INTERNATIONAL ENERGY MARKETS –
EMPIRICAL INVESTIGATIONS“

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Angestrebter akademischer Grad
Doctor of Philosophy (PhD)

Wien, im September 2010
Abstract

This dissertation titled “International Energy Markets – Empirical Investigations” covers three peer-reviewed publications in international journals (plus additionally three conference proceedings / presentations and one book chapter) which are guided by the common frame of energy markets and empirical methods. The individual papers can be related to the top-three energy policy objectives of the European Union.

The first paper deals with the impacts of daily green electricity production forecasting and 7-day-trading on the Austrian electricity market. The applied methods include an empirical survey, a natural experiment evaluation and an econometric analysis. This paper connects to the European Union’s goal of fighting against global warming and fostering green electricity production.

The second paper investigates the energy supply security of the European Union in the wake of Russian dominance of the gas supplies of the European Union. The demand for the Nabucco Gas Pipeline project is surveyed and the favorability of the Nabucco Gas Pipeline project versus other pipeline projects is evaluated. An empirical survey is carried out and econometric analysis is applied. This paper follows the European Union’s search for energy supply security and diversification of imported energy sources.

The third paper analyses the optimal auction design for gas pipeline transportation capacity. A combination of three research methods is applied: mathematical formulation, experimental testing, and empirical auction surveying. This paper – building on the enormous attention that auction theory has attracted in recent years leading to the award of Nobel Prices in Economics – accompanies the European Union’s search for competitive energy markets and market mechanisms.

In addition, for the further dissemination of knowledge, these papers were also presented at international research conferences. An extra book chapter contribution (see Annex) further demonstrates the author’s research ambitions.
Acknowledgments

Doing a PhD and writing a dissertation means in many instances to shine your own light, to follow your own path, and not to get off track during the tough times, for that is when in order to succeed you have to shine brightest and work hardest.

At the same time it is the undeniable truth that any dissertation would probably not be successful without the support by many contributors over the course of the dissertation project. Having said this I hope to manage to give credit to all people that have directly or indirectly contributed to this work over the course of the last years.

First and foremost I want to thank Univ.-Prof.Dr. Franz Wirl for supervising this dissertation. Professor Wirl mentored me throughout my research work and managed well the difficult trade-off between providing thought-provoking guidance and giving me the freedom to work on the things that interested me most.

Next, I want to thank Univ.-Prof.Dr. Markus Haider for volunteering as my second PhD-reviewer. Professor Haider is a role model for combining the realms of energy research and energy management practice.

I want to express my deepest gratefulness to Dr. Erich Wagner from Energieallianz Austria for being a partner in the first publication project. His time and effort to make this publication happen and the boost that this first publication gave to my work were outstanding. My wholehearted thankfulness goes to Mr. Gabor Diossy from Nabucco Gas Pipeline International. Further to serving as a sounding board of my work, he has granted me precious time to develop and carry out my research and this made the final two publications possible.

I feel truly indebted to my girlfriend Carmen for everything! Without her the completion of this dissertation would not have been broad to a successful end. During the time of this research work she has encouraged me when badly needed, given me countless hours of discussion and inputs to all the major road blocks encountered during this work. In earlier times a PhD was implicitly also awarded to a life partner. Here it would be justified!

Finally, I want to thank my friend Ron S. Faibish, PhD for making me yearn for a PhD! More than special thanks go to my brother Roman Pickl for having read and providing inputs to all of my papers. He has been instrumental in discussing and de-
I want to devote this dissertation to my mother, who surely would be very proud of me now, to my father Harald and to Silvia and my family: I owe everything I am to them!
“Aim for the Impossible, to Reach the Possible”
Hermann Hesse
# Table of contents

1. **Introduction** ................................................................................................................................. 1
   1.1. Common Frame ............................................................................................................................ 2
   1.2. Objective – Three Publications .................................................................................................... 3
   1.3. Paper 1 Summary ....................................................................................................................... 4
   1.4. Paper 2 Summary ....................................................................................................................... 5
   1.5. Paper 3 Summary ....................................................................................................................... 6
   1.6. Structure .................................................................................................................................. 7

2. **Paper 1 – The Impact of Introduction Seven-Day-Trading on the Austrian Electricity Market** ................................................................................................................. 8
   Abstract ............................................................................................................................................. 9
   2.1. Introduction and Motivation ...................................................................................................... 9
   2.2. Hypotheses .............................................................................................................................. 11
   2.3. Method ..................................................................................................................................... 14
   2.4. Results ..................................................................................................................................... 14
   2.5. Conclusion ............................................................................................................................... 20
   References ....................................................................................................................................... 21

