (CBS, 2019-c)	
	Financial privacy	Crowfinancing platforms hold financial information that should not be public record	F: Investors' financial information is not public record
	Liquidity	No secondary markets available for trading crowdfunded securities	F: Secondary markets are available
	Inclusive corporate governance	Geographical distribution and small investment size are a deterrent to participate in corporate governance (La Porta et. al, 2002)	F: Investors can exercise their voting power (if applicable) from distance
	Control of project funds	Crowdinvestors distrust a project initiator's use of funds (Gerber & Hui, 2013)	F: Investors can cut losses in failing projects
		Crowdinvestors are unsophisticated, i.e. lack the ability to assess investment opportunities (Ahlers et al., 2015)	
3.1 Local crowdinvestors	Inclusion	Local inhabitants are directly affected by the downsides of project development and exploitation, but don't benefit from the generation of profits	F: Local inhabitants are given priority to invest
4. Crowdfinancing platform	Compliance with laws on the prevention of money laundering and the financing of terrorism (Wwft regulation)	Investors' identities must be known and unusual transactions must be reported (AFM, n.d.-a)	F: Transactions are traceable to individual investors
	Cost efficiency	High administrative costs, especially if secondary markets are created (see NPEX data on appendix C)	P: Low administrative costs relative to existing crowdfinancing platforms
	Avoidance of capital pools	Capital pools on the platforms cause security and compliance risks (Zhu & Zhou, 2016), which have already been triggered in The Netherlands (Schelfaut, 2019)	F: Investor funds are not held by the platform
5. Government	Prevention of money laundering and the financing of terrorism	(If) the platform is considered to underwrite the issuance of securities, it has to comply with Wwft regulation (AFM, n.d.-a)	F: Transactions are traceable to individual investors
	Financial market supervision	(If) the platform is considered to underwrite the issuance of securities, it requires a license in order to comply with Wft regulation (AFM, n.d.-c)	

