This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 646116

H2020 REALVALUE

D6.4 ALIGNING BUSINESS MODELS WITH MARKET DESIGN AND REGULATION

Date	11.05.2018
Dissemination Level	Public
Responsible Partner	DIW Berlin
Editors	
Authors	Nils May, Karsten Neuhoff, Carmen Pajuste, Carlotta Piantieri, Nolan Ritter (all DIW)

Document History

Version	Date	Contributor	Comments
DRAFT	04.05.2018	NM, KN, CP, NR	
FINAL	11.05.2018	NM, KN, CP, CP, NR	

List of Abbreviations

Abbreviation	Definition
BM	*Business model*
DERs	*Distributed energy resources*
DG	*Distribution generation*
ES	*Energy storage facility*
ESS	*Energy storage systems*
EV	*Electric vehicles*
GHG	*Greenhouse gas*
PV	*Photovoltaics*
R&D	*Research and development*
RE	*Renewable energy*
SETS	*Smart Electric Thermal Storage devices*
SME	*Small and medium-sized enterprises*

TABLE OF CONTENTS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 646116

ALIGNING BUSINESS MODELS WITH MARKET DESIGN AND REGULATION

Potential business models around Smart Electric Thermal Storage devices (SETS) evolve in a quickly-developing environment, where power systems in transition and digitalization meet and where policy-makers can affect the viability of business models. Therefore, it is crucial to understand how business models function within the scope of energy transitions and which barriers they can face. To overcome these barriers, policy-makers have a number of policy instruments at hand in order to support certain business models. This report starts out by outlining the general barriers to new business models and how policy instruments can address them. In the second part, the report introduces a detailed and flexible numerical application which calculates the viability of a range of business models and how they are affected by policy instruments.

INNOVATIVE BUSINESS MODELS FOR CLEAN-TECHS

1. Policymakers call for new business models

Energy transition plays a critical role in climate change mitigation, yet it is not occurring at a speed necessary to effectively meet greenhouse gas (GHG) reduction targets. Policy makers are confronting the challenge to unlock flexibility and efficiency of energy systems. They call for new business models (BMs) (COM, 2017; EC, 2017; COM, 2016; BMWi, 2017; DECC, 2015) to overcome the inertia prevalent in the system[1]. They believe that BM innovation can help them unlock those factors for three reasons:

1. new BMs indirectly increase competition – hence, the pressure to incumbents for up-taking innovative measures;
2. new BMs directly boost the uptake of new technologies;
3. new BMs directly boost the uptake of new practices to engage with stakeholders.

Due to their heavy asset structure, and favored by a solid market share, incumbents are hesitant to invest in R&D and in the development of new technologies. On the contrary, new players are more likely to develop and/or adopt innovative technologies. Furthermore, they are also more likely to introduce new practices, such as energy efficiency and digitalization, to stakeholders – thereby, creating new market segments.

Innovative business models would accelerate the systemic shift from the current carbon-intensive economy to a cleaner economy where flexibility and efficiency are enhanced (Johnson et al., 2009; Schleicher-Tappeser, 2012; Wainstein et al., 2016). Indeed, consumers can play an increasingly active role in the energy market (through demand response and energy efficiency), given that the infrastructures

[1] Business models are the value proposition of a company i.e. the value creation and value capture strategy that a company pursues through the supply of goods/services (Niesten et al., 2016; Johnson et al. 2008; Magretta, 2002). Hence, they vary according to company's target market, distribution channels, product/service offer, cost structure and revenue model (Osterwalder et al., 2005).

and services to do so are offered. Furthermore, distributed energy resources (DERs)[2] within the distribution system, traditionally viewed as relatively passive load resource, have a large potential: distributed renewable energies and energy storage technologies are already at the forefront of the energy transition. The potential flexibility of the system can be maximized by energy system operators and service providers, if new BMs are adopted. Business models that allow such developments are crucial vehicles for innovation (Johnson et al., 2009). Nevertheless, they struggle to materialize in the current environment.

2. Barriers to business models innovation

This section explores the barriers to the emergence of new BMs for low carbon products and services, as identified by the academic literature.

1. The Dominant Model

First of all, the status quo represents a substantial barrier to the experimentation of new BMs, as it poses both material and strategic constraints. The development of new BMs is often in conflict with existing BMs since any form of innovation would require the redefinition of the value creation process (Christensen, 2003; Charitou, 2012). Indeed, in order to capture value from new technologies, new BMs may involve new assets' configuration, target new distribution channels and/ or different end-customers (Christensen, 2003). Due to their heavy asset structure, and favored by a solid market share, incumbents are hesitant to invest in R&D and in the development of new technologies. Hence, in general, managers do not change their core business model as long as they are still making profits (Grassman et al., 2014).

Utilities apply their traditional profit formula to DERs. Nevertheless, the strategic value of DERs does not lie in a competitive cost/ performance per kWh but in the possibility to supply different services, through different business models (Richter, 2013b; Helms et al., 2016). The simultaneous exploitation of different revenue streams from the different products that they can offer (simultaneous offer of peak load response, frequency response, price arbitrage, commodity sale, price stability to consumers, brokerage services, asset sale, lend, rent, lease etc.) is more profitable than the maximization of their energy supply/ storage capacity (traditional scale economy perspective). Time-based business models permit to balance the demand and supply of energy with enough flexibility for all the parties through timing (Helms et al., 2016).

2. Lack of Demand

Energy consumers are generally indifferent about the quality and quantity of electricity that they consume. Furthermore, in countries such as Germany, the price of electricity and heating is so low that consumers don't criticize their status quo (Richter, 2013b). Incumbent companies serve a population of customers which does not demand for the integration of DERs and the transition of the energy sector. Since utilities' customers show little interest in such a topic which does not directly address their energy consumption needs, incumbents are not encouraged to bring new technologies and/ or BMs to the market (Richter, 2013a; Richter, 2013b). While lack of demand may constrain incumbents' BM innovation, new cleantechs such as DERs and smart meters have the potential to engage consumers – thereby, increasing demand-side participation.

3. Low profitability (or low return on investment)

When BMs entail the installation of expensive technologies, the capital intensity of the upfront investment typically represents one of the biggest barriers (Niesten et al., 2016; Engelken et al., 2016). Furthermore, the profitability of innovative BMs tend to be low in the short term compared to traditional BMs that have shorter payback periods. As a result, innovative BMs tend to have a lower capability to attract financing.

[2] Distributed Energy Resources (DERs) include: Distribution Generation (DG), Behind the Meter Generation, Energy Storage Facility (ES) including electric vehicles (EV) charging stations, DERs aggregation that is a virtual resource formed by aggregating the aforementioned resources at different point of interconnection of the distribution system, Micro-grid that is an aggregation of multiple DERs types behind the customer meter at single point of interconnection, Cogeneration that is the production of electricity from the energy produced as by-product of another process, and Emergency, Stand-by or Backup generation. (NERC, 2017)

Hence, more flexible financing models are desirable for the adoption of new BMs (Schleicher-Tappeser, 2012). Startups, companies and cities struggle to create 'bankable' climate projects that attract debt/ equity capital, due to a lack of insufficient information about future return on investment.

4. Uncertainty about Financial Public Support

The absent or low profitability of Cleantech products and/ or services drives new BMs to depend on public financial support. Indeed, Cleantechs usually receive the financial support of policy makers who subsidize them through feed-in-tariffs, tax credits and other similar capital cost and/ or revenue payments. Thereof, innovative BMs rely upon the monetary support of public policies. This undermines the financial-viability of BMs, whose profitability becomes negative whenever governments amend the focal policy. As Burger et al. (2017) showed, the remuneration structure of DERs businesses is seldom resilient to such changes, giving rise to boom-and-burst cycles (examples include Solar PVs in Italy, Spain, UK, Nevada, Hawaii and several other countries). Furthermore, the uncertainty about public financial support in the long term does not permit businesses to have risk-free long-term planning (Engelken et al., 2016a) – eventually limiting the growth of companies (Aslani et al., 2013).

Overall, due to the temporal nature of public financial support schemes, new BMs tend not to be self-sustainable, whereas the economic-sustainability and independence of business models is crucial (Engelken et al., 2016a; Richter, 2013a).

5. Uncertainty about Future Market Design

Policies in promotion to the energy transition seize remarkable opportunities for reshaping existing BMs and designing innovative ones (Engelken et al. 2016a; Richter, 2013a). Nevertheless, the competition with incumbent companies, uncertainty about emerging technologies, and the lack of clarity about future market design have a counteracting effect. Often it is unclear which actor will take advantage of which opportunity and take over which role. The diffused uncertainty on the definition and distribution of responsibilities and roles to the various categories of actors in the energy market represents a substantial barrier to the roll out of innovative BMs (Niesten et al. 2016; Siano et al., 2014). Since BMs are exposed to regulations shaping the related markets, new BMs are exposed to regulatory uncertainty about future market design that may result in barriers for new technologies/ practices, or in new structures of prices and charges that may discriminate against clean technologies. Burger et al. (2017) illustrate the case of DERs which dispose already of the technical capability to offer certain services but often do not encounter appropriate participation models that allow them to adopt innovative BMs (e.g. PV voltage support in Germany, and community solar markets). Eventually, they can develop to the extent to which regulators allow them to sell the different range of products that they can supply.

