FME HighEFF

Centre for an Energy Efficient and Competitive Industry for the Future

D5.1_2018.10

Research Methods

PhD Research Design Course Paper

Delivery date: 2018-12-14

Organisation name of lead beneficiary for this deliverable:

NTNU Samfunnsforskning AS

HighEFF- Centre for an Energy Efficient and Competitive Industry for the Future is one of Norway's Centre for Environment-friendly Energy Research (FME). Project co-funded by the Research Council of Norway and Industry partners. Host institution is SINTEF Energi AS.		
Dissemination Level		
PU	Public	x
RE	Restricted to a group specified by the consortium	

Deliverable number:	D5.1_2018.10
ISBN number:	
Deliverable title:	PhD Research Design Course Paper
Work package:	RA5.1
Deliverable type:	Report
Lead participant:	NTNU Samfunnsforskning AS

Quality Assurance, status of deliverable		
Action	Performed by	Date
Verified (WP leader)	Jens Røyrvik	2018-12-14
Reviewed (RA leader)	Ingrid Camilla Claussen	2018-12-18
Approved (dependent on nature of deliverable)*)		

*) *The quality assurance and approval of HighEFF deliverables and publications have to follow the established procedure. The procedure can be found in the HighEFF eRoom in the folder "Administrative > Procedures".*

Authors		
Author(s) Name	Organisation	E-mail address
Jens Petter K. Johansen	NTNU Samfunnsforskning AS	Jens.petter.johansen@samfunn.ntnu.no

Abstract

This deliverable is the final exam paper of the Phd Research Design to the PhD course Case Study Research Methods at the University of Oslo. The paper was approved for 10 ECTS which will be implemented in the PhD.

Table of Contents

Innhold

1 Energy efficiency, circularity and exchange in the Norwegian industry

Jens Petter Kirkhus Johansen

PhD in Sociology

Norwegian University of Science and Technology

1.1 Research outline

This PhD project is a part of the research centre called HighEFF[1]. The objective of HighEFF is to contribute to reducing both direct energy uses as well as utilizing surplus energy (i.e. excess heat, CO_2, waste gases and materials) from Norwegian industry. With the industry being accountable for approximately 41 % of the national consumption of energy, there is a high expected potential for energy efficiency in Norwegian industry both by reducing input factors (direct energy used) with more efficient processes or by exchanging surplus energy from industrial processes to nearby users; industries, buildings.

The focus of this PhD project is investigate how inter-organizational *energy exchanges*[2] for utilizing surplus energy from industry processes emerge. At its core, energy exchange is a matter of logistics; to move energy from where (and when) it is produced to where (and when) it is needed. Exchanging surplus energy implies the construction of pipes, valves, heat-exchangers, energy centrals, control systems and other components necessary for transforming and transporting the thermal, electric or chemical energy from its origin to a

[1] Centre for an Energy Efficient and Competitive Industry for the Future (High-EFF) is a part of the centre for environment-friendly energy research (CEER) research program from the Norwegian Research Council.

[2] I will use the technical notion "energy exchange" throughout this project description for the particular practice of utilizing surplus energy within or outside organizational borders. Other terms describing the phenomena such as *industrial symbiosis* (Chertow 2000), *collective energy systems* (Johansen 2012) and to some extent *circular economy* have been used within the literature, but often contain additional concepts and connotations.

usable state in the process and company it will be utilized. However, while the techno-economical potential for energy exchanges in Norway are significant (Enova, 2011), such inter-organizational socio-technical systems are still "deviant cases" proposing a paradox since such solutions would both be environmentally beneficial of reducing primary energy input as well as cost-efficient for the companies involved. The main research question for this PhD is formulated as:

How do inter-organizational energy exchanges emerge and develop over time?

By studying the inter-organizational establishment processes and dynamics of four cases of energy-exchanges in Norwegian industry this PhD project with a specific focus on; a) informal networks, trust and shared visions, b) institutional and contextual factors, c) the role of intermediaries or key stakeholders, as well as a typology task related to the dependent variable d) the organization models for inter-organizational coordination and operations concept. Thus, the project aims to gain insight into the pre-conditions, enablers, limiters and consequences for establishing and maintaining such systems through comparative case analysis.