   Abstract ........................................................................................................................................... 26
   3.1. Introduction and Motivation ..................................................................................................... 26
   3.2. Hypotheses .............................................................................................................................. 29
   3.3. Method ..................................................................................................................................... 31
   3.4. The Nabucco Open Season Capacity Allocation Process ...................................................... 32
   3.5. Results ..................................................................................................................................... 33
   3.6. Conclusion ............................................................................................................................... 38
   References ....................................................................................................................................... 39

4. **Paper 3 – Auction Design for Gas Pipeline Transportation Capacity – The Case of Nabucco** ........................................................................................................................................... 43
   Abstract ........................................................................................................................................... 43
   4.1. Introduction and Motivation ..................................................................................................... 44
   4.2. Background .............................................................................................................................. 45
   4.3. Method ..................................................................................................................................... 47
   4.4. Designing the Nabucco Auction .............................................................................................. 48
      4.4.1. Strategic Objectives and Performance Measures ................................................................. 48
      4.4.2. A Process Description of the Nabucco Auction ................................................................. 51
      4.4.3. Mathematical Formulation of Bidders Optimal Bidding Strategy ..................................... 54
      4.4.4. Empirical Market Survey – Received Bids ......................................................................... 55
      4.4.5. Capacity Allocation – Experimental Design Overview ..................................................... 56
   4.5. Results ..................................................................................................................................... 59
   4.6. Conclusion ............................................................................................................................... 62
   References ....................................................................................................................................... 64
6. Annexes.........................................................................................................................81
  6.1. Dissertation Summary in German Language .......................................................... 81
  6.2. Expose – Registration of PhD Topic ................................................................. 83
  6.3. PhD Grades........................................................................................................ 85
  6.5. Additional Book Chapter............................................................................... 100
  6.6. Curriculum Vitae.............................................................................................. 124
1. Introduction

This introductory chapter is to provide the reader with a short overview of this dissertation titled “International Energy Markets – Empirical Investigations” and to put its three parts in context to each other.

This dissertation is concerned with the analysis of natural happenings on international energy markets (i.e. 7-day-trading on electricity exchanges; security of supply concerns and evaluation on a European Union level; auctioning of gas transportation capacities) and the application of empirical methods (i.e. surveying; experimentation; econometric analysis) to investigate these natural happenings. Written in a cumulative approach, it covers three peer-reviewed publications in international journals that are guided by the common frame of energy markets and empirical methods. As such it is divided into three parts; each forms a separate paper. The papers can be related to the top-three energy policy objectives of the European Union (Percebois, 2008).

The first paper deals with the impacts of daily green electricity production forecasting and 7-day-trading on the Austrian electricity market. The applied methods include an empirical survey, a natural experiment evaluation and an econometric analysis. This paper connects to the European Union’s goal of fighting against global warming and fostering green electricity production.

The second paper investigates the energy supply security of the European Union in the wake of Russian dominance of the gas supplies of the European Union. The demand for the Nabucco Gas Pipeline project is surveyed and the favorability of the Nabucco Gas Pipeline project versus other pipeline projects is evaluated. An empirical survey is carried out and econometric analysis is applied. This paper follows the European Union’s search for energy supply security and diversification of imported energy sources.

The third paper analyses the optimal auction design for gas pipeline transportation capacity. A combination of three research methods is applied: mathematical formulation, experimental testing, and empirical auction surveying. This paper – building on the enormous attention that auction theory has attracted in recent years leading to the award of Nobel Prices in Economics – accompanies the European Union’s search for competitive energy markets and market mechanisms.
In addition, for the further dissemination of knowledge, these papers were also presented at international research conferences. An extra book chapter contribution (see Annex) further demonstrates the author’s research ambitions.

These publications are governed by a common frame as further depicted in the next Section.

1.1. Common Frame

This dissertation covers three peer-reviewed publications in international journals (plus additionally three conference proceedings / presentations and one book chapter) that are guided by the common frame of i) energy markets and ii) empirical methods. Moreover as a third cornerstone this work focuses on iii) energy exchanges, auctions and trading.

Figure 1 below depicts this "Three Publications under One Common Frame"-Approach graphically.

Figure 1: Introducing this Dissertation – Three Publications under One Common Frame
1.2. Objective – Three Publications

The objective of this dissertation was to produce three publishable papers and thus to contribute to empirical knowledgebase and theory in the area of energy management.