6. Misalignment of Incentives

Firms along the energy value chain have different functions and/ or (sometimes contrasting) objectives. Each company tries to maximize its own interests (Narayanan and Raman, 2004). Nevertheless, coordination and cooperation among energy market stakeholders is important for the efficiency of the energy system, especially in the context of DERs – for better operational efficiency and distributed benefits. Similarly, with regards to financing, often the interests of companies and investors are not in line: payback periods of innovative BMs are not in line with the traditional financial instruments. Nevertheless, if they were in line, both would reach long term benefits (respectively, financing and returns). The misalignment of the value chain represents an important constraint to the development and uptake of innovative BMs. Aslani et al. (2013) identified inadequate coordination among various RE market stakeholders as the main barrier for innovative BMs, alongside budgetary limitations and lack of information on market demand and potential developments. Furthermore, uneven distribution of costs among stakeholders has been identified as a large barrier also to the development of the EV sector (Weiller et al., 2014). While the installment costs of energy storage systems (ESS) have decreased over the recent years, the exclusive access (single use) to the storage potential of ESS has been found to make ESS an investment not attractive to consumers (Lombardi et al., 2017) – whereas storage-space sharing BMs make ESS profitable and attractive to different consumers. Hence, lack of cooperation among stakeholders, both vertically and horizontally, represents a further source of inefficiency and a barrier to self-sustaining innovative business models.

7. Lack of Information

An additional barrier that merits consideration is the lack of information – lack of information on the technological performance, scalability and future technology, market, and policy advances (O'Keeffe et al. 2016; Girotra et al. 2013; Aslani et al., 2013). It is important to note that SMEs are particularly sensitive to such a barrier. In the specific case of SMEs, poor understanding of public Cleantech market support schemes and lack of access to the related information have been found by O'Keeffe et al. (2016) to be considerable engagement barriers, together with the inability to match the high initial costs with scale economies. Thereby, it compounds the risk stemming from the uncertainty about the sustainability of the market (uncertainty about policy makers' commitment).

3. Policy options

The following options are discussed in the literature for policy makers to address the barriers identified above.

1. Experimentation through pilots and funding to catalyze the transition

The first barriers to innovative BMs are the existing models, the low profitability of the new technologies and the resulting dependence on public financial support. Against this, the experimentation of innovative BMs, with different value propositions and revenue streams, would certainly foster the development and adoption of new BMs. Pilots have a strategic importance since they allow firms to test different BMs and, eventually, to adopt and invest in the most profitable ones (Chesbrough, 2010). If incorporated with subsidy and other revenue sources, such as ancillary services, pilots also provide a case study and proxy for future projects both in terms of revenue as well as technical requirements to access the revenue. Niesten and Alkemade (2016) propose that policy makers grant funds for such pilots in order to enhance the full potential of DERs. Indeed, in the case of DER services and services trying to integrate renewable energy, it is seldomly discussed how service providers capture the value offered. Usually pilots' focus lies on the technical feasibility and the systemic/ consumers' value creation. Nevertheless, in order to guarantee the economic-sustainability of the focal services, the profitability of the relative BMs shall be tested. This would enhance the development of commercially-viable business models.

Furthermore, it is also essential to unlock the opportunities emerged through successful pilots. On this regard, while it is key to shape the regulatory environment such that developments can then persist without dedicated subsidies, funding is indispensable to catalyze the transition. Niche markets need to be profitable within relatively short time horizons if we want to achieve GHG reduction targets. This is particularly the case of BMs that are not easily scalable because of linkages to regional customer base/ skills (Iliev, 2005) and, therefore, have constant returns on early investments.

2. Financial innovation

The cost and structure of the financing industry are inadequate to support the development of DERs and innovative BMs. Therefore, despite the presence of an active financial sector, the investments necessary to foster the energy transition have not been seen yet. Accordingly, innovative financial models would open up novel pools of funds and investment opportunities. After this purpose, the energy industry and the financial sector should cooperate to create new financing formulas for innovative BMs that meet the longer payback periods of innovative DERs businesses as well as bring attractive returns to investors. Since investors have heterogeneous preferences with respect to risk and return (Helms et al., 2016), new financial solutions could be designed to attract different ranges of investor types according to the risk profile of the BM, i.e. investors with different return requirements. From a BM perspective, this means attracting not only those focused on savings-based BMs but also those focused on revenue-based models with different value creation and capture structures[3]. In order to facilitate such a process, policy makers could create platforms bringing together businesses and investors for the joint design of a financial instrument suitable to the needs of both demand and supply of financing[4]. Furthermore, to enhance the alignment of the interests of businesses and investors, policy makers could set investment life-cycle labels that ensure fiscal advantages according to the carbon intensity of a BM. This would reduce the riskiness of long payback periods of innovative low-carbon BMs, and stimulate innovative financing models that match the needs of the focal BMs.

3. Definition of participation rules and market model

The competition with incumbent companies, the presence of restrictive regulations and the lack of clarity about future market design prevent companies from adopting new BMs. This requires competition policy makers to secure market entry, and energy market regulators to consider suitability for small new entrants in power market design.

DERs are emerging innovations with regards to which regulation plays a central role in the identification of the products to be supplied. As already mentioned, the value of DERs lies in the simultaneous exploitation of different value propositions. Therefore, defining the type of DERs products that can be offered, the relative market design and participation rules, is key to enable the development of innovative BMs. This would substantially decrease the regulatory risk of innovative BMs and decrease the cost of capital – hence, overall stimulate innovation.

4. Networks of actors

Networks are a powerful instrument to align the incentives of different actors and incentivize actors' coordination and cooperation (Sprenger, 2001). Inter-firm networks connect businesses among each other allowing them to interact, exchange information, cooperate and share objectives (Sprenger, 2001). They can favor the understanding of regulations and policy environment, and the engagement of businesses with the policies. Furthermore, they can ease cooperation among firms and may trigger the development of cooperative BMs – opening the field for revenue- as well as cost-sharing.

The interaction within networks has been identified as being beneficial to enhance stakeholders' information sharing, coordination and cooperation, especially for SMEs. O'Keeffe et al. (2016) recognized networks as a vehicle for the development of partnerships and of innovative business models that decrease the barriers to SMEs in energy efficiency initiatives. Networks have been recognized as source of value, returns and incentives also when comparing business models for PV water pumping in China, where they have been found to improve the internal rate of return, the return on investment and the discounted payback period of PV BMs (Zhang et al., 2017).

Similarly to inter-firm networks, regional networks can enhance communication, and often cooperation, between different actors along the value chain, not only businesses, but also research institutions, trade associations, public agencies, intermediary institutions, civil society and other groups (Sprenger, 2001). Bringing together diverse actors, regional networks motivate the consideration of different interests and expectations, bring various inputs into the discussion and may stimulate the design and development of innovative BMs. Eventually, they may also activate partnerships on different dimensions (Sprenger, 2001).

Finally, zooming in on the community level, local networks can enhance the engagement of local consumers with the low-carbon energy objectives of policy makers. In fact, they trigger the development

[3] Other things being equal, risk-adjusted returns of savings-based business models are higher than those of revenue-based models (Karneyeva et al., 2017). Savings-based models have a partial hedge against policy and revenue risk since the partial self-consumption of energy, whereas revenue-based models are fully exposed to those risks.

[4] An example of financial innovation is the City Finance Lab, a capacity building initiative which engages 200 cities worldwide, together with NGOs, private and public investors, and solution providers – helping them to develop innovative financial solutions: "The City Finance Lab is working to leverage USD 500 million per year in additional finance for climate action in cities" […] "by helping to develop finance that is longer-term, more attuned to emerging risks and more efficient at delivering returns for the economy and wider society" (Climate-KIC, n.d.).

of a shared vision within the community (Van der Schoor and Scholtens, 2015). Thereby, they can potentially galvanize the demand of DERs and innovative BMs in support of the energy transition. Furthermore, this would create supportive conditions for more distributed and local deals, and for marketing local energy (Engelken et al., 2016b). Hence, it would be particularly beneficial to those BM innovations that are not easily scalable because of links to regional customer base/ skills (Iliev, 2005).

Local networks can take particular advantage of the prospect introduced by DERs to have a flexible interplay between production and consumption of energy, and/or between several service alternatives that can be offered to consumers. Already a large part of BM innovation has been focusing on DERs flexibility (Midttun et al., 2017). Allowing for the exploitation of different revenue streams from different DERs products, supporting local networks can also boost the desired paradigm shift from economies of scale (capital-intensive BMs based on lowest price value proposition) to DERs service and customer tailored BMs. This would not only benefit the diffusion of DERs, but also is likely to favor the financial self-sustainability of innovative BMs. Indeed, according to Curtius (2012), in the absence of an industry-leading position, customer-tailored service-driven BMs are more appealing to financial investors than low-cost/ best-technology BMs.

Overall, networks have the potential to stimulate BM innovation, to improve BMs' viability and value proposition. The connection of businesses through inter-firm networks, the communication and coordination of actors through regional networks, and the engagement of local consumers through local networks are all triggers to the development of innovative BMs. In light of this, policy makers should facilitate the creation and diffusion of such networks. They should promote the use of ICT technologies that simplify network engagement efforts, and, at the same time, also regulate those networks, in order to ensure the competition of the market (Midttun et al., 2017).