1.1.1 Relation to existing literature

The PhD project relates to research on implementation of energy efficiency technologies, where the main research puzzle has been why cost-effective and technical viable solutions are not being implemented by companies, often referred to as an *energy efficiency gap* (Jaffe & Stavins, 1994). This literature is dominated by rational choice models (neo-classical economics) explicating a deductive starting point that *non-technical barriers* (i.e. access to information, lack of capital, lack of knowledge, etc.) hinders otherwise rational technology implementation. The research task is then to reveal these barriers and to inform appropriate policies to remove them (i.e. Cagno, Worrell, Trianni, & Pugliese, 2013). Although these perspectives have provided insights for policy makers through generalization of perceived difficulties for companies, the methodological approach with a particular focus on negative case-selection and causal inferences of non-events based on entification of barriers have been criticized by sociologists (Shove, 1998, 2017). This critique is supported by *within-case* studies of energy exchanges leaning on insights from infrastructure theories (i.e. Bijker, Hughes, Pinch, & Douglas, 2012; Hughes, 1987), revealing that such systems consist of much more than technical components and their interactions and must be understood as socio-technical systems (Haavik, Røyrvik, & Lindheim, 2017; Johansen, 2012; J.P. Johansen & Røyrvik, 2014). Altering technical systems and connecting companies' energy flows implies consequences such as necessity of deciding ownership of the energy and components, maintenance, pricing-models and arising interdependencies infers a need for changing (inter)organizational structures. Thus, instead of investigating why companies don't implement energy- and cost efficient technologies – the question is turned to investigate how and why some companies actually have succeeded in crafting such connections (ibid). By viewing energy exchanges as innovation processes of inter-organizational organization concepts – the research task for social scientists is then to explore these processes to uncover the role of informal networks, trust and contextual factors explaining the construction of such systems. Interdependencies implies risks for the companies involved, informing the second part of the research question to investigate how these systems develop over time. Within the field of industrial ecology and geography this view has taken hold through the concept of *industrial symbiosis*, highlighting the self-organizing dynamics of such constellations and arguing the role of informal networks and trust or intermediaries as a key foundation for the self-organization of similar systems (Boons, Chertow, Park, Spekkink, & Shi, 2016; M. Chertow & Park, 2016; M. R. Chertow, 2000). Currently, there is a weak connection between the social science perspectives on energy efficiency, ecological perspectives (industrial symbiosis) and case studies of energy exchanges inspired by infrastructure studies. Theoretically, the ambition of the project is not to verify pre-described hypothesis of any of these frameworks deductively. The theory building research objective by George & Bennett (2005, p. 74) building on the work of Lipjart and Eckstein (Eckstein, 1975; Lijphart, 1971) is a combination between heuristic as well as building block study towards understanding the role of informal capabilities in industrial symbiosis formation and infrastructure theories.

1.1.2 Dependent and independent variables

The dependent variable (outcome to be explained) is the emergence of energy exchanges between industry companies in Norway. Thus, the class of events that are under scrutiny are the socio-technical arrangements of recovering and redirecting waste energy between inter-organizational industry processes outside the boundaries of regulated infrastructure (power grid, district heating networks). While the rather binary outcome of "energy travelling between companies or not" serves as a criterion for the case selection, such phenomenon is not a binary state. The organizational (coordination concept, prices, contracts) as well as technical properties (amount of energy and number, infrastructure, chosen technologies) of these systems could often be different and still satisfy the requirement of becoming a case study. Other aspects are the degree of technical and organizational interdependence and reliance on informal or formal organizational structure for maintaining the system. Variance in the dependent variable involves more than just a success/failure dichotomy which must be described and explained. Thus, there is a clear variance in the dependent variable and an important part of this research is to investigate how the independent variables contributes to the establishment and dynamics of energy exchanges and manifest themselves in these socio-material arrangements.

The independent variables, are the explanatory factors for *how* these particular socio-technical arrangements emerged and eventually changed over time. While the main focus of this PhD is on investigating the impact of social and institutional variables other independent and intervening variables will inevitable be important for the construction of these infrastructures and must be accounted for. Inevitable explanatory conditions such as technical and economic feasibility of the energy exchange as well as geo-spatial restrictions and opportunities are necessary conditions for the establishment of energy exchanges. For example, the topography in an area can physically hinder the establishment of a low temperature heating network between companies. Based on previous studies, there is a need to look deeper into *how* informal aspects (networks, trust, shared visions) shapes the decision-making processes as well as materialize in the socio-technical arrangements (dependent variable). Second, while some energy exchanges are shown to be self-organized other forms of emergence has been identified where third-party or public intermediaries are important (Boons et al., 2016). Third, aspects of the institutional framework can be explanatory factors to the emergence and dynamics of energy exchanges such as; incentive systems, energy efficiency programs, connection to R&D environment, legislative restrictions. Also, a web of contextual conditions will always be relevant for explaining the emergence of energy exchanges. While some of these factors (or the particularity of the factors) must be regarded as context-specific, others can be inductively discovered in the project and generalized as explanatory factors.