Appendix G.1: Conceptual designs

Crowdfinancing for *low risk* projects – investing process

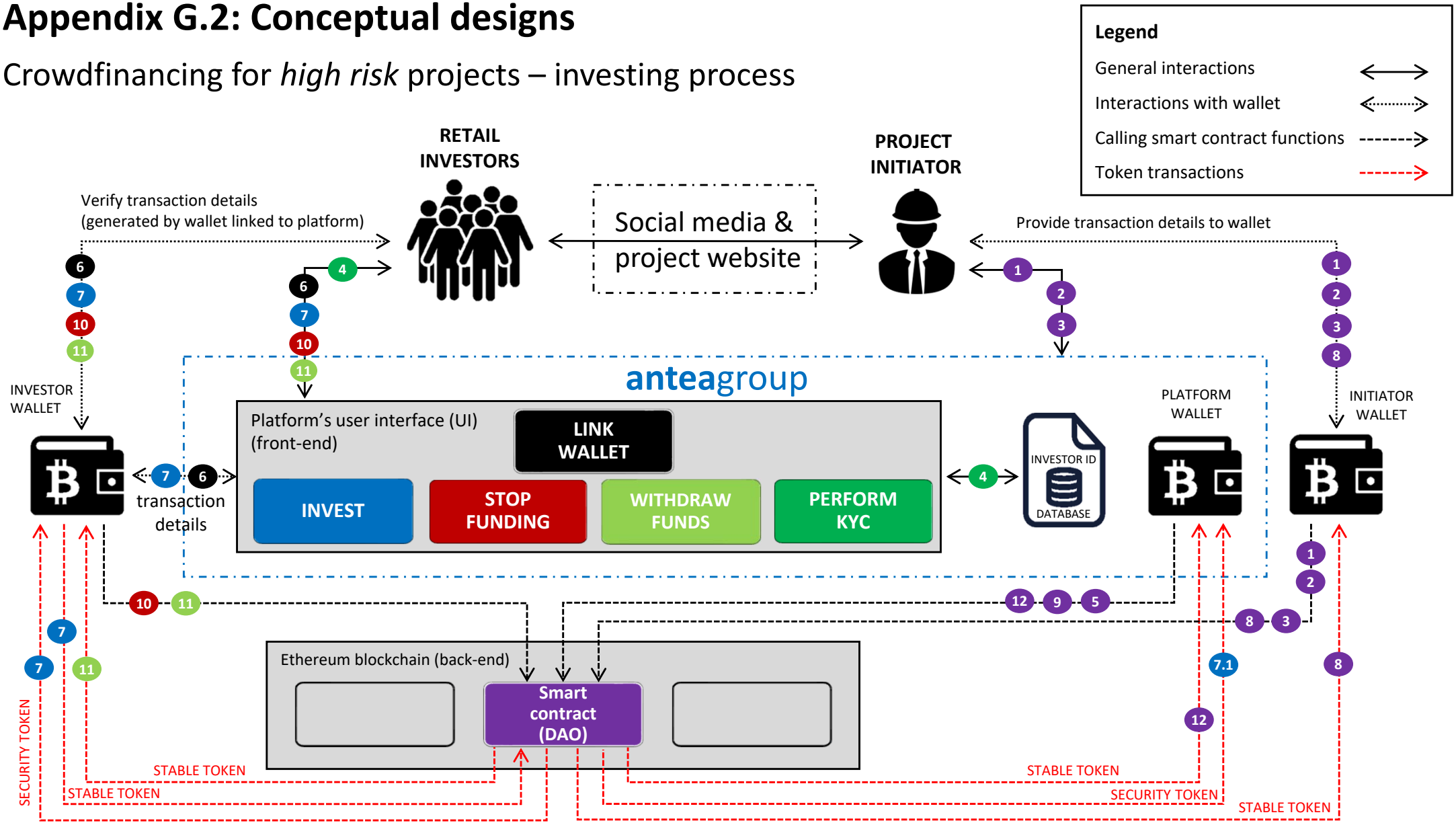


Investing in steps (excl. fiat to cryptocurrency on- and off-ramping)

1. Project initiator deploys the smart contract
2. Project initiator calls contract function to *delegate* whitelisting authority to Antea's address
3. Project initiator calls contract function to set another Antea's address as *beneficiary* of financing costs
4. Perform KYC: Investors submit their ID and address on the (ethereum) blockchain for whitelisting
5. Antea calls contract function to *whitelist* investors' addresses
6. Link wallet (optional): investors perform this action to interact with the contract through the platform's UI
7. Invest: Investors send stable tokens to the contract, which returns security tokens in exchange
7.1 The smart contract mints the financing costs automatically (in security tokens) to the beneficiary's address
8. Project initiator calls contract function to *withdraw* (all) stable tokens to his/her wallet
9. If financing target achieved: Antea calls contract function to *whitelist* additional addresses (for trading)

Appendix G.2: Conceptual designs

Crowdfinancing for *high risk* projects – investing process



Investing in steps (excl. fiat to cryptocurrency on- and off-ramping)

Steps 1 until 7.1 are identical than with low risk projects, but the following actions apply for high risk projects:

8 Project initiator calls contract function to *withdraw* unlocked stable tokens (planning based)

9 If financing target achieved: Antea calls contract function to *whitelists* additional addresses (for trading)

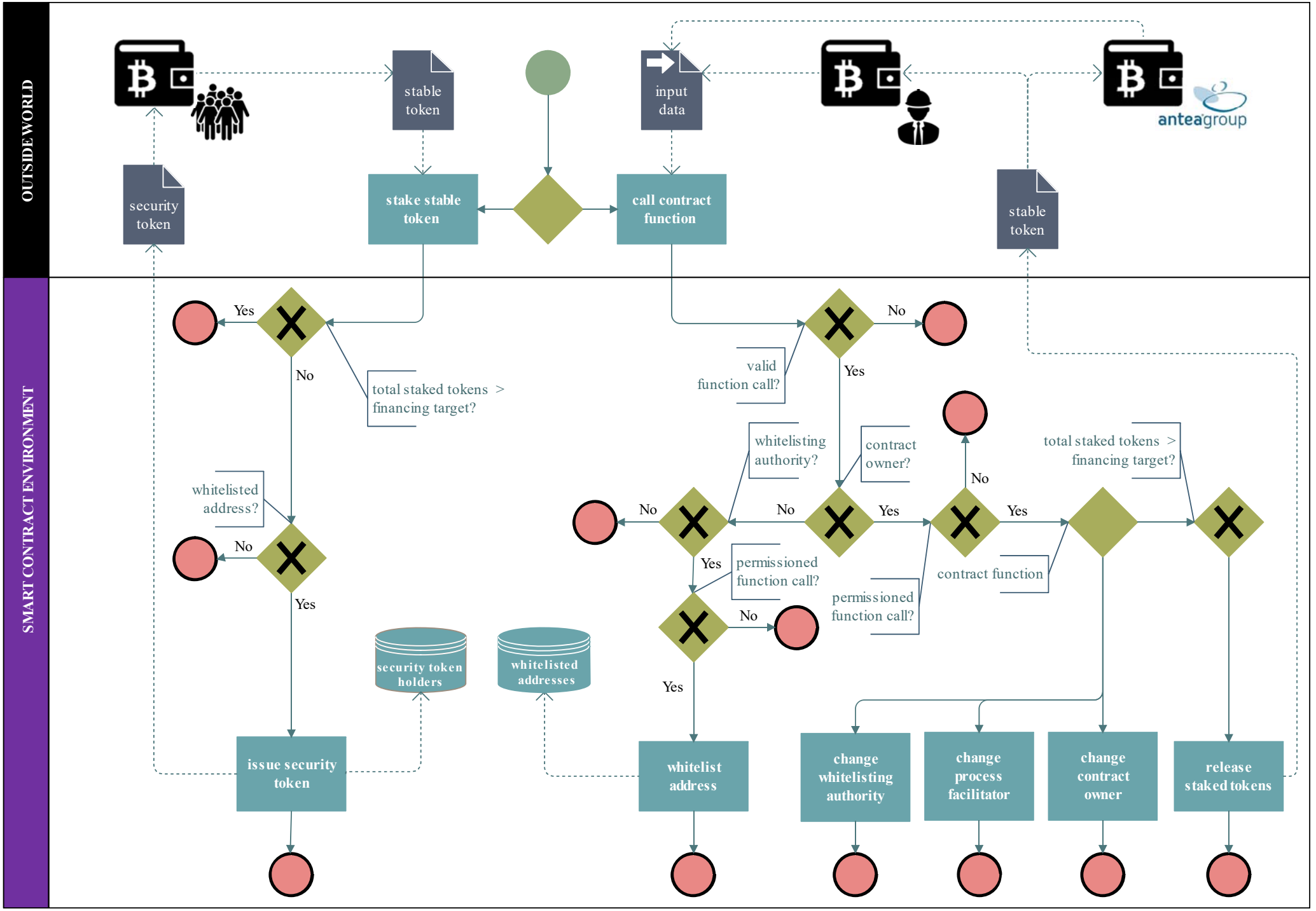
Other possible actions:

10 Stop funding: security token holders vote to stop the funding for the project

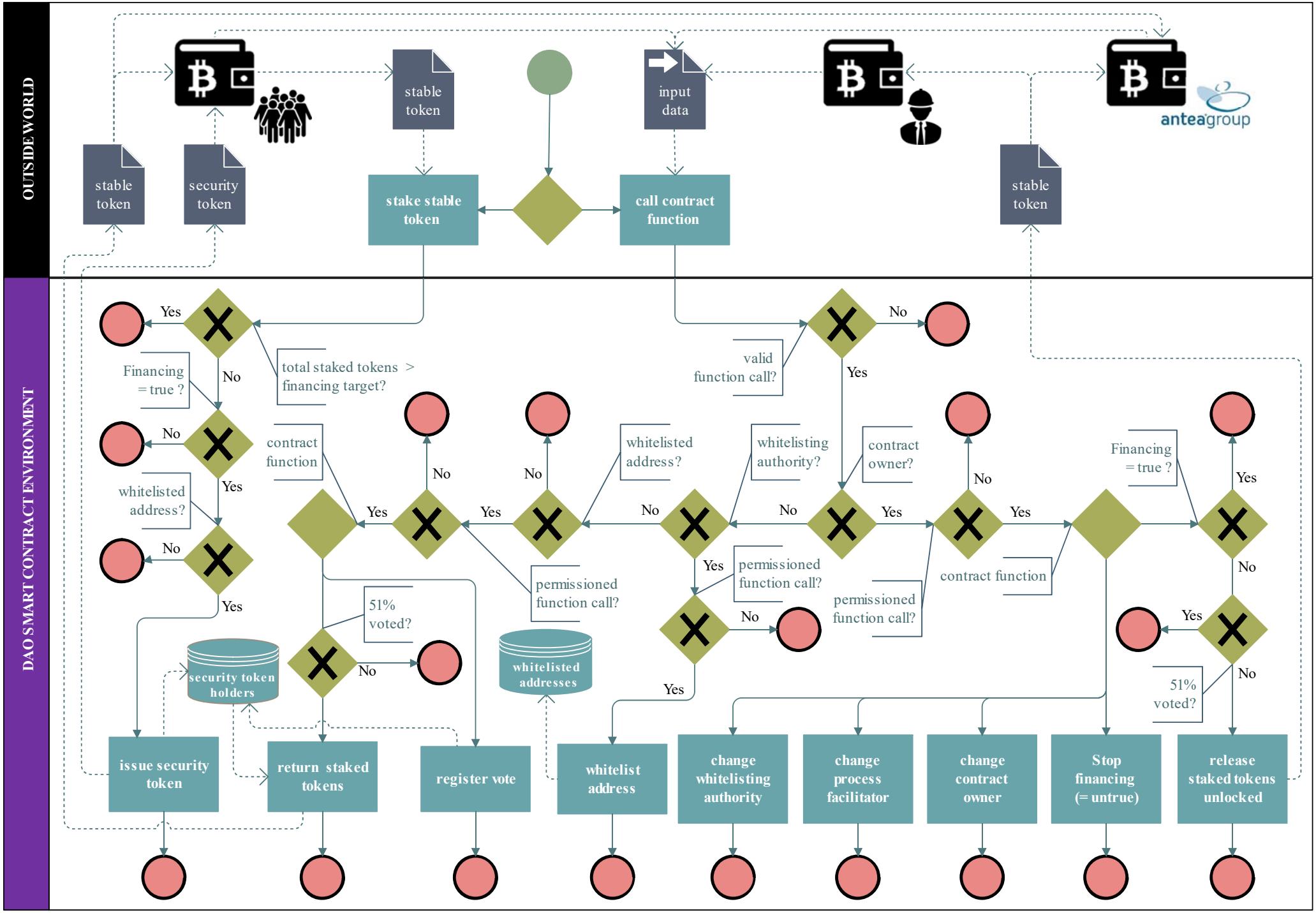
11 Withdraw funds: If 51% of security token holders votes, the remaining funds can be withdrawn (total withdrawalable funds = stable tokens in the contract – financing costs)

12 If 51% of security token holders votes, Antea calls contract function to *withdraw* the financing costs (financing costs = Antea's stake in the project * financing target)

Appendix H.1: smart contract model (flowchart) for low risk projects - investment process



Appendix H.2: DAO smart contract model (flowchart) for high risk projects - investment process



Appendix I: Direct Cost estimation

Variant description	Lower bound description	Upper bound description	Potential risk description
1: investing through project initiator's website	Antea provides the smart contract and front-end infrastructure to the project initiator	As with *lower bound* , but Antea manages the investor ID database as well	A (DAO) contract might fail, so extra audits might be required beforehand (to be determined)
2: investing through Antea's website	Overal optimistic cost estimation	Overal conservative cost estimation	As with *Variant 1* , but Antea could require a (banking) license to operate

	Variants					
	1			2		
	lower bound	upper bound	potential risk	lower bound	upper bound	potential risk
Investment costs						
Front-end (website) design[1]				5,000	10,000	
Development of smart contract (reusable code)[2]	1,000	2,000	2,000	1,000	2,000	2,000
License to mediate in the issuance of securities[3]						48,700
total	1,000	2,000	2,000	6,000	12,000	50,700
Fixed costs (per year)						
Front-end maintenance[5]				500	1,000	
Blockchain developer[6]	5,200	10,400		2,600	5,200	
total	5,200	10,400	0	3,100	6,200	0
Variable costs (per project)						
Review of application[7]	100	300		100	300	
(Outsourced) customer service[8]				250	500	
Deployment of smart contract[9]	5	10		5	10	
Management of investor ID database (120 whitelisted addresses)[12]		440		220	440	
Reporting unusual transactions (compliance with Wwft)[15]		500		250	500	
Administrative overhead (5.5% of total variable costs)[16]	5	63	0	41	88	0
total	110	1,313	0	866	1,838	0

List of assumptions

[1]The cost of designing of a website can go from a free template to a € 10.000 website (WebsiteBuilderExpert, 2019). The higher end is chosen here because of the wallet integration

[2]The smart contract is assumed to cost €1.000 for low risk projects and €2.000 for high risk projects (DAOs) because of higher complexity and risk exposure. The costs are derived from Tarasenko (2019). Given the potential damage to the platform's and the company's image in case of a failed contract, an extra €2.000 is reserved under potential risk for additional audits; in practice this risk would probably be insured against.