A graphical representation of the policy options proposed above and the relative barriers that they can tackle is presented in *Table 1*. The focal barriers are shown on the vertical axis while the instruments are shown on the horizontal axis. As we can see from the table, each instrument has the potential to resolve more than one barrier. Furthermore, all the instruments have the potential to enhance the profitability of innovative BMs. Hence, the combination of even only few policy instruments can promise a big boost to the development and adoption of innovative BMs.

	1. Pilots and funding	*2. Financial innovation*	*3. Market design*	*4. Networks of actors*
1. Dominant model	x		x	x *
2. Lack of demand				x *
3. Low profitability	x	x	x	x
4. Subsidy uncertainty		x		
5. Market design uncertainty			x	
6. Misalignment of incentives				x **
7. Lack of information	x			x *

Table 1 - Barriers and policy instruments for business models.
***** Local networks***
****** Inter-firm networks***

4. Conclusion

BM innovation is vital to the energy transition, and yet difficult to realize. Typically policy makers focus on the research of new technologies/products and their support through different forms of monetary incentives. Nonetheless, the evidence brought by the literature analyzed suggests that policy makers used policy instruments to address the barriers identified. There is a role both for funding to catalyze the development and for shaping the regulatory environment such that developments can then persist without dedicated subsidies. The combination of these two elements can allow for innovative business models to materialize, as well as for their economic self-sustainability. Indeed, in the long term, business models should be able to adapt to value-based pricing signals (i.e. market-based compensation structures), that is to capture value independently from policy incentives. This would allow innovative BMs to be commercially viable and sustainable – and the energy transition to be the same.

Overall, these considerations shall give impetus for governments to create a low-barriers environment for the development of commercially viable BM innovations. The constraints mentioned above can be taken into account to design support strategies for more sustainable BMs. Along these lines the prospects for the energy transition would be maximized.

REFERENCES

Aslani A, Mohaghar A. (2013). Business structure in renewable energy industry: key areas. *Renewable and Sustainable Energy Review*, 27, 569-75;

Balta-Ozkan, N., Davidson, R., Bicket, M., Whitmarsh, L. (2013). Social barriers to the adoption of smart homes. *Energy Policy*, 63, 363-74;

BMWi (2017). SINTEG Ordinance. Entwurf einer Verordnung zur Schaffung eines rechtlichen Rahmens zur Sammlung von Erfahrungen im Förderprogramm „Schaufenster intelligente Energie – Digitale Agenda für die Energiewende“. Retrievable at link;

Burger, S.P., & Luke, M. (2017). Business models for distributed energy resources: A review and empirical analysis. *Energy Policy*, 109, 230-248;

Charitou, C.D., & Markides, C.C. (2012). Responses to disruptive strategic innovation. *MIT Sloan Management Review*, 54 C;

Chesbrough, H. (2010). Business Model Innovation: Opportunities and Barriers. *Long Range Planning*, 43, 354-363;

Christensen, C.M. (1997). The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. Harvard Business School Press;

Christensen, C.M., & Raynor, M.E. (2003). The Innovator's Solution: Creating and Sustaining Successful Growth. *Harvard Business School Press*;

Climate-KIC (n.d.). City Finance Lab. *Climate-KIC Success Stories.* Retrieved from *http://www.climate-kic.org/success-stories/city-finance-lab/* (accessed 4 March 2018);

Curtius, H., Künzel. K., Loock, M., (2012). Generic customer segments and business models for smart grids: empirical evidence from across-European country study. *International Journal Mark*, 51, 63-74;

DECC (2015). Community Energy Strategy – Creating the conditions for long-term growth. URN [15D/133]. Department of Energy and Climate Change. Retrievable at link;

Darby, S.J., McKenna, E. (2012). Social implications of residential demand response in cool temperate climates. Energ Policy, 49, pp. 759-769;

EC (2017). Third Energy Union Report. Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee, The Committee Of The Regions, And The European Investment Bank. COM(2017) 688 final. Retrievable at link;

EC (2017). Clean Mobility Package. Press Release Database. Retrievable at link;

EC (2016). Accelerating Clean Energy Innovation. Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee, The Committee Of The Regions, And The European Investment Bank. COM(2016) 763 final. Retrievable at link;

EC (2016). Clean Energy for All Europeans. Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee, The Committee Of The Regions, And The European Investment Bank. COM(2016) 860 final. Retrievable at link;

Engelken, Römer, B., Drescher M., Welpe, I.M., Picot, A. (2016a). Comparing drivers, barriers and opportunities of business models for renewable energies: a review. *Renewable and Sustainable Energy Reviews.* 60, 795-809;

Engelken, M., Römer, B., Drescher, M., & Welpe, I.M. (2016b). Transforming the energy system: Why municipalities strive for energy self-sufficiency. *Energy Policy*, 98, 365-377.

Girotra, K., & Netessine, S., (2013). Business Model Innovation for Sustainability. *INSEAD – Faculty and Research Working Paper.* 2013/77/TOM;

Gassmann, O., Frankenberger, K., Csik, M. (2014). The St. Gallen Business Model Navigator, *Working Paper University of St. Gallen*;

Helms, T. (2016). Asset transformation and the challenges to servitize a utility business model. *Energy Policy*, 91, 98-112;

Iliev, I. (2005). Resource-Based Technology Innovation in South Africa: Pre-paid Metering Technology – Systemic Innovation in the South African Energy Sector. Human Sciences Research Council. Employment Growth and Development Initiative – Employment Innovative Strategies;

Johnson, M., & Suskewicz, J., (2009). How to jump-start the clean-tech economy. *Harvard Business Review* 2009: 52–60;

Johnson, M., Christensen, C., Kagermann, H. (2008), 'Reinventing your Business Model', Harvard Business Review 86(12): 50-59;

Karneyeva, Y., & Wüstenhagen, R. (2017). Solar feed-in tariffs in a post-grid parity world: The role of risk, investor diversity and business models. *Energy Policy*, 106, 445-456;

Kim, JH, Shcherbakova, A, (2011). Common failures of demand response. Energy, 36 (2011), pp. 873-880;

Lombardi, P. & Schwabe, F. (2017). Sharing economy as a new business model for energy storage systems. *Applied Energy*, 188, 485-496;

Midttun, A., & Piccini, P.B. (2017). Facing the climate change and digital challenge: European energy industry from boom to crisis and transformation. *Energy Policy,* 108, 330-343;

Magretta, J. (2002). Why business models matter. *Harvard Business Review* 2002; 80, 86–92;

Meyers, R.J., Williams, E.D., Matthews, H.S. (2010). Scoping the potential of monitoring and control technologies to reduce energy use in homes. *Energy and Buildings*, 42, 563-569;

Narayanan, V.G., Raman, A. (2004). Aligning Incentives in Supply Chains. *Harvard Business Review*. Nov 2004;

NERC (2017). Distributed Energy Resources – Connection Modeling and Reliability Considerations. North American Electric Reliability Corporation;

Niesten, E., & Alkemade, F. (2016). How is value created and captured in smart grids? A review of the literature and an analysis of pilot projects. *Renewable and Sustainable Energy Reviews*, 53, 629-638;

O'Keeffe, J. M., Gilmour, D. & Simpson, E. (2016). A network approach to overcoming barriers to market engagement for SMEs in energy efficiency initiatives such as the Green Deal. *Energy Policy*, 97, 582 – 590;

Osterwalder, A., Pigneur, Y., Tucci, C. (2005). Clarifying business models: origins, present and future of the concept. *Communications of the Association for Information Systems*, 15, 1–43;

Richter, M. (2013a). German utilities and distributed PV: How to overcome barriers to business model innovation. *Renewable Energy*, 55, 456-466;

Richter, M. (2013b). Business model innovation for sustainable energy: German utilities and renewable energy. *Energy Policy*, 62, 1226–37;

Roemer, B., Reichhart, P., Kranz, J., Picot, A. (2012). The role of smart metering and decentralized electricity storage for smart grids: the importance of positive externalities. *Energy Policy*, 50, 486–95;

Schleicher-Tappeser, Ruggero (2012). How renewables will change electricity markets in the next five years. *Energy Policy*, 48, 64-75;

Siano, P. (2014). Demand response and smart grids – a survey. *Renewable Sustainable Energy Review*, 30, 461–78;

Sprenger, R.U. (2001). Inter-firm Networks and Regional Networks. ADAPT. OECD;

Van Der Schoor, T., & Scholtens, B. (2015). Power to the people: local community initiatives and the transition to sustainable energy. *Renewable and Sustainable Energy Reviews*, *43*, 666-675;

Weiller, C., & Neely, A. (2014). Using electric vehicles for energy services: industry perspectives. Energy, 194–200;

Wainstein M.E., & Bumpus, A.G. (2016). Business models as drivers of the low carbon power system transition: a multi-level perspective. *Journal of Cleaner Production*, 126, 572-585;

Zhang, C., Campana, P.E., Yang, J. & Yan, J. (2017). Economic performance of photovoltaic water pumping systems with business model innovation in China. *Energy Conversion and Management*, 133, 498-510.

EVALUATING POTENTIAL REALVALUE BUSINESS MODELS: A MONTE-CARLO ANALYSIS

1. Introduction

This document describes how to conduct Monte-Carlo analyses of potential business models using Smart Electric Thermal Storage devices (SETS). In the absence of observational data, a Monte-Carlo analysis may be a useful tool for approximating outcomes. It provides a framework that allows the user to make assumptions regarding necessary inputs such as revenues or costs. Moreover, instead of assuming specific values, the user specifies distributions, for example uniform, normal, or χ^2. The existing uncertainty is reflected in the width of the distribution. The wider the distribution, the larger the uncertainty for any given input. Often times, users have relatively precise information with regards to some parameters. In these cases, a narrow distribution that centers around the known parameter is chosen.