Figure 2 gives an overview of the three publications and their values according to the PhD-guidelines for cumulative dissertations (PhD-Guidelines, 2008). The ranking marked with * corresponds to the applicable VHB Jourqual 1 ranking (VHB Jourqual 1 Ranking, 2010). The weighted points marked with ** represent the factor-weighted points when considering contributions of co-authors according to the PhD-guidelines for cumulative dissertations (PhD-Guidelines, 2008). It shall be noted that the third paper is at the date of submission of this dissertation under second stage review by an International Journal. According to the PhD-guidelines for cumulative dissertations (PhD-Guidelines, 2008) the PhD-reviewers can especially evaluate the value of papers that have not yet been published. This third paper has furthermore been presented at a peer-reviewed conference and was also presented and graded positively in the course of the PhD Forschungsseminar (see PhD Grades in the Annex).

The sum of all weighted points of 3.75 marked with *** highlights that the requirements for a PhD dissertation – 3.00 points according to the PhD-guidelines for cumulative dissertations (PhD-Guidelines, 2008) – are more than fulfilled. Even more so since according to the Habilitation-guidelines of the University of Vienna (Habilitation-Guidelines, 2010) conference proceedings – for the further dissemination of knowledge papers were also presented at international research conferences – would deserve additional points. Similarly, and again referring to the Habilitation-guidelines of the University of Vienna (Habilitation-Guidelines, 2010) that mentions monographs, the extra book chapter contribution (see Annex) could provide further points.
In the following subsections a brief overview of the three main Chapters of this dissertation will be given.

### 1.3. Paper 1 Summary


This paper analyses the impacts of the new daily green electricity production forecasting policy by the Austrian Green Electricity Settlement Agency (OEMAG) and the newly introduced seven-day electricity trading mechanism by the European Energy Exchange (EEX) on the Austrian electricity market.

By treating these two market policy alterations as natural experiments and applying statistical and econometric methods to a unique data set, it is investigated whether thereby (i) a reduction of the green electricity production forecasting uncertainties and (ii) a generally more efficient electricity market with accompanying lower net costs is attained. Furthermore, we analyse whether (iii) seven-day-trading helps to
mitigate the Friday-Monday effect that is often observed on stock and other exchanges markets. Finally, we investigate whether or not (iv) the underlying market design might tempt OEMAG to systematically overstate its forecasts on green power generation.

Results show that this new market design reduces forecasting uncertainties and also lowers costs of electricity balancing, at least when not taking into account additional costs (e.g. personnel) to administer the trading on the incremental days. Friday-Monday effects are somewhat mitigated, thus decreasing volatility on power exchanges. The Austrian Green Electricity Settlement Agency systematically understate its forecasts on green power generation versus actual green power production.

1.4. Paper 2 Summary


The Russian dominance of the European Union (EU)’s natural gas supplies has put the independence of the EU at risk. This paper presents an evaluation of the Nabucco gas pipeline project – considered by some to be the most economical link to new natural gas sources – to determine whether it would help the EU to diversify its gas supplies in a cost-effective way, thus improving its energy supply security in future years. Furthermore, an introduction to the Nabucco Open Season Capacity Allocation Process is given.

Applying empirical methods and competitive pipeline benchmarking analysis, three hypotheses related to the Nabucco natural experiment are evaluated: while hypothesis (1) focuses on the strength of demand for the Nabucco pipeline transportation capacities, hypotheses (2) and (3) examine fair usage rights and overall cost effectiveness of this project. Empirical results show that, due to the EU’s increasing long-term gas demand and decreasing indigenous production, there is a strong demand for the Nabucco gas pipeline by gas shippers. Furthermore, the empirical survey reveals that Nabucco provides a fair capacity allocation of fifty percent to third party
shippers. Finally, competitive benchmarking shows Nabucco is indeed a cost-effective new pipeline and a link to fresh natural gas sources for Europe.

Based on these results, it is anticipated that “Nabucco” will not only remain the name of a famous opera, but will also become the term associated with one of the most successful energy projects in Europe.

### 1.5. Paper 3 Summary

The third paper “Auction Design for Gas Pipeline Transportation Capacity – The Case of Nabucco” is at the time of submission of this dissertation under second stage review by an International Journal and was presented at the 11th IAEE European Energy Conference in Vilnius / Lithuania in August 2010.

As a response to the Russian dominance of the European Union’s (EU’s) natural gas supplies and the combination of the EU’s increasing gas demands and decreasing indigenous gas production, major gas pipeline projects are currently under way in order to enhance the security of the EU’s energy supply. Oftentimes to raise financing and to allocate gas transportation capacities special forms of auctions are carried out to allow gas shippers to make firm bookings.