[3]Mediating in the issuance of securities requires a license. However, since with the crowdfinancing mechanism proposed in this thesis the issuance of securities is managed autonomously by the smart contract and the platform performs a relatively smaller (and non-essential) role, it is unclear whether the platform's activities fall within the existing regulatory framework, if at all. Nevertheless, a license for these actrivities costs: € 48.700

- license application[4]: € 45.100
- suitability test per daily policymaker and commissioner (1 assumed): € 2.900
- Reliability test per daily co-policymaker and commissioner (1 assumed) : € 700

[4]The costs charged by the AFM for a license application can go up to € 100.000, but in recent years the average costs have been around € 45.000 (Ministry of Finance, n.d.). The costs of preparing the application itself are not included in this cost estimation.

[5]maintenance include domain registration, hosting and SSL license; € 500 for a small Ecommerce website and € 1000 for a professional Ecommerce website (O'Connor, 2019)

[6]developer assumed to be necessary between 1 hour per week and 1 hour per 2 weeks, twice as often in variant*1-lower bound.* Costs based on Western European rates (Tarasenko, 2019)

[7]lower bound based on the rate charged by Greencrowd (non-profit)

[8]outsourcing 5 calls and 5 e-mails per day for 2 months costs € 500 (Direct Klantcontact, n.d.)

[9]Deployment of smart contract (incl. 120 whitelisted addresses): € 10 (conservative)

- Deploying the contract without whitelisted addresses: € 2,71 (Ryan, 2017)
- Including 120 whitelisted addresses in the contract upon deployment: € 1,23
  - 1 Ethereum address is 20 bytes big (Ether World, n.d.)
  - 1 byte costs 640 gas[10] to store on the Ethereum blockchain (Stack Exchange, n.d.)
  - The gas price[11] as of October 30, 2019 is 5 gwei (= 5*10-9 ETH [Eth gas station, n.d.])
  - ETH price as of October 30, 2019 is € 163 (Bitstamp Exchange, n.d.)
  - Cost per address: € 0,01

[10]Gas is the fee paid to conduct transactions on the Ethereum blockchain and is measure in ETH (Ethereum's native currency)

[11]Gas prices fluctuate due to network congestion, as the supply (size of each block) is fixed and demand (amount of signed transactions in the pool waiting to be picked up by miners) varies. However, from my own experience transactions can be normally confirmed under 5 minutes with a 5 gwei gas price.

[12]Crowdfinanciers in the Netherlands invest on average € 3.400 per renewable energy project, while the average renewable energy project raises € 400.000 (ASN Bank, 2019). This results in 118 (≈120) investors per project. The cost of managing the investors ID database is: € 240

- Performing KYC on 120 addresses[13]: € 120
- Approving 100 additional investors (traders) to trade the security tokens[14]: € 100

[13]Crowdinvestors invest on average in 44 different projects (ASN bank, 2019). Therefore, it can be expected that in the future less Know your Customer (KYC) checks will be required per project. The cost of performing KYC (checking ID documentation and proof of residence) on 1 investor is assumed to be € 1.

[14]The addresses of investors that did not invest initially in the project, but want to trade its security token, need to be added to the contract manually. Some traders might have already performed KYC and the costs of adding new addresses to the contract is negligible, so the costs of approving 1 new trader is conservatively assumed to be€ 1.

[15]The Wwft requires businesses to report unusual transactions of their customers (AFM, n.d.-a). Given the (pseudo) anonimity of blockchain transactions I assume that the platform will only be required to analyse the transactions related to the projects' security tokens between withelisted addresses. Since this process can be automated I assume a cost of€ 250 per project.