1.2 Case selection

Four case studies have so far been selected to be investigated in this PhD project[3]. The main criteria of selection the case studies are that they have completed or ongoing initiatives for establishing energy exchanges. Thus, although in different ways, the technical, economic and geo-spatial restrictions have been solved. However, characteristics of the industries involved, technical complexity and organizational properties of the energy exchange systems will differ between the cases. While the variances are unique for the chosen cases, variances on these parameters, is in itself representative of the population of successful, attempted and failed energy exchanges. The case selection is made on the basis of elucidating different stages, respectively how energy exchanges are constructed (emergence), and how they develop, change or (dynamics). The case studies are chosen to represent cases from both of these stages and also vary with the factor that an intermediary was present or not. The case comparison research design will investigate similarities and differences of the organization, establishment and dynamics of these cases. In accordance with suggestions from Seawright & Gerring (2014) the cases achieve variance on some key dimensions for

[3] Case 1 and 2 have been partly completed with interviews and field visits in addition to meta-analysis of two previously conducted master thesis (Johansen 2012, Jakobsen & Steinmo 2010).

the phenomena under scrutiny. There is certainly a trade-off between theoretical parsimony, rich explanations and number of cases (George & Bennett, 2005, p. 31), where the number of cases chosen provides a starting point to later address saturation. There is still an opportunity to include negative-case studies inspired by the possibility principle (Goertz, 2012, pp. 178–179), cases where the establishment of an energy exchange was *possible*, but for some reason did not happen. Optionally, the background cases both within the literature on barriers to energy efficiency and industrial symbiosis may serve as background cases (Seawright & Gerring, 2014).

1.2.1 Case studies

Case 1: Alimentary industry cluster

This industry cluster has a unique energy exchange infrastructure where surplus heat and CO2 from an industrial dairy is utilized in a nearby greenhouse producing peppers and tomatoes. There are plans of further expanding the energy exchange system to include three industrial meat producers already located in close proximity as well as an external bio-fueled district heating system. This case study was first investigated in 2011 as a single within-case research design in a master thesis (by this PhD student, Johansen 2012, Johansen & Røyrvik 2014) and forms a basis for this PhD project. The case will be revisited in 2018 – making it possible to investigate the dynamics with two data points and further investigate the development of the energy exchange, organization and operations concept and eventual changes.

Case 2: Process and metal industry cluster

This case study involves an established industry cluster with four major companies within the metal and process industry (ferro-alloys, ferro-manganese, scrap metal steel and coke). The emergence of this cluster and symbiosis is tied to the privatization of a public iron plant in the late 1980s, which led to a splitting of the existing value chain of materials and energy into several companies. The case was chosen as a unique case to investigate stability and changes of an energy exchange of CO-gas between the ferro-alloy company and surrounding companies as well as the network of utilizing surplus heat. Where the history of emergence is less available, this case provides a history of the dynamics of inter-organizational energy exchange over time where ownership of the companies has changed to multi-national owners, key frame conditions has changed over time (i.e. EU ETS, changing energy prices, etc) and the people involved during the establishment phase have retired.

Case 3: Emergence of a 'greenfield' industry cluster

The third case study is unique in the sense that there is not yet an industry cluster or energy exchange – but there is currently an initiative to establish one. The access to the case is through a municipality-owned coordination and development company acting as an intermediary in charge of facilitating a new cluster between existing companies in the middle of Norway. In this case I will follow monthly steering group meetings (including facility managers and local municipality) for the duration of the PhD as well as follow-up interviews with company representatives underway. The value of this case is to follow an on-going process and provides the possibility to "test" assumptions from the other case studies.

