Report on **Bachelor / Master Thesis**

Institute of Economic Studies, Faculty of Social Sciences, Charles University

Student:	**Amalie Kasparova**
Advisor:	**Lubos Hanus**
Title of the thesis:	**The Impact of Renewable Electricity on Czech Electricity Balancing Market**

OVERALL ASSESSMENT *(provided in English, Czech, or Slovak):*

Please provide a short summary of the thesis, your assessment of each of the four key categories, and an overall evaluation and suggested questions for the discussion. The minimum length of the report is 300 words.

Short summary This thesis takes a recent article on impact of renewable energy forecast errors on electricity imbalance volumes published in Energy Policy (Goodarzi et al. (2019)) and applies it on Czech data with some noticeable extensions (and with not considering prices part of the Goodarzi article). This is similar to the way Sirin and Yilmaz (2021) did a similar thing for Turkey in their Energy Policy article. (I am writing this report in a locality without internet access, so I am not able to look at both Goodarzi et al. (2019) and Sirin and Yilmaz (2021) and I am not able to see if Sirin and Yilmaz are using Goodarzi approach).

Contribution The author presents original ideas on the topic demonstrating critical thinking and ability to draw conclusions based on the knowledge of relevant theory and empirics. There is a distinct value added of the thesis. The thesis covers an interesting topic, with just a little coverage internationally and so far no academic coverage on Czech data (what about some attention being paid to this topic on the profesional level of Czech institution responsible for this issue, or being impacted by this issue?) While the author is using Goodarzi et al. (2019) approach with some extensions, especially using ARFIMA-GARCH for investigation of impact of renewables forecast errors on volatility of dependent variable (and limitation only to non-price part of source Goodarzi et al. (2019) article), the issue is how much the resuls on Czech data make sence. There are some problems with significance and signs of some explanatory variables as well as problems with some missing variables (mainly Czech wind, which is solved in a relatively satisfactory manner by the author). As long as these unintuitive results of Czech (and German) data are taken care of, this will be a very good replication (application) on Goodarzi et al. (2019) on an interesting, so far not investigated market of Czech Republic. So I think that this thesis has a potential of being transformed into a good journal article on the level of Energy Policy.

Methods The tools used are relevant to the research question being investigated, and adequate to the author's level of studies. The thesis topic is comprehensively analyzed. The author uses a number of different techniques, all of them nicely connected into one research topic. The level of explanation of particular techniques or tests is fully fine for IES diploma thesis, however for a future journal article, some texbook style lengthy discussion of standard tests should be substantially reduced. Some institutional discussion of European energy market issues was not directly related to electricity balancing topic, so it should be reduced in order to keep the thesis clearly focused on the central topic of electricity balancing in the era of intermitent renewables.

Literature The thesis demonstrates author's full understanding and command of recent literature. The author quotes relevant literature in a proper way.The paper is properly documenting the major relevant papers (Goodarzi et al. (2019), Sirin and Yilmaz (2021). In the literature review the autor also mentions several other papers dealing with balancing energy markets. The paper properly uses a lot of references to the papers relevant to econometric techniques, energy pricing and volatility and the institutional situation on energy markets, especially with respect to balancing. I hope that the student properly uses Latex and Bibtex, so there should not be any missing or redundant references. The use

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of Bibtex and other tools for automatization of referencing process does not mean that the autor can leave everything to the computer code – in this case student committed a usual mistake of not taking care of capitalization. Jabref does not take care of putting {} around the capital letter to keep them capital, so the list of references if full of gb, czech,r, etc.
I never wrote a paper with Prsa (it was Prusa).
Look at reference Gross, … - it has several clear mistakes there.
It is not enough to write Greene, W. (2002): „Econometric analysis“ – this is not a full citation.
So I am taking 1 point off for not taking care of capitalization, 0.5 point off for typos like Prsa and 0.5 point off for incomplete citations like Greene (2002).

Manuscript form The thesis is well structured. The student uses appropriate language and style, including academic format for graphs and tables. The text effectively refers to graphs and tables and disposes with a complete bibliography. I think this is a well written paper, with a very good structure. I noticed a few typos or grammatical/stylistic deficiencies (much lower than in average IES thesis), but given that I already took half a point off for misspelling the name of my co-author and other minor deficiencies in the Literature section, I am fine with giving full points for Manuscript form here.

Overall evaluation and suggested questions for the discussion during the defense

I think this is a good IES thesis, both the advisor and the student did a good job. I am also glad to hear that Matej Kourilek was involved since both Kourilek brothers are excellent IES graduates and energy economics experts. I am a little sorry that despite the reminders from Tomas Havranek Amalie Kasparova did not realize that GEMCLIME project contributed to her excellent thesis, not only through general support for energy economics research at IES, but also through long term crutial involvement of her advisor in the GEMCLIME project. GEMCLIME (and ECOCEP and GEOCEP) would never bring so many benefits to IES without Lubos Hanus.
In the similar way as Sirin and Yilmaz (2021), who probably applied Goodarzi et al. (2019) on Turkish data, made it into Energy Policy, I believe that this thesis can be developed into a publishable article. With Energy Policy being a natural first choice in the submission tree for that article.