[16]assumption of 5.5% based on internal discussions with Antea personnel

Appendix J: Verification of design requirements

	Smart contract implementation		
Design requirements	**Low risk projects**	**High risk projects**	**Comments**
Functional requirements			
Project initiator can assume the responsibilities of the platform or outsource to another third party	✓	✓	
Local inhabitants are given priority to invest	✓	✓	The priority is given by humans by whitelisting addresses in phases
Secondary markets are available	✓	✓	
Investors' financial information is not public record	✓	✓	
Investors can exercise their voting power (if applicable) from distance	✗	✓	With low risk projects the security token holder has no voting power
Investors can cut losses in failing projects	✗	✓	With high risk projects the security token holder has control over the project funds
Transactions are traceable to individual investors	✓	✓	
Performance requirements			
Cost efficiency (1): low brokerage fees relative to existing crowdfinancing platforms	✓	✓	
Cost efficiency (2): low administrative costs relative to existing crowdfinancing platforms	✓	✓	The issuance and trading of securities is taken over by smart contracts
Cost efficiency (3): low interest rates relative to bank financing	✗	✗	
Accessibility: the mechanisms are accessible everywhere, to everyone with an internet connection	✓	✓	
Reliability: the mechanisms are online 24-7	✓	✓	
Security: the mechanisms are secure from attacks from the outside	✓	🕐	Smart contracts are audited against known attacks, but new attack types are still possible in the future

Immutability: Transactions are final and tamperproof	✓	✓	Transaction finality becomes more certain with more network confirmations
Speed: Transactions are confirmed within reasonable times (say 5 minutes)	✓	✓	The speed of confirmation depends on network congestion, but it is currently down to seconds for the first confirmation to occur
Scalability: the mechanism is able to handle hundreds of transactions within hours	✓	✓	On January 18, 2020, Ethereum's blocks are 68% full. Assuming 15 TPS of possible throughput results in 17.280 possible extra transactions per hour

Appendix K: Validation of practical plan

1.1. Purpose

These feedback comments and processing thereof constitute the validation of the solution proposed in this thesis. The purpose of the validation was to judge the assumptions and proposed solution from the perspective of professionals in relevant fields in order to establish whether the solution proposed is indeed the right one.

1.2. Expert panel members

The reasoning behind the selection of expert panel members is laid out in section section 4.4 of the thesis report. The panel of experts consisted of:

- A stakeholder manager for infrastructure projects from Antea Groep
- An infrastructure project manager from Antea Groep
- A representative from the department of Strategy & Innovation at Centric, a Dutch IT company with existing research on blockchain technology

My responses to their feedback are market in red color.

1.3. Assumptions

1. **The proposed solution is smart enough, i.e. it fulfils its intended purpose**

With projects where crowdfinancing becomes part of the citizen participation process there could be a conflict of interests if Antea Group has a stake in the crowdfinancing process by receiving a percentage of project initiator withdrawals from the contract as brokerage fees, since Antea Group must remain neutral with regards to local inhabitants vs project initiators.

Response: Traditionally Antea Group is always contracted by the project initiator anyway, so the same could be said of that business model. If anything, the proposed solution is better aligned with the interests of the local inhabitants, as Antea Group does not receive brokerage fees upfront, but during the contract's life cycle and only if it fulfills its function.

2. **The proposed solution is attractive for crowdinvestors, although the average retail investor in the Netherlands is 52 years old (AFM, 2017)**

Financial citizen participation is not likely to decrease opposition from local communities, as not all inhabitants are equally benefitted. Maybe project initiators should pay a share of the profits to local communities / municipalities instead.

Response: I do agree with the fact that with financial participation only investors are benefitted, but I also think that forcing projects to pay for the right to develop sets a dangerous precedent that could incentivize even more opposition in the future in order to extract more rents from projects. Additionally, the added costs are counterproductive because the main goal is to allow more projects to take place – in my proposal by sharing risks (investment) and benefits (return on investment) – and not to further increase the costs of project development. Lastly, I think that having more active supporters for a project will always help balance the scales with regards to the net effect that the opposition can actually have, regardless of whether said opposition was actually reduced or not by crowdfinancing.

Public engagement with regards to the transition decreases with the use of (blockchain) technology, as human interaction and therefore engagement itself is deteriorated.