In recent years, auctions have emerged as one of the most successful allocation mechanisms in microeconomic theory. However, different auction design allocation mechanisms can lead to different outcomes making the choice of auction design a decisive one, especially for divisible-good auctions. This paper seeks to give a formulation of an optimal auction design for gas pipeline transportation capacity. Specifically three different allocation mechanism designs are tested: (i) Biggest Net Present Value Contract Allocation; (ii) Pro Rata Allocation; and (iii) Allocation per Optimization. In addition, the Nabucco Gas Pipeline Project is taken as a case study to experimentally and empirically show the results of such auction designs.

Results show that a trade-off between revenue optimization and fair and transparent allocation can be observed: Allocation per Optimization is the favourable auction design when revenue maximization is more important than fair and transparent allocation. On the other hand, Pro Rata Allocation is the auction design to be chosen when fairness and transparency of allocation are considered most central.
1.6. Structure

The remainder of this paper is structured as follows: Section 2 presents the full paper titled “The Impact of Introduction Seven-Day-Trading on the Austrian Electricity Market”. Next, Section 3 covers the paper “Enhancing the EU’s Energy Supply Security: An Evaluation of the Nabucco Project”. Finally, Section 4 features the paper “Auction Design for Gas Pipeline Transportation Capacity – The Case of Nabucco”. Implications for theory and practice are highlighted in the specific paper Sections 2, 3 and 4. Equally limitations and directions for future research are highlighted in these specific paper sections. Section 5 provides literature references. In Section 6 Annexes are included to provide for a summary of this dissertation in German language and to present a brief curriculum vitae of the author. Furthermore this Section 6 includes the author’s additional book chapter contribution, research conference proceedings / certificates and organizational items like the PhD Expose and PhD Grades.
2. Paper 1 – The Impact of Introduction Seven-Day-Trading on the Austrian Electricity Market

This Paper has been published in the “Zeitschrift für Energiewirtschaft” (Wiesbaden / Germany) in Quarter 4 / 2009 and presented at the 10th IAEE European Energy Conference (International Association of Energy Economics, Policies and Technologies for Sustainable Economics) in Vienna / Austria in September 2009.
Abstract

This paper analyses the impacts of the new daily green electricity production forecasting policy by the Austrian Green Electricity Settlement Agency (OEMAG) and the newly introduced seven-day electricity trading mechanism by the European Energy Exchange (EEX) on the Austrian electricity market.

By treating these two market policy alterations as natural experiments and applying statistical and econometric methods to a unique data set, it is investigated whether thereby (i) a reduction of the green electricity production forecasting uncertainties and (ii) a generally more efficient electricity market with accompanying lower net costs is attained. Furthermore, we analyse whether (iii) seven-day-trading helps to mitigate the Friday-Monday effect that is often observed on stock and other exchanges markets. Finally, we investigate whether or not (iv) the underlying market design might tempt OEMAG to systematically overstate its forecasts on green power generation.

Results show that this new market design reduces forecasting uncertainties and also lowers costs of electricity balancing, at least when not taking into account additional costs (e.g. personnel) to administer the trading on the incremental days. Friday-Monday effects are somewhat mitigated, thus decreasing volatility on power exchanges. The Austrian Green Electricity Settlement Agency systematically understate its forecasts on green power generation versus actual green power production.

2.1. Introduction and Motivation

The Friday-Monday effect in stock exchange markets is a well documented phenomenon linked to the interruption of the usual flow of information during weekends (Fama, 1965 & 1970; French, 1980; Gibbons & Hess, 1981; Keim & Stambaugh, 1984; Linn & Lockwood, 1988; Lakonishok & Smidt, 1988; Bessembinder and Hertzel, 1993; Jaffe & Westerfield, 1985; Chang & Pinegar & Ravichandran, 1993; Tong, 2000; Pettengill, 2003; Hirshleifer, 2001; Shiller, 2003) and has been further empirically shown for other asset classes (Gibbons & Hess, 1981; Flannery & Protopapadakis, 1988; Griffith & Winters, 1995) as well as for commodity (Ball & Torous & Tschögl, 1982; Ma, 1986) and electricity markets (Higgs & Worthington, 2005). In the
case of electricity markets this information break is of particular concern for day ahead trading auctions. The reasons are that weather forecasts become increasingly unreliable with the forecast horizon (three days on any Friday in a five-days trading regime) but are crucial to predict demand and even more crucial to forecast renewable productions like wind energy (Sinden, 2007).

