INCONVENIENT CALCULATIONS: ESTIMATING THE COST OF ENERGY THROUGH CALCULATIVE FRAMES

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Abstract: As Denmark's share of wind energy in electricity consumption surpassed 39% in 2014, discussion about the cost of wind energy has intensified. As a result, several energy cost calculations comparing wind energy to other energy sources were released to inform policy makers on this topic. Through a discursive analysis of two such energy analysis reports, the author compares how financial analysts provide calculative frames to shape investors' decisions on unknown companies, to how energy analysts provide similar calculative frames for wind energy. Without sufficient transparency of assumptions made by energy analysts, these reports may potentially mislead more than they inform.

Keywords: Energy, Wind energy, Valuation studies, Public policy, Market devices.

1. INTRODUCTION

How do we ascribe value to an unknown company, service or product and how do we determine intangible and complex aggregate effects of actions taken today, but affecting us 20-30 years from now? Predictions about the future production and infrastructure costs within energy markets have become increasingly complex, and now require answers to the above questions.

Wind energy has emerged from supplying less than 2% in 1990 up to 39% of total electricity consumption in Denmark by 2014 (Link 1;Link 2). Denmarks high ramp-up of wind energy has over the last two decades raised growing discussions with the dominant discourse that wind power is a costly resource and difficult to fit in the danish energy system (Lund, 2010; Karnoe, 2010). In 2014, two electricity cost calculations were developed which inconveniently attribute significantly different values to wind energy in the Danish power system. The author will analyze the two energy calculation reports in relation to the challenge of ascribing value to an unknown entity and producing calculative frames.

Professors Beunza and Garud point out that the challenge of ascribing value to an unknown future was first identified by Frank Knight in 1921 (Beunza and Garud, 2007). Economists have since the emergence of the so-called Knightian challenge, divided themselves into two opposite positions; one being that calculations can be done straightforward, the other claiming that the high level of uncertainty causes analysts to act like lemmings who merely follow colleagues' predictions Previous work on the topic of valuation of intangible topics has focused on financial analysts' categorization of new types of enterprises (Beunza and Garud, 2007). Beunza and Garud have in their example of the valuation process of the internet-retailer Amazon, emerged the claim that none of the two above-mentioned positions are at play. Financial analysts are neither 'straightforward calculators nor lemmings', but instead have three overarching roles: information processors, imitators and critics. These interacting roles lead Beunza and Garud to view analysts as makers of calculative frames.

"We denote by calculative frame the internally consistent network of association, including (among others) categories, metrics and analogies, that yield the necessary estimates which go into the valuation of a company." (Beunza and Garud, 2007, P.27)

Beunza and Garud use the framework shown in fig. 1 to analyse how financial analysts ascribed value to an unknown entity such as the internet retailer Amazon during its emergence in 1998.

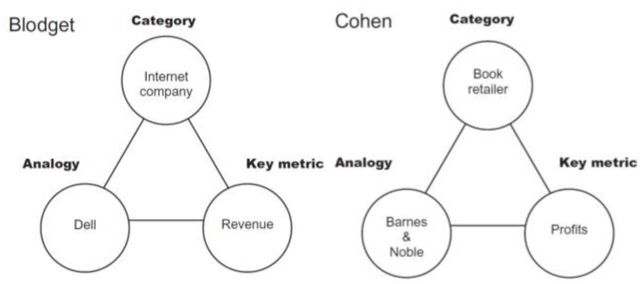

Fig. 1. Example of two financial analysts' calculative frames for Amazon, reproduced from Beunza and Garud 2007, p. 27

It has yet to be analyzed how economic analysts ascribe value to different energy source choices for a society. When valuing the cost of a renewable energy source such as wind power against a fossil fuel source such as coal or gas, several complex factors such as intermittency cost and predicted CO2 quotas come into play.

This paper aims to build upon current models for calculative frames to compare two calculations for the monetary costs for wind energy in the Danish energy system. The paper will examine whether analysts' choices about which elements are counted determine which conclusions are reached. For instance, how analysts decide to calculate elements such as intermittency and CO2 quotas depend on their categorization of both the energy source and the system it is used in.

Hereafter, the author will explain how the framework for calculative frames is used to analyze how two Danish reports from 2014 differ in their categorization of wind energy, and how this potentially affects their metrics and results. Following the analysis, main findings and their implications will be discussed.

2. METHODS AND MATERIALS

Two reports are examined through discursive analysis in this paper, namely "Electricity production costs" by Energy Analysis (Link 3, hereafter EA) under commission of the Danish Energy Agency, and "The cost of producing electricity in Denmark" by the Rockwool Foundation Research unit (Link 4; hereafter RW). The two reports have been chosen as sources due to the recognized image of the authoring institutions, their stated aim of advising policy makers (EA, p. 4; RW, p. 2), and their comparability in attempting to make a conclusion regarding societal costs of wind energy. The EA report concluded that onshore wind energy is the cheapest energy choice for Denmark (EA, p. 5), whereas the counterfactual analysis in the RW report concludes that wind energy has made electricity 13% more expensive (RW, p. 6).

When estimating how wind energy should be valued in comparison to other energy sources, a number of assumptions determine the final outcome. The author will in this paper focus on two significant areas that separate the two reports from each other. The first will be the categorization of wind as either a regular energy source or as a non-conventional energy source added to an existing energy system. The choice of "non-conventional" as a source emphasizes the cost calculation of intermittency, the fact that the wind is not a steady resource. The second area is to what extent EU climate change policies represented by CO2 emission quotas are either calculated in as a cost factor or omitted from the calculation. The reports will be analyzed with a focus on which assumptions the analysts make about the Danish energy system, and how this affects their categorization of wind energy. The full overview of assumptions made and the role played by the networks supporting each of the calculations, will be covered in a more elaborate article.