In case of the Monte-Carlo analysis for the viability of business models revolving around SETS, assumptions have to be made with respect to distributions of revenues and of costs. Revenues might be generated in the form of monthly payments for optimizing charging, or might accrue due to successful energy arbitrage, or the provision of frequency response. Costs accrue in the form of fixed costs for buildings, workers, or IT infrastructure.

The level of detail appropriate for analysis depends on the available information and the purpose of the analysis. From each of the specified distributions, we take ten thousand draws. By combining randomly chosen values from the distributions, for example by adding the revenues and subtracting the cost, it is possible to generate distributions of the cash flow after all costs including that of debt are accounted for. Of course, SETS are used for more than just one year. To simplify the analysis, it is assumed that the combination of revenues and costs for each of the ten thousand draws remains identical over the course of the business, for example five years.

The viability of the business model is expressed in terms of the return after all costs including debt and depreciation are covered. Dividing the return by the average equity commitment indicates the return on equity.

2. Assumptions

Table 2 indicates the assumptions that have to be made with regard to a certain business model. For example, the user has to specify the number of years in which the initial investment has to be amortized.

The analysis takes place either at the level of the average household and indicates absolute revenues and costs or the costs relative to the equity initially invested. For the case of Germany, the HORST model (cp. WP 3) indicates potential values for energy arbitrage at the per square meter level. Therefore, some information has to be transformed. This is easily done by the model by letting the user specify the size of the average dwelling.

The combination of assumptions characterizes the business model and determines its financial viability. For example, in case of a business model that focuses only on energy arbitrage, the assumed revenues and costs from frequency response are set to zero. If the business only performs frequency response, the revenues and costs from energy arbitrage are set to zero. In the following, the assumptions that have to be made are laid out in detail. Altogether, the quality of the insights generated by the Monte-Carlo analysis depends heavily on the assumptions made and the assumptions differ in their sensitivity. In fact, the results are deterministic in the sense that they are driven solely by the assumptions.

The parameters are generic and not country-specific. Major country-specific factors that need to be adapted are: fixed costs, since absolute costs might differ and, importantly, the alternative technology might differ in different markets; energy arbitrage; and potential revenues from frequency response (if applicable).

variable	bounds	
	lower	upper
number of years	5	10
interest on debt	0.02	0.12
fixed costs	1030	1030
average living space	80	80
capacity of SETS (in kWh per sq. m)	1.2	1.2
cost of communication (per household and year)	5	25
cost of trading 1 MWh	1	3
cost of customer service (per household and year)	2	5
share of potential in energy arbitrage realized	0.4	0.6
share of frequency response realized	0	1.0
revenues from energy arbitrage in Euro (per square meter and year)	1.73	2.59
revenues from frequency response in Euro (per week per MW (off-peak)	50	200
revenues from frequency response in Euro (per week per MW (peak)	0	15
monthly lump sum payment to household for flexibility	5	10
households' share in revenues when no lump sum payment	0.25	0.55

Revenue potentials and costs in Euro.

Table 2: Overview of assumptions

Some of the assumptions are varied in the analysis of business models and policy instruments. For example, the number of years in which debt has to be repaid is increased from five to ten years. The fixed costs of 1,030 euro per household in the case when the company owns the devices is reduced to 350 euro when the SETS are owned by the households.

2.1. Revenues

The annual total revenues r consist of revenues from energy arbitrage r_{arb}, from revenues from frequency response $r_{\text{freq.}}$. In one specific business model ("service contract"), monthly payments for services are added.r_{serv}:

$$r = r_{\text{arb}} + r_{\text{freq}} + r_{\text{serv}} \ . \qquad (1)$$

The revenues from energy arbitrage are illustrative for possible revenues obtained from consuming electricity in times of low power prices and not-consuming in times of high power prices. As these revenues are highly uncertain, we assume them to follow a normal distribution, lying somewhere between 1.73 and 2.59 euro per square meter and year.

$$r_{\text{arb}_{\text{pot}}} \sim \text{uniform}(l, u) \ . \tag{2}$$

Uniform distributions assign equal probability to all intervals of similar size between the upper and the lower bound. In comparison, a normal distribution places more emphasis on small compared to large deviations from the mean.

The actual revenues r_{arb} consist of the share of the potential that a business can realize $s_{\text{arb}_{\text{pot}}}$ times the potential for revenues from energy arbitrage $r_{\text{arb}_{\text{pot}}}$:

$$r_{\text{arb}} = s_{\text{arb}_{\text{pot}}} \cdot r_{\text{arb}_{\text{pot}}} \ . \tag{3}$$

The share of the potential in energy arbitrage that can be realized is assumed to be uniformly distributed between 0.4 and 0.6

$$s_{\text{arb}_{\text{pot}}} \sim \text{uniform}(0.4, 0.6) \ . \tag{4}$$

If revenues from frequency response are part of business models, the revenues from frequency response r_{freq} are calculated in a similar manner and have to be approximated. The upper bound for the potential $r_{\text{freq}_{\text{pot}}}$ is when SETS provide frequency response services for all times of the year at a given price p_{freq}. This potential is indicated by the price for service times the capacity c of SETS that can be charged:

$$r_{\text{freq}_{\text{pot}}} = p_{\text{freq}} \cdot c \ . \tag{5}$$

Here, it is assumed that SETS provide negative frequency response by charging at times of surplus electricity supply. The market for positive frequency response is more lucrative. However, to participate in this market, SETS would have to be able to reduce charging at any time. This assumption seems rather untenable because SETS only charge at certain times of day. Thus, when no SETS are charged, there is no possibility to decrease consumption.

In a first step, those willing to provide negative frequency response have to make an offer that includes a price and a capacity offer. There exist separate auctions for peak and off-peak times. These are held on a weekly basis. Off-peak prices are usually higher compared to prices at peak times.

Those selected for providing frequency response have to indicate the price for electricity in a second auction. But because most revenues are derived by providing capacity, we do not need to concern ourselves with this type of remuneration. Therefore, the revenues from frequency response are a compensation for making capacity available. It is also assumed that performing energy arbitrage and providing frequency response is possible at the same time.

The actual revenues from frequency response r_{freq} at peak times consist of the share of the potential of the frequency response that a business can realize $s_{\text{freq}_{\text{pot}}}$ times the revenue of the frequency response potential $r_{\text{freq}_{\text{pot}}}$:

$$r_{\text{freq}} = s_{\text{freq}_{\text{pot}}} \cdot r_{\text{freq}_{\text{pot}}} \ . \tag{6}$$

The share of the potential ot the frequency response that can be realized is assumed to be uniformly distributed between 0 and 1

$$s_{\text{freq}_{\text{pot}}} \sim \text{uniform}(0, 1) \ . \tag{7}$$

Similar assumptions have to be made with respect to the frequency response at off-peak times.

The revenue from frequency response is assumed to be uniformly distributed between 0 and 15 for peak prices

$$r_{freq_{peak}} \sim uniform\ (0,15)$$

and 50 and 200 for off-peak prices.

$$r_{freq\ off} \sim uniform\ (50,\ 200)$$

The monthly payments for services r_{serv} are assumed to follow a uniform distribution with lower bound *l* and upper bound *u*:

$$r_{\text{serv}} \sim \text{uniform}(l, u)\ . \tag{8}$$

In case information exists that indicates a fixed monthly payment for all households, the bounds *l* and *u* can be set to the same value. This way, the payment will be exactly identical for each of the draws in the Monte-Carlo simulation. Fixed revenue streams may be generated for providing services, for example by optimizing charging times for users of SETS.

2.2. Costs

Total variable costs per square meter c_v are the sum of costs for information and communication per square meter c_c plus costs for trading electricity per Megawatt hour c_t plus the costs for customer service per square meter c_s

$$c_v = c_c + c_t + c_s\ . \tag{9}$$

Instead of assuming costs per square meter, it is also possible to indicate costs at the level of the household or per Megawatt hour. These assumptions are easily translated to the level of the square meter using the information on the average size of the customers' dwellings. It is assumed that the variable costs are uniformly distributed with upper and lower bounds that need to be specified

$$\begin{aligned} c_c &\sim \text{uniform}(c_{c_l}, c_{c_u}) \\ c_t &\sim \text{uniform}(c_{t_l}, c_{t_u}) \\ c_s &\sim \text{uniform}(c_{s_l}, c_{s_u})\ . \end{aligned} \tag{10}$$

2.3. Refinancing

The overall interest rate *i* is defined as

$$i = i_d \cdot s_d + i_e \cdot (1 - s_d)\ , \tag{11}$$

with i_d indicating the interest on debt, s_d *being* the share of debt and i_e indicating the expected return on equity. Consequently, $1 - s_d$ indicates the share of equity.

In addition to interest, lenders want to recoup their investment. By assumption, the annuity AN, that is the absolute sum of interest and installments, shall be identical in each year:

$$\text{AN} = c_f \cdot s_d \cdot \frac{(1 + i_d)^n \cdot i_d}{(1 + i_d) - 1} \tag{12}$$

Given that revenues and costs are identical in all periods of the business model, it seems prudent to choose a form of financing that leads to similar annual payments. At the end of the defined amortization period, the debt is fully repaid.