In the beginning of October 2008 the seven-day electricity trading mechanism was introduced on the European Energy Exchange (EEX Announcement, 2008) to create a more efficient continuous market that offers trading participants the possibility of improving portfolio optimization. Previously power trading on the EEX’s spot market took place from Monday to Friday only and on Friday trading was carried out for the delivery days Saturday, Sunday and Monday (EEX Customer Information, 2007). While the much smaller Austrian Power Exchange EXAA still holds on to the Monday to Friday trading mechanism (Austrian Power Exchange, 2009), the decision of the German EEX - on which de facto all Austrian electricity trading companies are active1 - in favour of a seven day auction for spot market electricity for the first time creates a sufficiently liquid trading platform also for weekends. Thus an important pre-condition for any electricity market to function effectively by establishing a continuous spot market as well as a market for future delivery periods has been fulfilled (McDermott & Peterson, 2002).

Simultaneously in October 2008 the Austrian Green Electricity Settlement Agency (OEMAG, 2009) decided to allocate green electricity production forecasts on a daily basis. This step was taken to reduce prediction uncertainties and in response to the growing wind power share, that especially with increasing lead times – e.g. forecasting Sunday’s wind on Friday rather than on the same day – is difficult to predict owing to its natural intermittency and limited predictability (Vandezande et al., 2009). Furthermore, this should lead to a more efficient electricity market with lower costs, in particular for balancing energy.

OEMAG allocates two types of renewable power produced i) in small hydro power plants and from ii) other renewable resources to all Austrian electricity suppliers. The amount allocated to each supplier corresponds to the suppliers’ share in total consumption three months ago. OEMAG assigns green power at different allocation tar-

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1 EEX trades in APG grid possible, and, there are no capacity restrictions between Germany and Austria
iffs for small hydro and other renewables. These tariffs are annually adjusted by the Austrian regulatory commission E-Control (E-Control, 2009).

This institutional change provides a unique real world experiment how continuous trading enhances the efficiency of markets, specifically of electricity markets. Natural experiments (Meyer, 1995; Wu & Lampietti & Meyer, 2004; Asche & Osmundsen & Sandsmark, 2006; Douglas, 2006; Florio, 2007; Bellas & Lange, 2008) are a widespread research method where artificial laboratory controlled experimentation is difficult to be carried out. Of course these efficiency gains must be weighed against the costs of setting up and running trading all seven days. More precisely, this paper analyses the impacts of the new daily green electricity production forecasting policy by the Austrian Green Electricity Settlement Agency (OEMAG) and the newly introduced seven-day electricity trading mechanism by the European Energy Exchange (EEX) on the Austrian electricity market. Specifically, it is investigated whether thereby (i) a reduction of the green electricity production forecasting uncertainties and (ii) a generally more efficient electricity market with accompanying lower costs can be attained. It is determined whether the newly introduced seven-day electricity trading mechanism is aiding in making electricity on the whole more affordable. In addition, we analyse whether (iii) seven-day-trading helps to mitigate the often observed Monday effects on exchanges. Finally, we investigate whether or not (iv) the underlying market design might tempt OEMAG to systematically overstate its forecasts on green power generation, because its remuneration exceeds the costs of buying any shortfall in the market.

This paper is structured as follows: Section 2 gives an overview and reasoning of the hypotheses that we wish to examine. Next, section 3 describes the applied research methodology. In section 4 results are presented and discussed. A conclusion is provided in Section 5.

2.2. Hypotheses

This paper seeks to investigate four major hypotheses about the impact of the newly introduced seven-day electricity trading mechanism and daily green electricity production forecasting policy on the Austrian electricity market.
This paper examines whether the “seven-day per week” green electricity allocation by the Austrian Green Electricity Settlement Agency (OEMAG) indeed results in a reduction of the renewable production forecasting uncertainties. Figure 1 below shows the quarter-hourly renewable power production (small hydro power and other renewables, including wind) in the control area Austrian Power Grid (APG) from October 2008 to March 2009 in megawatt hours. As can be seen this renewable power production exhibits strong volatility (mean: 582 MW; standard deviation: 244 MW; minimum: 263 MW; maximum 1,190 MW that was recently rising due to the growing wind power generation share (Jacob, 2008; Ladenburg, 2008; Bolinger & Wiser, 2009).

Since forecasting should get easier with shorter lead times (Roulston et al., 2003) – e.g. forecasting Monday’s wind energy on the previous day rather than beforehand on Friday – a reduction of the renewable production forecasting uncertainties can be expected from this change in market settings from a logical point of view. Hence, the first hypothesis claims this formally:

**Hypothesis 1**: The “seven-day per week” green electricity allocation reduces forecasting uncertainties versus the “five-day per week” green electricity allocation.