Response: although the technology itself does not increase engagement, in my opinion having a (potential) financial stake in a project incentivizes crowdinvestors to be involved. Ordanini et al. (2011) also find that contributors that identify themselves with a project act as agents of the offering and engage in promotion organically. Ultimately, the argument is made for crowdfinancing and not for blockchain, as the latter is only a tool to facilitate the former.

Solar and wind parks are often built in rural areas, where older and more conservative people live. Is this not a barrier for adoption given the complexity of blockchain technology?

Unfortunately, I do not think there is an easy way to overcome this limitation. Educating users about a new technology always helps, but I think that social exclusion in this case might be a real problem due to the added responsibility to the users in decentralized blockchain ecosystems. As a result I would expect new intermediaries to emerge for the management of digital assets, but the organization thereof falls outside the scope of this research.

3. The proposed solution is attractive for potential project initiators

Municipalities are always the last entities to adopt new developments, so the proposed solution might be viewed as too risky for them to use.

I also agree that most municipalities would hold back at first, but maybe not all given the diversity between them. Right now there are several municipalities that want to become energy independent and that is not conservative at all.

Municipalities normally borrow from government funds, so they are not likely to pay out dividends/rent. Crowdfinancing might not be a good fit if the municipalities themselves are the project initiators.

I also agree with this. Municipalities can be the kickstarters of projects, but only if the projects are later outsourced to third parties through concessions.

4. **The short-term exposure to the risks associated with stable tokens are acceptable**

*no feedback was received for this assumption

5. **Blockchain technology is suitable for compliance with laws and regulations**

*no feedback was received for this assumption

6. **The complexity of using blockchain technology (e.g. signing up for exchanges, setting up wallets, securing private keys) is compensated by the benefits**

If blockchain-based crowdfinancing mechanisms indeed reduce costs relative to traditional practices and thus increase returns for investors they will participate. If the hurdles cannot be lowered, they will just have to overcome them.

I also think that the benefits outweigh the required effort of learning about blockchain technology, but also that many people will experience the crowdfinancing process as too complex at first due to the extra steps that need to be taken before actually investing in a project.

Extra feedback:

Antea Group does not have a role in the financing market at this moment. Why should the company expand its business model?

Response: the added value for Antea Group entails being able to facilitate alternative financing for their clients, either as a goal on itself or as a tool for financial citizen participation, thereby absorbing a bigger share of an expanding energy market. Whether this is strategically in the

interests of the company or not, remains outside the scope of this research and is ultimately up to the company board of directors to decide.

A smart contract cannot replace a number of functions, especially trust. By example, a notary provides a certain amount of trust because it is a human being that can be looked in the eyes and given a handshake.

Response: I complete disagree with this statement. Shaking someone's hand does not remove the need for trust – on the contrary – the act of shaking a person's hand is the mere establishment of the trust that is required to make an agreement about future actions. Smart contracts on the other hand are trustless because the only possible actions that the parties involved can take are defined by the smart contract, so there's no trust needed in that all parties will live up to their agreement.

Absent knowledge of programming there is a certain trust required in the correctness of the code that makes up the smart contract, but open source software is for all to see and audit, thereby decreasing the need for trust over time.

Is the lack of support for the transition related to financing, or to something else? Are there not enough funds available in the market for the bigger projects, which make up most of the renewable energy market?

The bigger projects do (still) make up most of the market, but they rely primarily on bank financing, which has been decreasing in general and is only suitable for low risk projects with proven technologies. The problem is not a lack of funds, but a lack of willingness to invest by professional investors due to a variety of institutional policies and investment preferences. The purpose of utilizing blockchain-based crowdfinancing is to reduce the growing financing gap by improving the crowdfinancing process and empowering the crowd, which is less driven by financial rewards and therefore a better suited investor for renewable energy than professional investors.

With regards to energy cooperatives, if a collective wants to start a renewable energy project the municipality should provide the funds required, so crowdfunding is not the right solution.

Response: In this case the municipality would have to take a loan or increase taxes in order to provide the funds, for which consensus among a majority of citizens would be required. The inability to achieve consensus is in my opinion the main reason why there is a financing gap in the first place, so I don't think this is likely to happen in the short term.

I argue that projects should be financed by the people that support the transition and are willing to invest their own money in it, instead of proliferating the current paradigm where relatively little can be done by governments due to lack of consensus.