For the business to repay the loan with interest, the free cash flow to equity has to be greater or equal to zero:

$$\text{cash flow to equity} = r - c_t - c_c - c_s - \text{AN} \geq 0 \,, \tag{13}$$

where *r* indicates revenues. Thus, the Monte-Carlo model returns the cash flow on equity according to

$$\begin{aligned}\text{cash flow to equity} = \; & s_{\text{arb}_\text{pot}} \cdot r_{\text{arb}_\text{pot}} + s_{\text{freq}_\text{pot}} \cdot r_{\text{freq}_\text{pot}} + r_{serv} \\ & - (c_c + c_t + c_s) \\ & - \left(c_f \cdot s_d \cdot \frac{(1 + i_d)^n \cdot i_d}{(1 + i_d) - 1} \right) \,.\end{aligned}$$

3. Potential business models

So far, a general framework for analysis was introduced. To approximate the viability of any potential business model, this framework has to be adapted according to the risk businesses assume, e.g. the energy price volatility risk. In case that electricity prices are flat, there is no opportunity for energy arbitrage. Revenues from ancillary services are also risky. Potential revenues might fluctuate considerably across time. Moreover, the market for ancillary services seems small and the market entry of additional competitors such as batteries may drive down revenues significantly.

Overall, seven potential business models are analyzed in *Table 3*. The first four business models are based on selling electricity to the customers. Model 5 is a service contract which offers households a guaranteed indoor temperature at fixed costs. Business models 6 and 7 revolve around either selling or leasing SETS, without supplying electricity or heat. In the following discussion, we focus on energy and service contracts, since the mere selling or leasing of SETS poses a less interesting variation.

model description	energy contract				service contract	SETS only	
model number	1	2	3	4	5	6	7
ownership	lease	sell	lease	sell	lease	lease	sell
lump sum payment	yes	yes	no	no			
relative compensation	no	no	yes	yes			
energy price volatility	✓	✓	(✓)	(✓)	✓		
ancillary services	✓	✓	(✓)	(✓)	✓		
comfort level					✓		
outdoor temperature					✓		
technical performance	✓		(✓)		✓	✓	
arbitrage performance	✓	✓	(✓)	(✓)	✓		
regulation and taxes	✓	✓	✓	✓	✓	✓	✓
customer support	✓	✓	✓	✓	✓	✓	✓
technological competence	✓	✓	(✓)	(✓)	✓		

Checkmarks imply that the company carries the respective risk, while checkmarks in parentheses indicate that the company and customers share the risk. To facilitate model comparison, we refer to the models indicating the type of contract, for example energy contract, in addition to whether the SETS are leased and whether the compensation for flexibility is fixed or relative to a business's revenues. The term energy contract with leasing and lump sum, for example, indicates model 1.

Table 3: Characteristics of business models

3.1. Energy contract business model

The energy contract business models analyze the difference when households receive a compensation for rendering their flexibility in energy consumption and who carries the risk in the respective case. The first two energy contract models offer lump sum payments to households. In business models 3 and 4 households receive a relative share. Thus, they also share some of the risk. Should households, for example, behave in a way that is detrimental to the profits from energy arbitrage, their benefits decline.

Most business models depend on households understanding the technology. When this is not the case, households may unintentionally interfere with how the business generates value. Some households might disconnect gateways or SETS for periods of time to save energy without realizing that uninterrupted communication between the aggregator and the devices is the basis of the business model.This risk is related to the cost of customer support. Customers must be educated to gain competence in using SETS. They might need additional support in using SETS compared to conventional storage heaters. Given the saving potential per square meter and year, labor intensive customer support may have a considerable impact on the business outcome.

There is also the risk that the SETS break down. In case of households owning the SETS and the communication equipment, households carry this risk. In case of SETS and the communication equipment being leased to the households, this risk is carried by the business.

In addition to the technical risk, there is also the risk that the expected margins from energy arbitrage cannot be realized. On one hand, the precision with which times of cheap electricity can be anticipated may be too low to generate value. On the other hand, the model based results for energy arbitrage indicate that its potential varies considerably across the years. With market entry of new technologies, such as batteries, the potential for energy arbitrage may further decline.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 646116

3.2. Service contract business model

In the second type of contract, businesses supply households with heat at a fixed price. The level of service needs to be measured precisely, for example by relying on thermostat readings. Thus, households would be placed into tariff groups according to their thermostat settings. Households then barely face incentives to limit or adjust their energy consumption.

While household behavior can be dealt with efficiently using thermostat readings, the service contract carries the risk of variations in the outdoor temperature. If outdoor temperatures are lower than expected, households need more electricity to reach their usual indoor temperature. The profitability of the service contract declines. Thus, the business model of service contracts relies on accurate forecasting of the outdoor temperature.

3.3. Sensitivity of results to assumed distribution of parameters

One of the main risks revolves around energy price volatility. Energy arbitrage generates value by postponing the charging of SETS to the times when electricity is cheap. When, however, the level of volatility is low so that the absolute difference in prices between high and low declines, energy arbitrage becomes less profitable. This can be simulated by altering the lower r_{arb_l} and upper r_{arb_u} bound of revenues from energy arbitrage. All other assumptions are identical for the energy contract with leasing and lump sum payment (model numbers 1-4).

Figure 1 shows how varying levels of energy arbitrage affect the profitability of SETS. The left hand side figure depicts free cash flow after all expenses, debt payments and operational costs have been taken care of. The right hand side figure illustrates how varying levels of energy arbitrage influence free cash flow relative to initial equity. *Figure 1* indicates the consequences of altering $r_{arb_l} = 1.73$ and $r_{arb_u} = 2.59$ to $r_{arb_l} = 1.00$ and $r_{arb_u} = 2.00$. The blue line indicates the probability density of the initial choice of the potential of energy arbitrage. The red line indicates the consequences of narrowing the income from energy arbitrage. The same technique can be used to address the risk that households with a flat tariff for warmth increase their comfort level. In this case, the cost for the business increases.

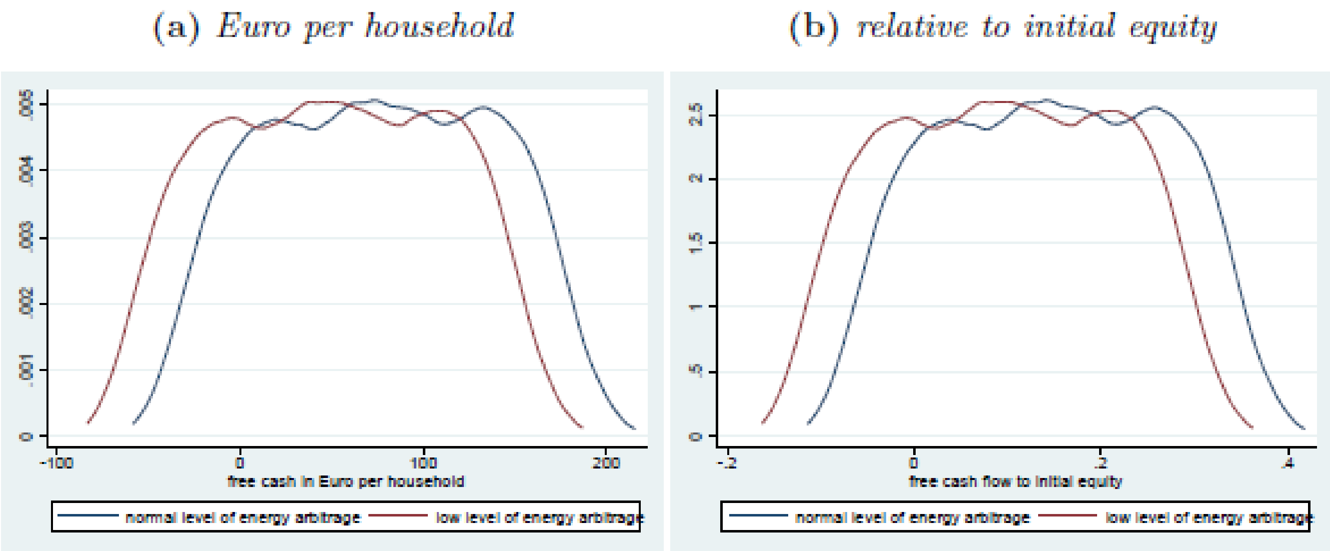

Figure 1: Free cash flow by varying levels of energy arbitrage

Figure 2 indicates that businesses provide ancillary services such as frequency response. The red line indicates the return on equity of a business model that generates no revenues from frequency response. Again, all other assumptions are identical to the business model that sells energy contracts with leasing and lump sum payments. The blue line indicates the return on equity in case that frequency response is part of the business model. The incorporation of additional revenue streams has an impact on the shape of the distribution while the impact of the risk of low price volatility only has an impact on the location of the distribution.