Case 4: *Construction of a single-plant industrial dairy*

The last case study is a single-plant in difference to the industry-clusters in the other three cases. While the surplus heat is not utilized externally it is transported and utilized in other industry processes internally at the plant. The reasoning for this case study is to include an outlier case by removing the "inter-organizational" variable and investigate the main differences and similarities of utilizing surplus heat within company borders – the technological solutions are similar to the other cases. While the design process of the dairy is completed in June 2018, the construction process will start in late 2018 which allows following the trade-offs between design and construction phase.

Table 1: Case overview

	Case 1	Case 2	Case 3	Case 4
Industries	Industrial food	Metal, process, fishery	Metal, process, industrial food	Industrial food
Model	Cluster	Cluster	Cluster	Single-plant
Energy exchanged	Surplus heat, cooling, CO2	Surplus heat, CO-gas	T.B.D	Surplus heat, cooling
Phase investigated	Emergence, Dynamics	Dynamics	Emergence (or failure?)	Emergence
Third party intermediary involved?	No	Yes	Yes	No
To be conducted	2011 / 2018	2010 / 2017	2018-2020	2018-2019

1.2.2 Reflections on variance and selection bias

As noted by George and Bennett (2005), the selection of case studies can sometimes be opportunistic which is also true for this project for several reasons; there are few examples in Norway of successful industrial energy exchanges, there are also few ongoing initiatives of establishing industry clusters with ambitions for such systems, investigating these processes requires access to key arenas (i.e. steering group meetings, interviews with stakeholders and key informants) which are difficult to obtain due to time constraints and openness issues. While these are not 'elite interviews' per se, as noted by Goldstein (2002), "getting the interview" is very much a sampling issue. Thus, the selected case studies have a connection to the research center High-EFF where either one or several of the companies are partners in the project. While this provides an opportunity, it also introduces a selection bias which must be addressed in the scope of findings and generalizations; the companies involved in the center might have stronger connections to academic resources than industrial counterparts, the choice of engaging in this research center in itself does indicate a focus and willingness to invest in energy efficiency which have previously been identified as an important barrier (Cagno et al., 2013). As addressed by George and Bennett (2005, p. 25) the scope of the findings must be limited in this regard. Also, as noted above the inevitable variances in the energy exchange system, previously addressed as the problem of equivalence for industrial symbiosis (Boons, et al. 2016) must be addressed when drawing analytical implications.

1.3 Measurement of variables and data requirements

Describing the emergence of energy exchanges implies leaning on qualitative explanations (why and how) rather than quantitative (how much). The ambition of the project is for example not to quantify "trust" or "role of intermediaries" but rather understand how these qualitative aspects affects the establishment and dynamics of energy exchanges. In line with George & Bennett's (George & Bennett, 2005, p. 25) remark that case studies remain much stronger at assessing whether and how a variable mattered to the outcome than at assessing how much it mattered. Instead of asking a range of informants 'what hindered or enabled' the energy exchange, the methodological approach involves a reconstruction the history of establishment and changes in the systems to understand the unfolding of such processes. Thus a detailed narrative (George & Bennett, 2005, p. 170) will be constructed for each of the case studies as the starting point for process-tracing. Inspired by George & Bennet (2005, pp. 86–87) remarks on formulating data requirements a set of

instrumental questions which will be answered by each case study to reflect the main philosophical research question:

- How are the energy exchanges organized? Do they rely on informal as well as formal organizational structures?
- How have informal networks, trust and shared values impacted the decision for establishment – and the socio-material design? How have these factors contributed to resilience in existing exchanges?
- What is the impact of involving intermediaries in the establishment phase or pre-establishment phase?
- Which aspects in the institutional framework have been important for the establishment and dynamics of the energy exchange?

While these are the main research questions, other contextual factors must be assessed to address equifinality. The sources of evidence include interviews, participation in meetings, document and media narrative studies as well as site visits. In-depth and semi-structured interviews will be the main form of data collection and "evidence" in these case studies. Informants include decision-makers at managerial level, engineers in charge of design and optimization, municipality or government officials and R&D personnel from academic partners involved in the projects. While key informants are identified beforehand, additional informants will be chosen based on snowball method sampling. Case 1 and 2 have been previously studied in two master-thesis (Jakobsen & Steinmo, 2010; Johansen, 2012) which allows for a certain "before and after" comparison of the dynamics based on interview data where the connection between key events (i.e. change of ownership, energy prices, institutional framework) and changes in the industry symbiosis will be investigated to address the dynamic of such constellations. In case 3 & 4 which are two "in process" cases, participation in monthly board room meetings will also be possible to observe aspects of the decision making processes. Field visits will be conducted to each of the case sites both to ease the interview situation, but also to achieve a first-hand impression of the industry sites and technical system. Documents that will be scrutinized include public records of emission- and building allowances which involves the official statements of the construction of the energy exchange systems. These can in combination with interviews strengthen eventual statements regarding role of municipalities and compare the rationale provided in the documents towards the informant's accounts. Also relevant media narratives will be investigated to strengthen the historical accounts.