Second, we investigate whether the seven-day electricity trading mechanism brings about a generally more efficient electricity market with accompanying lower costs. In
principle, improved forecast accuracy should reduce the variance of uncovered market positions. Up to now the liberalization of the electricity sector in Europe has often been accused to be responsible for a trend, which materialized in the opposite way of what was expected and hoped for by policy makers and consumers: increasing electricity prices (Percebois, 2008). The main interest of market participants in a liberalized electricity market is, however, to minimize balancing electricity and the costs associated with it. And this is exactly the aim of the seven-day electricity trading mechanism: to lower the costs of balancing electricity. Whether this is actually the case remains to be proven. Therefore, the following second hypothesis can be formulated:

**Hypothesis 2**: The “seven-day per week” trading mechanism lowers balancing costs.

Third, this paper analyses whether the closed-market, weekend or Monday effect as observed and well-documented on various types of exchange markets (for references see section 1), can be reduced by the introduction of the seven-day-trading mechanism. Following the calendar time hypothesis (Fama, 1965; French, 1980) the exchange process operates continuously and the expected return for Mondays or other days following holidays should therefore be different from the distribution of returns for other normal days of the week. In the case of electricity exchanges the impossibility to store energy means that it has to be generated and consumed in real time (Glachant & Saguan, 2007) with imbalances leading to higher price volatility. By analysing the volume of balancing energy on Mondays in a seven-day-trading mechanism versus a five-day-trading setting, it shall be investigated whether a reduction in the Monday effect can be determined. In positive expectations the third hypothesis claims:

**Hypothesis 3**: Seven-day-trading helps to mitigate the Friday-Monday effect on energy exchanges.

Finally, we investigate whether or not the new underlying market design might tempt the Austrian Green Electricity Settlement Agency (OEMAG) to systematically exaggerate its forecasts on green power generation, because its remuneration might exceed the costs payable for any shortfall in balancing energy.

More principally all available announced green power will be used and refunded at the fixed feed in tariff. Any shortfall must be bought on the balancing market. Since
the feed in tariff is much higher than the cost for balancing energy, firms have an incentive to provide systematically too optimistic projections on the availability of green electricity. Thus it is analysed whether the new seven-day-trading market design creates an incentive problem. The forth hypothesis states that this is the case.

Hypothesis 4: The underlying market design tempts OEMAG to overestimate its forecasts on green power generation.

2.3. Method

The decisions to trade electricity and allocate green electricity production daily from Monday to Sunday, rather than only from Monday to Friday serve as an excellent natural experiment (Meyer, 1995) that allows us to analyse the impacts of an exogenous variation in market settings on the Austrian renewable electricity market. That is, as has become popular in energy research (Wu & Lampietti & Meyer, 2004; Asche & Osmundsen & Sandsmark, 2006; Douglas, 2006; Florio, 2007; Bellas & Lange, 2008), some kind of event study is applied.

The analysis is performed by applying statistical and econometric methods in SPSS (2005) to a unique data set containing time series of green power allocation from “other renewables” (not “small hydro”) balancing deviation and balancing prices in the APG control area of eastern Austria (data used with permission). Additionally, we use data from the European Energy Exchange (2008) to analyse electricity prices (data used with permission). The period analysed comprises the six months from October 2008 to March 2009.

2.4. Results

Results concerning the first hypothesis confirm the expected outcomes: The “seven-day per week” green electricity allocation tends to reduce forecasting uncertainties versus the “five-day per week” green electricity allocation since lead times are shortened. Figure 2 and Table 1 below illustrate that in all six months analysed the “seven-day per week” forecast (i.e. V2) fares better than the “five-day per week” forecast (i.e. V1) both when counting occurrences and comparing means of absolute deviations. Overall, in 68% of all quarter-hourly forecasts the “seven-day per week”
forecast (V2) comes closer to the actual total renewable energy production than V1. Also, in all months the means of absolute differences are lower for the “seven-day per week” forecast (V2). Table 1, comparing the mean deviations shows that, on average, the V2 Forecast (Sunday to Monday) is 26.27% better.