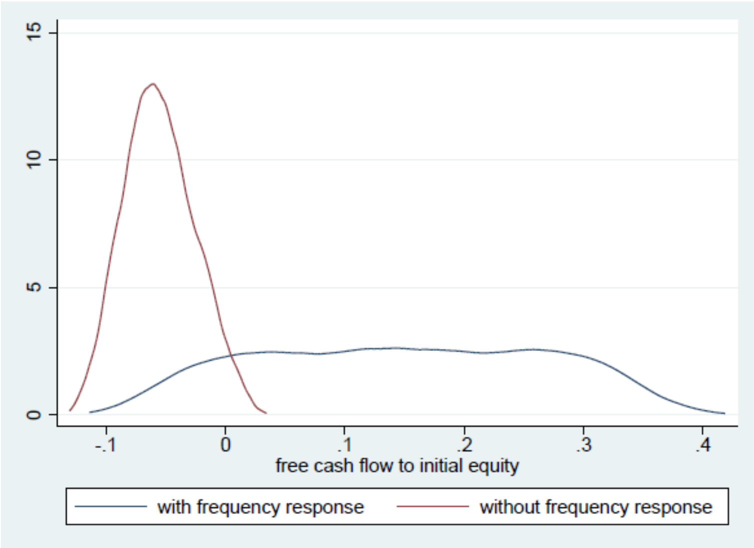

Figure 2: Free cash flow to equity with and without returns from frequency response

Finally, there is also the risk of unanticipated costs. This is exemplified here by increasing the average cost of customer service per household by ten euro per year, so that the distribution of the cost of customer service is uniformly distributed between twelve euro and 15 euro per year and household instead of being between two and five euro per year and household (*Figure 3*). Again, all other assumptions are identical to those for the energy contract with leasing and lump sum payment.

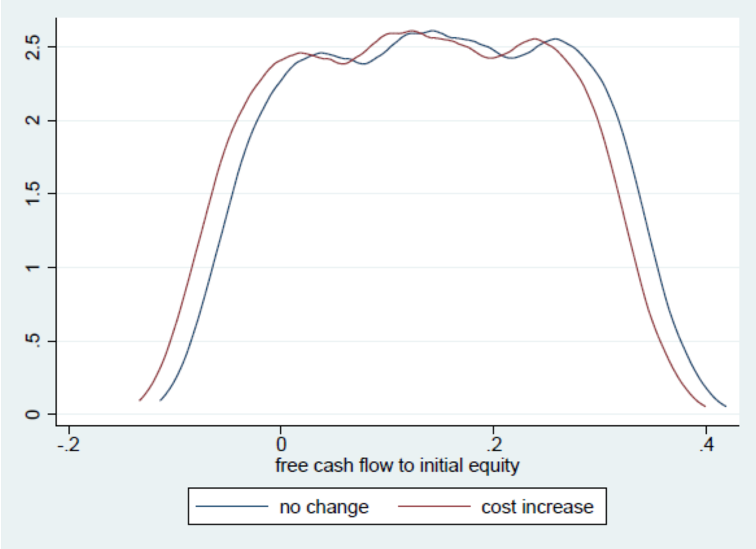

Figure 3: Influence of ten euro annual cost increase per household on the free cash flow to equity

4. Policy instruments

The Monte Carlo analysis outlined here takes into account how refinancing costs affect the viability of a given business model. Hence, it is possible to simulate the impact of any policy instrument that alters either the interest on equity, the interest on debt, or the share of equity and debt. For example, if preferential loans that reduce the cost of the interest on debt were available, the net present value would increase. Other potentially promising policy instruments are grants. Here, the share of equity is reduced without increasing the amount of debt needed. Because the refinancing costs are lowered, the net present value increases. Governments can also apply procurement and thereby reduce the impact of policy and market uncertainties on future revenue streams.

4.1 Preferential loans

Policy makers may grant businesses preferential loans i_p. These are characterized by interest rates that are below the interest the market demands on debt i_d given the risk profile of the business. The level of support is the difference in interest rates $\Delta = i_d - i_p$. This reduces the refinancing costs and impacts the viability of the business model.

Under otherwise similar assumptions, *Figure 4* indicates how preferential loans impact the profits in case of the energy contract with leasing and lump sum payment. In both cases, debt covers 50% of the initial investment. By assumption, the preferential loan reduces the interest on debt from 10% to 4%. The cost reduction from lower interest payments shifts the distribution of the return on equity to the right. Altogether, the provision of preferential loans increases the viability of the business model. The magnitude of the impact depends on how much lower the interest rate is on preferential loans compared to market priced loans.

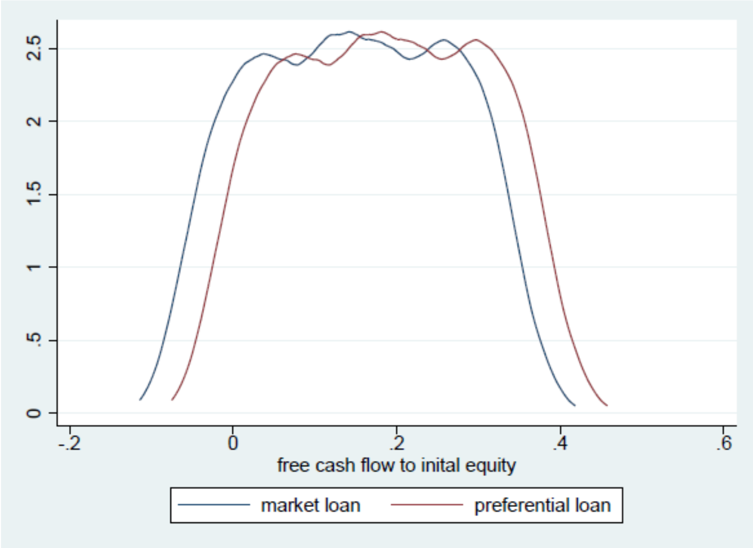

Figure 4: Impact of preferential loans on the free cash flow to equity

4.2 Grants

Grants reduce the amount of the initial investment that has to be refinanced. In the present example, it is assumed that grants substitute the need for debt. The example at hand is also based on the energy contract business model 1 with leasing and lump sum payment (*Figure 5*). By assumption, the interest rate is 10%. In both cases, 30% of the initial investment costs are refinanced using equity. In the absence of grants, 70% of the initial investment has to be financed by debt. The grant reduces the need for debt to 20%. This reduction in the cost of debt shifts the distribution of the free cash flow to the right.

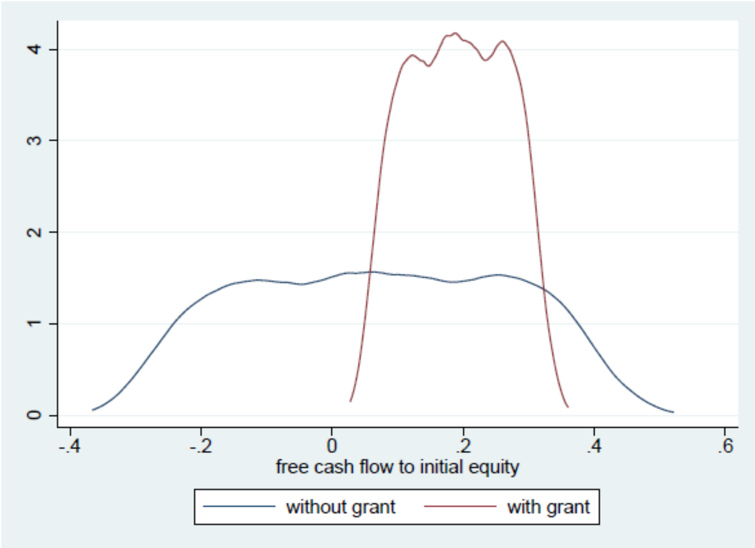

Figure 5: Impact of grant on the return on equity

4.3 Procurement

In the case of SETS, the government might procure a share of the overall potential for frequency response on long-term contracts - thus reducing policy and market uncertainties' impact on future revenue streams. *Figure 6* indicates how the return on investment is influenced in case the government pursues no procurement strategy (blue line) compared to the case that 50% of the potential revenues from frequency response that SETS can generate are guaranteed (red line).

Instead of guaranteeing a share of the revenue stream, procurement might also take the form of purchasing the SETS. As we indicate below, the capital costs can be considerably reduced if households own the SETS instead of the aggregator. The consequences would be identical from moving from a business model with leasing to one without. The government might purchase and use SETS in social housing as a substitute for direct resistance heating.

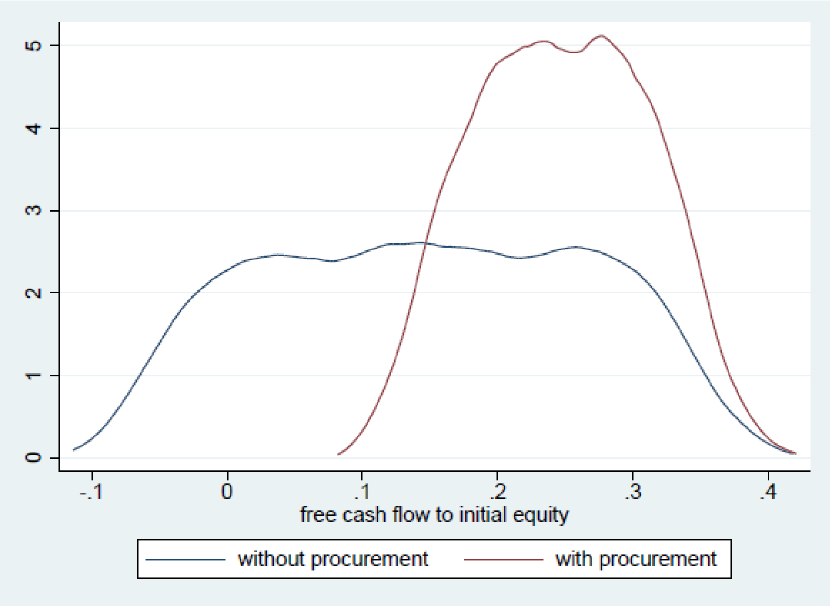

Figure 6: Impact of procurement on the return on equity

5. Comparison of the different business models' viability

So far, the influence of defined risks and the influence of refinancing conditions were analyzed holding all other factors constant. In the following, we present results obtained by Monte Carlo analysis when comparing different business models to one another. This implies that several factors may vary, instead of just one. While this does not indicate the effect of one specific influence on the free cash flow, it generates an assessment of the business model as a whole. Moreover, we scrutinize the whole set of impacts of policy instruments on all the business models.