How does the balancing work (in Czech Republic)? Is it a continuous process or a discrete one? I.e. is balancing done continuously or say only at each full hour (in the case of Czech Republic and each 15 minutes in Germany)? It looks like that electricity system has to balances all the time, not just each 60 minutes – I guess there is some (maybe considerable) interval during which insufficient supply simply means that frequency (or some other technological) characteristics adjust (maybe automatically), so I guess there is some flexibility?

I did not really understand what exactly is the issue with end-use level (non metered generation) mentioned on page 47? Is it really the case that these energy producing units are not registered in any way (meaning that they principally cannot be taken into consideration when modelling electricity balances because nobody know anything about them)? Or is it just that they cannot be exactly quickly measured in real time because they do not provide any electricity into a system? Or are there some different important considerations, issues? It looks to me that as long as all or majority of roof-top solar instalations are of this nature, this may be an interesting research issue (and practical issue as well).

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Are the imbalances driven mainly by production forecast errors (mainly with intermitteble sources, as analysed in this thesis) or by errors in forecasting the consumption? I think this is an important consideration, related to the underlying models and the regression equations used for estimating and testing that model.

Did you discuss your thesis with somebody working on Czech electricity market balancing on a professional level?

I am not sure how much seriously we (and more importantly the referees and editor in journals where a paper based on this thesis should be submitted) should take Czech wind forecast errors (I think German ones are O.K.) since they are created somehow artifically (but they are econometrically performing better than some German ones)? See also all the problems with insignificance or unintuitive (or rather nonsensical) effects of German wind on Czech electricity system balances.

On page 23 the author talks about eliminating extremes. Is it reasonable for a research dealing with system balances (where the extremes are key issue) to use the approach described on page 23? Especially given that quantile regression and LAD estimator take care of extremes (well, Roger Koenker came with quantile regression as a part of his robust statistics research, as I was reminded may time in the past by our resident robust statistician prof. Visek, who explained me that the core of robust statistic is in influential observations (influential observation does not have to be extreme one, but it is very related to extremes)). Also all 3 references used on p. 23 as justification for adjusting extremes are not electricity system balancing papers, but they are electricity prices papers (i.e. for electricity prices the extremes are important, but not as crutial and defining as for balancing).

The thesis does not use any prices or any economic variables, it uses only physical variables – electricity in MW (I hope that student took care of understanding the difference between MWh a MW and that she is using correct units). So my two questions related to this are: 1. What do you think about possible extension of electricity balancing research with respect to prices and costs (you have some references to UK situation, where it look like that the regulators take economics more seriously than in other countries) and economics more generally (providing proper price incentives and analysing the pricing and costs)?
2. How are all the references to electricity pricing literature relevant to this particular thesis? Are they really needed – well, I understand that some of them are relevant either with respect to econometric technique or with respect to understanding the institutions and electricity balancing market, but I guess, some of them are not really essential for this technically (quantities) oriented thesis.

The major conclusion of the paper - that it is more difficult to deal with insufficent production than with overproduction - is very intuitive one. Do you actually know how is system balancer dealing with overproduction? Is it done just by switching off some coal-burning generators or is electricity storage in the form of pumped hydro also used in this balancing process?

In my view, the thesis fulfills the requirements for a master‘s thesis at IES, Faculty of Social Sciences, Charles University, I recommend it for the defense and suggest a grade A.
The results of the Urkund analysis do not indicate significant text similarity with other available sources.

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SUMMARY OF POINTS AWARDED *(for details, see below):*

CATEGORY		**POINTS**
Contribution	*(max. 30 points)*	25
Methods	*(max. 30 points)*	29
Literature	*(max. 20 points)*	18
Manuscript Form	*(max. 20 points)*	20
TOTAL POINTS	*(max. 100 points)*	**92**
GRADE	**(A – B – C – D – E – F)**	**A**

NAME OF THE REFEREE: Karel Janda

DATE OF EVALUATION: May 17, 2021

Digitally signed (May 17, 2021):
*Karel Janda*_____
Referee Signature

EXPLANATION OF CATEGORIES AND SCALE:

CONTRIBUTION: *The author presents original ideas on the topic demonstrating critical thinking and ability to draw conclusions based on the knowledge of relevant theory and empirics. There is a distinct value added of the thesis.*

METHODS: *The tools used are relevant to the research question being investigated, and adequate to the author's level of studies. The thesis topic is comprehensively analyzed.*

LITERATURE REVIEW: *The thesis demonstrates author's full understanding and command of recent literature. The author quotes relevant literature in a proper way.*

MANUSCRIPT FORM: *The thesis is well structured. The student uses appropriate language and style, including academic format for graphs and tables. The text effectively refers to graphs and tables and disposes with a complete bibliography.*

Overall grading:

TOTAL	**GRADE**
91 – 100	**A**
81 - 90	**B**
71 - 80	**C**
61 – 70	**D**
51 – 60	**E**
0 – 50	**F**