3. RESULTS

The first examined area is whether wind energy is considered a source of energy on equal terms as coal, gas etc. or as a non-conventional energy source, which is added to an already existing energy system of conventional sources. The difference can here be found in the purpose text of the two reports (Table 1). In the EA report's introduction of renewables and fossil energy sources, no distinction is made between them in conventionality. In contrast, the RW report supplements the overall goal *'to study the costs of generating electricity in the Danish power system'*, with an additional counterfactual analysis aimed at discovering which added cost to the total energy generation costs, wind energy is specifically responsible for.

Table 1. Wind energy as non-conventional

Energy Analysis (EA)	Rockwool (RW)
to analyze costs of producing electricity from new plants from a societal-economic view (4) We are presenting long-term marginal production costs for new units, wherein capital-, operational-, fuel- and environmental costs are included. (4)	to study the costs of generating electricity in the Danish power system. (1) A counterfactual analysis is carried out to investigate what the production cost would have been under the thought experiment that no wind power capacity had been introduced into the Danish power system (6)

The stated rationale for the additional RW analysis comes in a distinction between conventional energy sources and added new sources, which can be found in one of the first questions raised in the authors' foreword to the RW report:

"How does the relatively quick introduction of non-conventional generating technology (wind turbines) into a national power system affect the cost of generating electricity?" (RW, Foreword p. 1)

Once wind power is categorized as a non-conventional generating technology, the price of intermittency becomes calculated as an added cost of total generation. Wind energy is thus measured by the cost of back-up capacity as a percentage of total electricity generation costs. This metric is derived from the categorization of wind as non-conventional, which leads to an evaluation of the cost of wind as an added resource to an already existing energy system consisting of conventional energy sources, i.e. coal and gas power plants. The calculative frame that is created in the RW report is found in fig 2 on the next page.

The second factor which differentiates the RW and EA report is the extent to which they incorporate EU measures to combat climate change in their calculation or leave it out (Table 2, on page 3). The EA report uses the International

Energy Agency's (IEA) prediction that the price of CO2 Emission Quotas will rise from 8 € per ton today to over 25 € per ton in 2035.

Table 2. Wind Energy as solution to meet CO2 Quotas

Energy Analysis (EA)	Rockwool (RW)
The calculation is based on fuel and CO2 prices from the IEA New policies scenario up to 2035, wherefrom the assumptions are extrapolated linearly to 2050. (10)	We do not include the social cost of emitting CO2 into the atmosphere. (7) We do not evaluate economic or environmental policies that influence the Danish energy system. (7)

The RW report uses current CO2 quotas and do not calculate the added cost of reaching the EU CO2 reduction goals through other measures, in the hypothetical scenario that wind energy was not existing in the Danish energy system. It is by the omission assumed that EU would either waiver it's unfulfilled CO2 reduction demands to Denmark or Denmark would reach these goals without added cost to electricity generation. The two calculation frames are seen in Fig. 2.

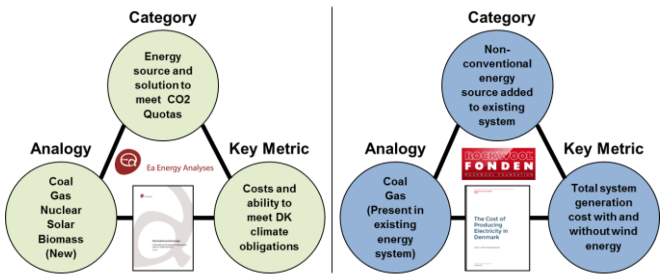

Figure 2: Calculative frames in EA and RW reports

4. DISCUSSION

It is critically important that the complexity and political assumptions behind calculative frames are transparent, when report results are communicated to decision makers. However, the RW authors' own reservations towards their hypothetical analysis, which they on page 91 of their report call 'counterfactual' and 'unobservable' (RW, p. 91), is not reflected in Danish news media coverage (Link 5;6;7). Although the counterfactual analysis only takes up a third of the RW report, it becomes the main takeaway of the report. A topic for further investigation is thus whether a given calculative frames legitimacy within energy analysis only is as strong as the network which will support it. The Danish news medias' selected conclusions from the RW report could suggest that there is still strong support for the viewpoint that wind energy is an expensive non-conventional energy source.

5. CONCLUSION

Beunza and Garud have in their research shown how different calculative frames affect financial analysts' conclusions regarding an unknown company such as Amazon. The presented study in this paper demonstrates that energy analysts also create calculative frames, and that the metric used to make a recommendation regarding wind energy, is highly dependent on the chosen categorization of wind; a categorization which is based on assumptions made by the analysts, regarding complex and unpredictable topics such as intermittency and international climate policy. Calculative frames are used to equip financial investors with tools to measure company value. In a similar manner, energy analysts develop calculative frames to equip policy makers in making complex decisions on energy investments. Even though the EA and RW reports measure wind energy from two separate analytical perspectives, they share the characteristic of aiming to create information about wind energy costs aimed at policy makers. Considering the possible implications of said policy makers' energy infrastructure decisions, transparency of calculative frames in use becomes of significant importance.

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