1. TOPIC OF THE PhD DISSERTATION

Titre : Households' heating and electricity : towards a new economic model.

2. SUMMARY

At the household level, solar photovoltaic can provide the electricity necessary for some devices and/or be sold on the grid, while c-pumps or solar thermal energy takes care of heating, hot water and ventilation. Such energy uses require investments that are expensive, with a long lifetime. As a consequence, these investments generate gains that are uncertain because energy markets and climate are far from known at a long-term horizon. This rises interesting questions related to their profitability and their financing. The objective of the research project is to provide an economic and financial appraisal of the complex investments that are related to energy uses at the household level. The analysis will help selecting financial contracts to optimize energy use and the global monthly price. Ultimately, the research will also help the user choosing among different types of investment (*i.e.* for instance thermal solar vs c-pumps) or their combination. It could also suggest the design of public policies regarding the financing of RE.

3. DETAILED RESEARCH PROJECT

Context and motivation

Given the large scientific consensus on global climate change, it is often asserted that renewable energy (RE), such as wind and solar power, will replace fossil fuels (see van Benthem et al., 2008 and Hirth, 2015). As nearly 30% of global electricity consumption comes from residential buildings (see EIA, 2016), RE investments at the household level can significantly contribute to the expansion of RE capacity; This is in particular the case as far as solar photovoltaic, thermal energies and c-pumps are concerned. Households then need less energy and can even become prosumers. Photovoltaic can provide the electricity necessary for some devices in the house and/or be sold on the grid, while c-pumps or solar thermal energy takes care of heating, hot water and ventilation. Intermittency is a challenge associated with a higher penetration of such electricity generation (Speer et al., 2015). Effective storage capacity, that can be hot water tank in case of solar thermal, and demand management offers new opportunities for flexibility to tackle this challenge (see Jeon et al., 2015; De Castro and Dutra, 2011; MITei, 2015). RE generation and storage possibilities require investments that have the following important features. First, they are expensive. Second, there lifetime is at least 20 years. As a consequence of the latter, these investments generate gains that are uncertain because energy markets and climate are far from know at a 20-year horizon. This rises interesting questions related to their profitability and their financing.

Scientific objective

The objective of the research project is to provide an economic and financial appraisal of the complex investments that are related to energy consomption. Ultimately, the analysis could help the user selecting financial contracts and choosing among different types of investment (*i.e.* for instance thermal solar vs c-pumps). It could also suggest the design of public policies regarding the financing of RE.

Profitability of innovative systems installed by households has already been studied (see Dato et al., 2019, Durmaz et al., 2017). However, to our knowledge, financial contracts that could help funding the required investments have not been studied yet. In addition, there is nothing in the economic literature regarding the profitability of solar thermal systems or c-pumps, accounting for intermittency as well as the storage possibility they offer, not to speak about their financing. In particular, the issue is to find the optimal contracts between on the one hand the investment provider (*e.g.* Viessman) and the household (should it be a leasing, or service rental, or energy rental?) and on the other hand, the investment provider and the financial system.

This research would fill the gaps regarding first the profitability of solar thermal and c-pumps at the household level and second the financing of the heavy investments that are required for RE (including heating) generation.

Methodology and outline

The first chapter will be devoted to study the profitability of c-pumps and solar thermal provided they are self-financed by the household. The next two chapters will be focused on financing issues. The last chapter will provide comparisons between the different sources of RE generation and provide recommendations regarding the choice of one or the other system by the RE investment producer and public policy regarding the financing of these systems.

First chapter: Profitability of solar thermal and c-pumps
In this chapter, the student can start from Durmaz et al. (2017, 2019) to appraise the profitability of solar thermal and c-pumps. An interesting departure from this paper will be that this equipment not only generates energy but encompasses a storage capacity as well. In line with Durmaz et al (2017, 2019), the student could consider different constraints relative to the consumption optimization. The analysis will result in an evaluation of the willingness to pay of a household for solar thermal and/or c-pumps equipment. Note that these results can be location dependent notably for climate reasons. The methodology will require theoretical modelling under uncertainty (at least on energy prices and climate) together with calibration on existing data.

Second chapter : Contracts with households
In this chapter, it is assumed that the equipment is owned and self-financed by the producer. The question is about the type of contract the energy manager will offer to the household. The objective can be to maximise the producer's profit subject to some constraint on the cost of the contract for the household. For instance, this cost should not exceed the expected discounted cost of buying energy on the market, that would be necessary to provide the same service as the investment on its lifetime. Another possible constraint could be that this cost should not exceed that the household would bear in case of self-financing. Different contracts will be considered, including but not restricted to leasing of the equipment, rental of the equipment, and rental of the energy. Methodology will be close to that used in finance and actuarial sciences.

Third chapter : Contracts with financial institution to fund investment
In this chapter the student will compare different sources of funding for the producer to own the HVAC investment. We already know from the literature that taxation is enough introduces a departure from Modigliani-Miller theorem: financing through debt or own funds does make a difference for the profit of the firm as debt repayment reduces taxable profit. Here we want to account for risk accruing from future energy prices and climate change (and any other risk that would appear significant during the research project, in particular chapter 1) and design the most suitable financial contract between the firm and financial institutions. It has to be kept in mind that such a contract may depend on the contract offered to the household as well. In other words, optimal contracts between the producer and the household on the one hand and on the producer and the financial institution on the other hand may be dependent. Again, methodology will be close to that used in finance and actuarial sciences.

Fourth chapter: Investment and public policy recommendations
Having designed the optimal contracts in the previous chapters, the students will have the required knowledge and tools to effectively compare the different types of investments (solar thermal, solar photovoltaic and c-pumps) to make recommendation regarding their most suitable combination. As a result, the producer will know which investment she should focus on. In addition, it could be studied whether interest of the different agents – investment producer, household, and society as a whole- are aligned. In case they are not, public policy recommendation could be proposed as well.

Chapter 1 will not only provide results regarding the profitability of RE generation at the level of the household; it will also help the student getting a good understanding of the key features in HVAC investments and exhibits therefore some aspects of a preliminary work that is preparatory for chapter 2 and 3. Chapters 2 and 3 could be started simultaneously as some work on the different types of contracts can be made separately. Anyway, results from chapter 2 will be needed to complete chapter 3. Chapter 4 has a concluding flavor and will contain most of the recommendations (whether for the RE investment producer or public policy) of the PhD dissertation.

References

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Hirth L. (2015), “The Optimal Share of Variable Renewables: How the Variability of Wind and Solar Power affects their Welfare-optimal Deployment”, The Energy Journal 36(1), p127—162.
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Van Benthem, A.,Gillingham, K. and J. Sweeney, (2008), “Learning-by-doing and the optimal solar policy in California”, The Energy Journal 29(3), p131-151.

4. REQUIREMENTS FOR THE CANDIDATE :

The student must have graduated in Economics at the Master level. He/she should have demonstrated a very good level in theoretical modeling and econometrics. Having already shown some interest for environmental issues (through internships, master thesis or other pieces of work) is a plus.

5. FINANCING OF THE PHD:

CIFRE environné

6. CONTACT:

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