Figure 2: Descriptive Comparison: Percentage of Quarter-Hourly-Forecasts when “seven-day per week” forecasts (V2) are better than “five-day per week” forecasts (V1)

<table>
<thead>
<tr>
<th>Month</th>
<th>V1 Mean Absolute Difference (MW)</th>
<th>V2 Mean Absolute Difference (MW)</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 08</td>
<td>51.65</td>
<td>32.88</td>
<td>Average V2 Monthly Forecast Better</td>
</tr>
<tr>
<td>Nov 08</td>
<td>161.10</td>
<td>115.20</td>
<td>Average V2 Monthly Forecast Better</td>
</tr>
<tr>
<td>Dec 08</td>
<td>105.74</td>
<td>70.30</td>
<td>Average V2 Monthly Forecast Better</td>
</tr>
<tr>
<td>Jan 09</td>
<td>105.08</td>
<td>59.96</td>
<td>Average V2 Monthly Forecast Better</td>
</tr>
<tr>
<td>Feb 08</td>
<td>93.28</td>
<td>83.19</td>
<td>Average V2 Monthly Forecast Better</td>
</tr>
<tr>
<td>Mar 09</td>
<td>162.32</td>
<td>131.75</td>
<td>Average V2 Monthly Forecast Better</td>
</tr>
<tr>
<td>Average</td>
<td>111.66</td>
<td>82.31</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Descriptive Comparison of Mean Absolute Differences between “five-day per week” forecasts (V1) and Actual vs. “seven-day per week” forecasts (V2) and Actual

Finally, as forecasting differences / errors are broadly normally distributed, a paired two sample t-test shall evaluate whether the null hypothesis of equal mean differences between “five-day per week” forecasts (V1) and “seven-day per week” forecasts (V2) can be rejected. A paired test is chosen as the forecasts are not independent from each other. The resulting p-value in Table 2 below point out that there is a statistically significant difference between the absolute mean differences of the “five-day per week” forecasts (V1) and the “seven-day per week” forecasts (V2) at the 0.01 level. Thus, we can conclude that “seven-day per week” green electricity allocation indeed reduces forecasting uncertainties. These results replicate previous findings of Roulston et al. (2003).
Table 2: Results of a Paired Two Sample t-Test for equal means (with SPSS (2005))

The second hypothesis deals with the question of whether “seven-day per week” green electricity allocation lower balancing electricity costs. To evaluate this question the following cost function is applied:

\[ \text{Cost} (V(i)) = \sum (E_{\text{bal}}(i) \cdot p_{\text{bal}}) - E_{\text{sh}} \cdot p_{\text{sh}} - E_{\text{oth}}(i) \cdot p_{\text{oth}} + \text{Cost}_{\text{fix}} \]  
\[ E_{\text{bal}}(i) - E_{\text{oth}}(i) = \text{const.} \]

\[ \text{i = } 1 \ldots \text{five-day per week; i=2 \ldots seven-day per week} \]

\[ E_{\text{bal}} = \text{balancing energy} \]
\[ p = \text{prices} \]
\[ \text{sh = small hydro} \]
\[ \text{oth = other renewables} \]

Constraint: Balancing prices \( p_{\text{bal}} \) are not influenced by green electricity allocation

The cost function (1) is made up by balancing energy costs (monthly sum of the product of \( \frac{1}{4} \)-hourly balancing power \( E_{\text{bal}} \) and respective balancing energy prices \( p_{\text{bal}} \)) minus earnings from assigned green electricity (small hydro and other renewables, each per volume \( E \) and allocation tariff \( p \)) plus a constant fixed costs term covering all operational costs.

The variable parts are marked in bold letters. To elevate the forecast implies to increase green power allocation \( E_{\text{oth}} \), and, in turn, to increase the amount of balancing energy \( E_{\text{bal}} \). This interrelation is expressed in equation (2).

We then compare the cost of \( V1 \) with \( V2 \) in order to evaluate the impact of the different trading schemes on balancing costs.

Figure 3 underneath demonstrates that in three out of six months the net differential costs of balancing electricity are higher under the old regime of \( V1 \) Forecasts (Friday to Monday) than under \( V2 \) Forecasts (Sunday to Monday). These results are significant at the 0.01 level. The results show a slight tendency towards decreasing costs, especially in March 2009.

Furthermore, the total average monthly net cost of electricity balancing is lower when utilizing a \( V2 \) forecast (Sunday to Monday) mechanism.
Results with reference to the third hypothesis – i.e. seven-day-trading helps to mitigate the Friday-Monday effect - tend to confirm the expected outcome. To come to this result we investigated whether the average volume of balancing energy on Mondays is reduced when seven-day-trading is present compared to one year ago and two years ago when trading was carried out only on a five-days-per-week basis. Figure 4 below illustrates that the volume of balancing energy on Mondays in the seven-day-trading period October 2008 to March 2009 on average amounts to 23.650,88 kWh and is thus indeed lower than the average balancing energy volumes of previous years (October 2006 to March 2007: 24.358,11; October 2007 to March 2008: 24.121,39) when five-day-trading was followed. Table 3 gives more details into the month by month comparisons.

