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1. Background

Socio-technical systems fulfill societal functions and comprise of clusters of aligned elements such as artefacts, knowledge, markets, regulations, policies etc.(Geels and Schot 2007). Socio-technical systems transition from one state to another. These transitions generally encompass complex and inter-related processes, especially within the elements mentioned above. Energy transitions are generally characterized as socio-technical transitions. Within energy transitions, local energy transitions are considered a sub-set, especially dominated by small-scale transition initiatives and practical examples (Turnheim et al. 2015). But, Selvakkumaran and Ahlgren (2017) point out that local energy transitions have certain specific characteristics, such as the need for governance under uncertainty and spatial relevance, which set them apart from wider energy transitions.

We define local energy transitions as sub-national energy transitions which happen with the influence and participation of local persons. Dalsland, Sweden, is a collection of five municipal administrative bodies in the county of Western Sweden. From herein Dalsland will be used to imply the collection of the five municipalities. Dalsland is classified as a rural locality (Swedish Association of Local Authorities and Regions 2017) and has a population of approximately 45 000 in 2017. Dalsland has a goal of achieving fossil-free transport by the year 2030, but is significantly lagging in its adoption of fossil-free, battery electric and biogas cars. At the end of 2016, there were approximately 24 000 passenger cars in Dalsland, and in the period between the beginning of 2016 until February 2017, two battery electric cars and zero biogas cars were added. On the other hand, almost 80% of the added cars were pure diesel or gasoline cars (Trafikanalysis and Statiska Centralbyrån 2017) (Statiska Centralbyrån 2017). Thus, clearly Dalsland is facing challenges in its transition to a fossil-free transport sector and the municipality actors are engaged in a co-creation drive to overcome this challenge (Dalsland Kommunalforbund, n.d.).

Co-creation, and by extension social innovation are not new concepts, but in the field of local energy transitions, they have not been studied before, according to Voorberg et al. (2014). In the case of Dalsland, the objective of the co-creation effort is to have at least 10% of the total passenger cars as electric or biogas cars by the year 2019.

2. Research objectives

The objective of this study is to determine the underlying causal loops in the local energy transition process, namely transition in the transport sector, from fossil-fuel cars to electric and biogas cars in Dalsland, and identify the impact of the co-creation efforts taken by the municipality actors. We also aim to theorize and conceptually frame co-creation in the context of local energy transitions, and qualitatively determine its impact on the transitions process.

Thus, we want to understand the dynamics and the underlying feedback loops in a local alternative fuel vehicle (AFVs) transitions case, especially in the context of a rural municipality, and in the context of co-creation actions, undertaken by the municipality actors.

Local energy transitions and co-creation have not been analysed together, especially in the context of systems thinking. We want to fill this gap, given the importance social welfare states place on co-creation and social innovation (OECD 2011; Bureau of European Policy Advisers 2014). The use of causal loop diagramming in the context of a local energy transitions case is novel.

The scope of this study is limited to causal loop diagramming the feedback loops in a local energy transitions process. The next step will be to convert the final causal loop diagram (CLD) to a simulation model, which we are not attempting in this step of the study.

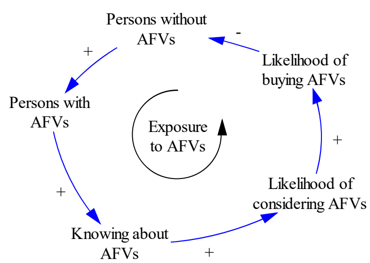
3. Methods and preliminary findings

Struben and Sterman (2007) identify the underlying factors that need to be considered in understanding the transition dynamics in alternative fuel vehicles and transportation systems. We consider the factors, especially the social, economic and behavioural factors identified and diagrammed by them, but at the same time since the analysis is to be done for a smaller locality (Dalsland) we think it is necessary to incorporate primary data as well.

Hence, we start with a simple CLD which represents a nominal technological diffusion/adoption process, given by Sterman (2000) and then add further factors pointed out by the municipality actors, and incorporate those factors and the ensuing feedback loops to the initial CLD. Here, for simplicity's sake we assume only one AFV, as opposed to considering electric and biogas cars separately.

Figure 1 gives the initial CLD, which has the negative feedback loop titled 'Exposure to AFVs', where with contact with the first person who has an AFV, persons without AFVs buy AFVs. In this CLD when persons buy AFVs, persons without AFVs reduce in number. In Dalsland, the extent to which this exposure has led to actual transitions to AFVs is low. Nevertheless, this is the starting point of our diagramming and our initial CLD. For the sake of simplicity, we have not introduced an exogenous increase in the number of cars at this stage.

We use the initial and successive CLDs as a tool in our semi-structured interviews with the municipality actors. We use the interview method to question the municipality actors about the representation of the transitions processes and factors, and question them about their co-creation actions, and the impacts they have witnessed. Thus, determining the underlying feedback loops in the local transitions case is an iterative process, with multiple interviews with the municipality actors. Thus, we are trying to incorporate a participatory modeling framework into our methodology, in determining the causal loops in the AFVs transition process.



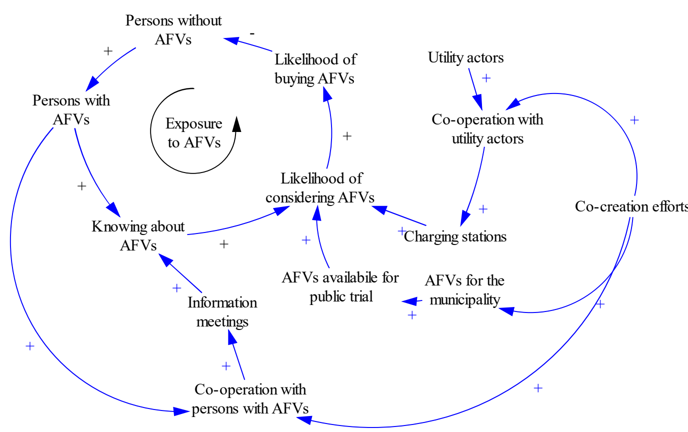


Figure 1 (Left). The initial CLD of the local AFV transition case of Dalsland
Figure 2 (Right). The CLD of the local co-creation activities and their feedbacks

The co-creation actions have been diagrammed as having an impact on the likelihood of considering AFVs, and increasing the knowledge about AFVs (see Figure 2).

Preliminary findings suggest that the different co-creation activities are designed to have an impact in increasing the knowledge about AFVs, and increasing the likelihood of buying AFVs. For example, the municipality actors organize information meetings, where they get the help of a 'popular' electric car owner to speak to owners of fossil-fuel cars, and invest money in buying electric cars for the municipality office's use, which in its downtime they 'loan' to prospective fossil-fuel car owners to 'try out'.

Also, municipality actors found that "what's in it for me" attitude dominates the reason for Dalsland citizens not transitioning to AFVs, and the cost subsidy the Swedish government gives for electric and biogas cars (approximately 50 000 SEK or 6 200 USD) is not sufficient to sway them. The co-creation actions and the installation of electric charging stations have happened concurrently, but even with a ready supply of biogas (raw), there is still no upgraded biogas filling station in the five municipalities which make up Dalsland, with the first one to be opened in the middle of 2018.

The subsequent steps will be to model the facts mentioned above by integrating them into the CLD in Figure 1, thus capturing the different feedback loops impacting on the AFVs transition in Dalsland.

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