5.1 Comparison of business models

Table 3 presented an overview of potential business models revolving around SETS. Now, we compare these business models to one another in terms of their free cash flow (*Figure 7).* Business model 1 incentivizes households to render their flexibility by providing a monthly lump sum on the order of five euro or 60 euro annually. The SETS are the property of the aggregator who assumes fixed costs for purchasing and installing them on the order of 1,000 euro. Leasing out SETS generates additional income on the order of 100 euro annually. No such compensation is paid when the households own the SETS (model 2).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 646116

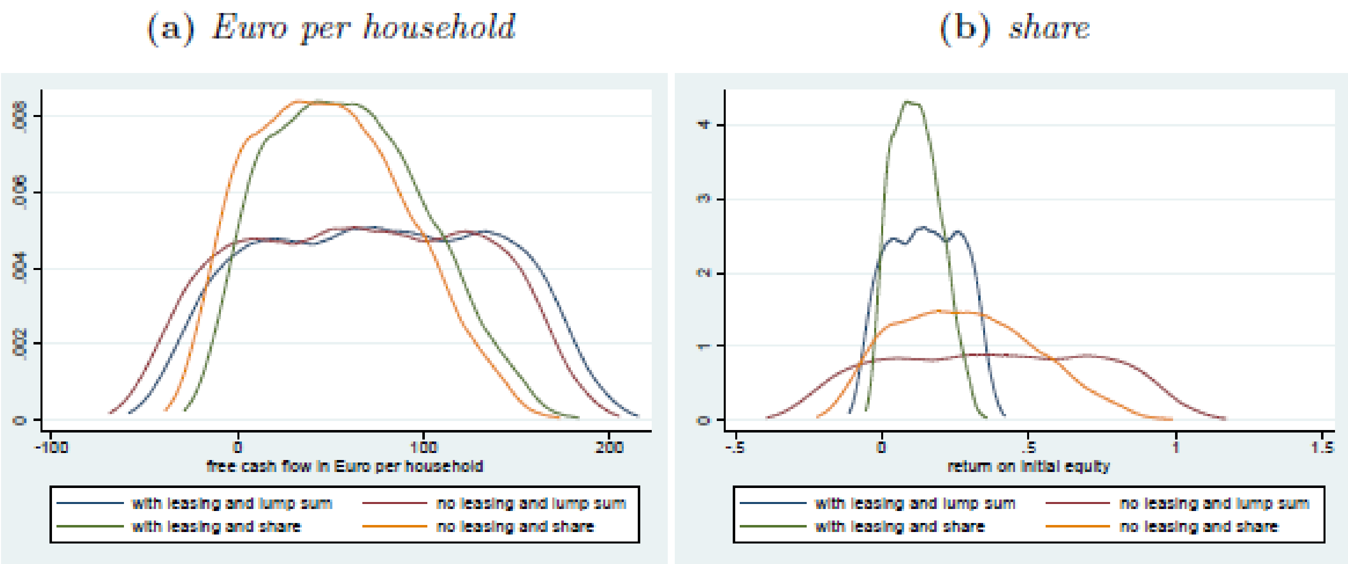

Figure 7: Return on equity for all variants of energy contracts

The return on investment follows two different distributions. Distributions for the models with lump sum payment are slightly wider compared to the relative compensation. With the assumption that the lump sum payments are 5 to 10 euro per month (60 to 120 euro per year), the relative share of revenues that households receive as compensation when they do not receive a lump sum payment is set between 25% and 55%, so that the annual payments would also be about 60 euro (i.e. roughly equivalent to monthly payments of 5 euro). The location of the distribution depends on whether the business generates revenues from leasing.

Figure 8 exemplifies that the impact of financial instruments is considerably smaller the less capital the business requires. In particular, the interest rate on debt is varied in increments of two percentage points between 4% and 12%. Because the capital costs are higher for business model 1 ((a) leasing of SETS) compared to model 2 ((b) sale of SETS), the absolute impact of the financial support is higher for model 1.

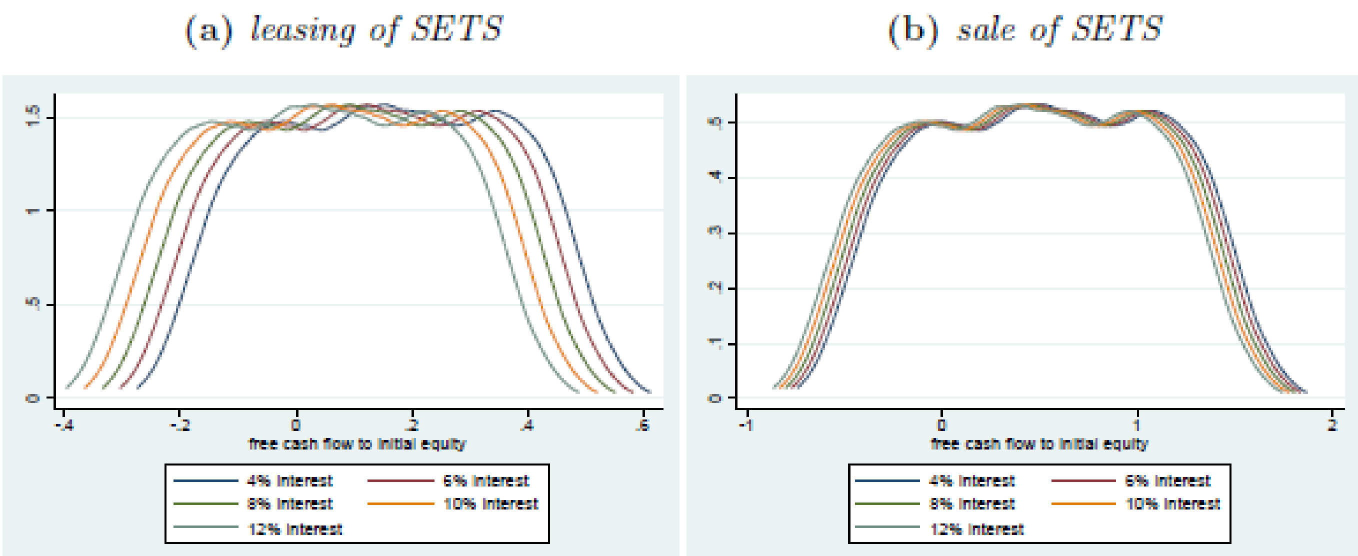

Figure 8: Impact of interest rates on return on equity

In business models 1 and 2, the household receives a lump sum payment. In comparison to a relative compensation, this does not constitute an incentive to reduce behavior detrimental to the business model. *Figure 9* shows how the return on investment decreases when household behavior reduces business opportunities. By assumption, detrimental behavior reduces the relative share of the potential in energy arbitrage and frequency response. To illustrate the impact of such risk, *Figure 9* indicates the return on investment in the absence of risk and when risk reduces the realized potential by 10% or 20%.

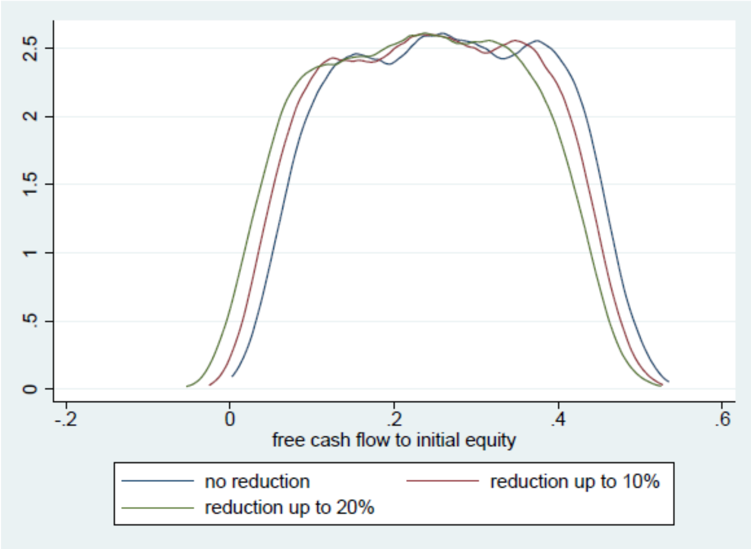

Figure 9: Detrimental behavior and return on equity

Business model 5 offers households an energy service. Ownership of the SETS is with the company. By assumption, the energy service generates a profit of ten euro per month and household in addition to the leasing payments. Households receive no lump sum payments and do not share in the profits from energy arbitrage or frequency response. Because an energy service was contracted, the risk that the outer temperatures are lower than anticipated lies with the company. In this case, holding the indoor temperature constant requires more energy and, thus, drives down the profitability of the business model. *Figure 10* indicates the impact of lower than anticipated outdoor temperatures on the free cash flow to equity.