1.4 References

Bijker, W. E., Hughes, T. P., Pinch, T., & Douglas, D. G. (2012). *The social construction of technological systems: New directions in the sociology and history of technology*. MIT press.

Boons, F., Chertow, M., Park, J., Spekkink, W., & Shi, H. (2016). Industrial Symbiosis Dynamics and the Problem of Equivalence: Proposal for a Comparative Framework. *Journal of Industrial Ecology*, *21*(4), 938–952. https://doi.org/10.1111/jiec.12468

Cagno, E., Worrell, E., Trianni, A., & Pugliese, G. (2013). A novel approach for barriers to industrial energy efficiency. *Renewable and Sustainable Energy Reviews*, *19*, 290–308.

Chertow, M., & Park, J. (2016). Scholarship and Practice in Industrial Symbiosis: 1989–2014. In *Taking Stock of Industrial Ecology* (pp. 87–116). Springer, Cham. https://doi.org/10.1007/978-3-319-20571-7_5

Chertow, M. R. (2000). Industrial Symbiosis: Literature and Taxonomy. *Annual Review of Energy and the Environment*, *25*(1), 313–337. https://doi.org/10.1146/annurev.energy.25.1.313

Eckstein, H. (1975). Comparative Politics and the Comparative Method. In *Handbook of Political Science* (Vol. 7, pp. 79–138). Reading: Mass: Addison-Wesley.

Enova. (2011). Utnyttelse av spillvarme fra norsk industri - en potensialstudie. Enova.

George, A. L., & Bennett, A. (2005). *Case Studies and Theory Development in the Social Sciences*. MIT Press.

Goertz, G. (2012). *Social Science Concepts: A User's Guide*. Princeton University Press.

Goldstein, K. (2002). Getting in the Door: Sampling and Completing Elite Interviews. *PS: Political Science and Politics*, *35*(4), 669–672.

Haavik, T. K., Røyrvik, J., & Lindheim, C. (2017). A question of power: the politics of kilowatt-hours. *Nordic Journal of Science and Technology Studies*, *5*(1), 17. https://doi.org/10.5324/njsts.v5i1.2249

Hughes, T. P. (1987). The evolution of large technological systems. *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, *82*.

Jaffe, A. B., & Stavins, R. N. (1994). The energy-efficiency gap What does it mean? *Energy Policy*, *22*(10), 804–810.

Jakobsen, S., & Steinmo, M. T. (2010). Mo Industripark - Et industrielt økosystem.

Johansen, J.P. (2012). Konstruksjonen av et kollektivt energisystem: En kvalitativ casestudie av energisamarbeidet mellom bedriftene i Kviamarka industriklynge. *Master Thesis:* Retrieved from https://brage.bibsys.no/xmlui/handle/11250/268545

Johansen, J.P., & Røyrvik, J. (2014). Organizing Synergies in Integrated Energy Systems. *Energy Procedia*, *58*, 24–29. https://doi.org/10.1016/j.egypro.2014.10.404

Lijphart, A. (1971). Comparative Politics and the Comparative Method. *The American Political Science Review*, *65*(3), 682–693. https://doi.org/10.2307/1955513

Seawright, J., & Gerring, J. (2014). Case Selection Techniques in Case Study Research: A Menu of Qualitative and Quantitative Options. In M. Tight, *Case Studies* (pp. II213–II213). 1 Oliver's Yard, 55 City Road, London EC1Y 1SP United Kingdom: SAGE Publications Ltd. https://doi.org/10.4135/9781473915480.n31

Shove, E. (1998). Gaps, barriers and conceptual chasms: theories of technology transfer and energy in buildings. *Energy Policy*, *26*(15), 1105–1112.

Shove, E. (2017). What is wrong with energy efficiency? *Building Research & Information*, 1–11.