All business models presented so far were based on the assumption that the business has to repay the debt within five years. To indicate the impact of the choice of investment horizon, we now contrast the free cash flow to equity from energy contract with leasing and lump sum payment with five and ten years horizons (*Figure 11*). All else equal, a longer time horizon increases the profitability of the business model.

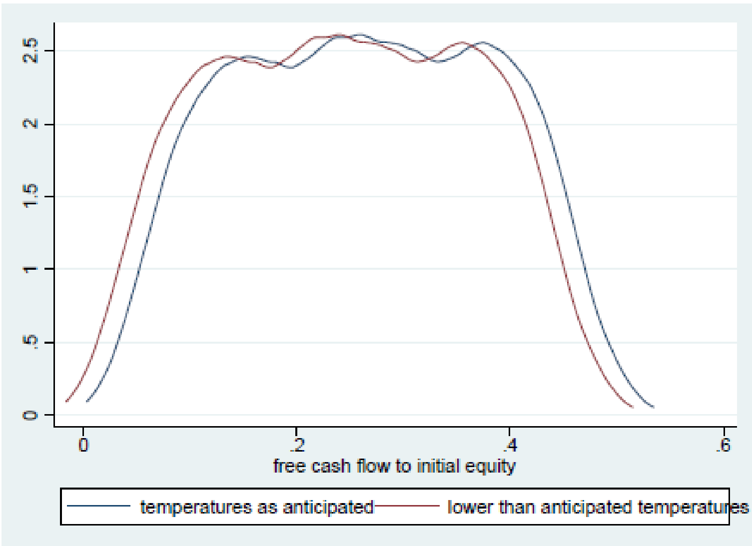

Figure 10: Impact of lower than anticipated outdoor temperatures on free cash flow to equity

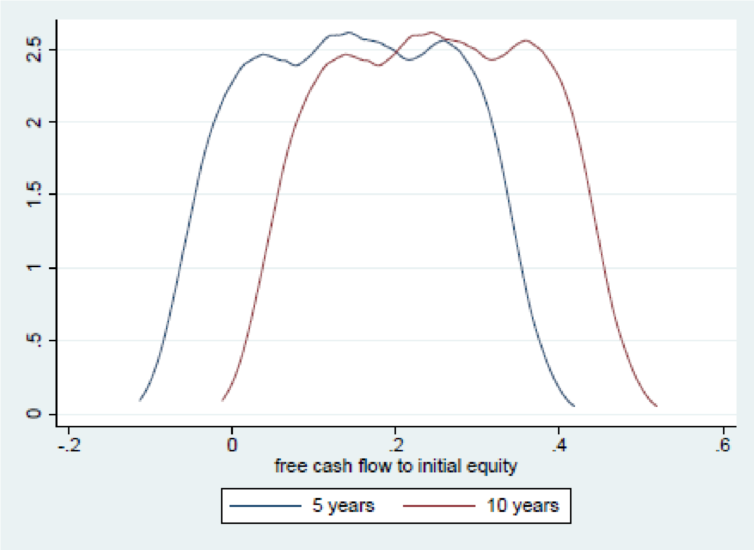

Figure 11: Impact of varying debt repayment period on free cash flow to equity

5.2 Impact of financial instruments on the business models' viability

Figure 12 indicates how grants, preferential loans, and procurement impacts the free cash flow of the business models. Although the business models are subjected to the same policy measures, the impact on the cash flow differs by the business model.

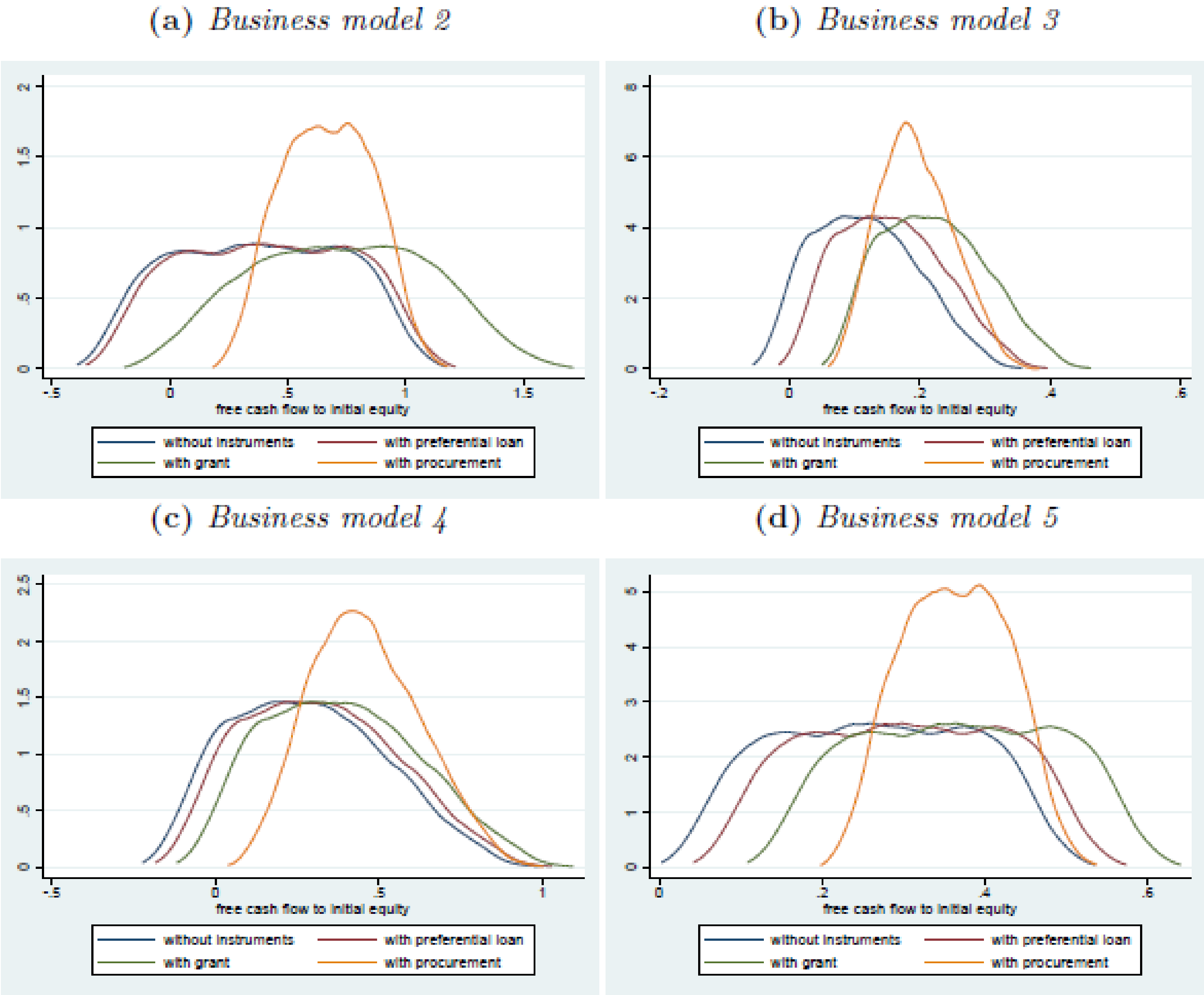

Figure 12: Impacts of policy instruments on the business models' viability

The visualization of the results reveals that some business models are riskier than others, but also provide larger return possibilities. Business model 2, for example, energy contracts without leasing and with lump sum payments, shows both the lowest and the highest profitability, depending on the input parameters and the policy instruments. On the other hand, business model 3, energy contract with leasing and relative compensation, exhibits much less variability of profitability. For the same input parameters as business model 2, it shows only positive cash flows to initial equity under any of the policy instruments. Thus, when any of these instruments is in place, especially under business model 3 (and similarly for business model 5), debt can always be served and a positive return on initial equity is provided.

Furthermore, the magnitude of the effects of the policy instruments also differs between business models. For business model 2, preferential loans and public procurement function very similarly. Yet, regarding business models 3 and 5, preferential loans appear to have a considerably stronger effect than public procurement. Consequently, policy-makers need to consider the types of business models that they want to support. Vice versa, companies need to be aware of the effect of policy instruments on their business models, knowing that some policy instruments apply more or less to particular business models.

6. Summary and conclusion

In order to analyze business models in terms of their profitability, we developed a Monte-Carlo analysis. The analysis requires assumptions about revenues and costs. Specifically, it requires the user to specify distributions that reveal information about the uncertainty associated with the assumptions. The wider the distribution, the less information is available. After the distributions regarding revenues and costs are determined, the Monte-Carlo analysis continues by drawing ten thousand observations from the distributions of all the variables. Combining these draws regarding revenues and costs with debt shares and interest rates returns the distributions of the free cash flow to equity which is defined as the cash that is left after taking into account all costs, including the instalments and the interest rates on debt.

Altogether, the Monte-Carlo analysis informs about the potential viability of specific business models. Because the user is free to specify the distributions of revenues and costs, any potential business model can be analyzed. The quality of the analysis depends only on the accuracy of the input and the shape of the distribution chosen.

Specifically, the analysis identifies the effects of different policy instruments on the viability of a range of business models. The analysis reveals that the effects of the policy instruments differ by business models. Therefore, policy-makers need to consider the types of business models that they want to support. Accordingly, companies should be aware of the differences in impacts and how their particular business model is affected by the different policy instruments.