Next, to determine statistical significance of the descriptive results a Wilcoxon signed-rank test is consulted as the population is not normally distributed (Corder & Foreman, 2009). The obtained p-values in Table 4 indicate that, in contrast to the descriptive statistics that show that volumes of balancing energy on Mondays in a seven-day-trading regime are lower than in a five-day trading mechanism, results are not statistically significant at the 0.10 level. While October 2006 to March 2007 versus October 2008 to March 2009 comparison at least comes somewhat close to significance, October 2007 to March 2008 versus October 2008 to March 2009 comparison does not. Consequently, we cannot reject the null hypothesis of equal means of balancing volumes. The descriptive results, on the other hand point at a mitigation of the Monday effect due to seven-day-trading and therefore reduced weekend volatility on power exchanges.

Table 4: Results of a Wilcoxon signed-rank test (with SPSS (2005))
Finally, we turn to the evaluation of hypothesis four that claims that the underlying new market design tempts the Austrian Green Electricity Settlement Agency (ÖE-MAG) to systematically forecast higher generation volumes because its remuneration exceeds the costs payable for any shortfall in terms of balancing energy. Rather than looking at the absolute forecast errors as under the first hypothesis, this is done by analyzing whether individual quarter-hourly negative and positive forecasts cancel each other out over the observation period. If so, than no tendency for too positive or too negative forecasting can be determined. On the other hand, if mean differences of forecasts are significantly different from 0, than a general tendency for too positive (or too negative) forecasting of green power generation volumes is present.

Figure 5 below indicates that in the period October 2008 to March 2009 there was a surprising tendency to underestimate green power generation volumes. While in October 2008 and in January 2009 there was a propensity of slightly exaggerated forecasts, in four out of six months (i.e. November 2008, December 2008, February 2009, and March 2009) the forecasts for green power generation by far underestimated the actual green power occurrences. In total it can be seen that over the observation period a negative bias of 37,51 MW is present for V1 Forecasts (Friday to Monday). This negative bias with 31,69 MW on average is slightly narrowed down for V2 Forecasts (Sunday to Monday).

Figure 5: Descriptive Comparison of Individual Average monthly Forecasting Errors (in MW)

Statistical significance of this overall negative bias is tested with a one sample t-test for means (forecasting differences / errors are broadly normally distributed) to determine whether mean forecasting errors are significantly different from 0. Table 5 and 6
show that both the means V1 Forecasts (Friday to Monday) as well as the V2 Forecasts (Sunday to Monday) are statistically negatively different from 0 mean forecasting errors at the 0.01 level. The result, V2 > V1, supports our hypothesis that OEMAG might increase its forecasts on days affected by "seven-days per week" trading. But, surprisingly and also in contraction to our expectation, it generally underestimates green power generation volumes. Maybe this is an inheritance from the former green certificates mechanism, when OEMAGs predecessor "Ökostrom Bilanzgruppe" was eager to avoid being short in terms of certificates.

Table 5: Results of a One Sample t-Test for equal means, V1 Forecasts (Friday to Monday) vs. 0 mean forecasting errors

```
<table>
<thead>
<tr>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>-37.8810</td>
<td>146.74039</td>
<td>1.94910</td>
</tr>
</tbody>
</table>
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Table 6: Results of a One Sample t-Test for equal means, V2 Forecasts (Sunday to Monday) vs. 0 mean forecasting errors

```
<table>
<thead>
<tr>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>-32.7145</td>
<td>110.16131</td>
<td>1.40324</td>
</tr>
</tbody>
</table>
```

2.5. Conclusion

This paper analysed the impacts of two electricity market policy alterations - the new daily green electricity production forecasting policy by the Austrian Green Electricity Settlement Agency (OEMAG) and the newly introduced seven-day electricity trading mechanism by the European Energy Exchange (EEX) - on the Austrian electricity market. Four main research hypotheses were posed centering around the question of how continuous trading and continuous forecasting enhances the efficiency of electricity markets. In conclusion the new market mechanisms seem to improve availability of renewable electricity (and presumably also demand) which should make the market more efficient. At least three of the four hypothesis results point into that di-
rection. Firstly, results show that the new market design reduces forecasting uncertainties by 26.27% (highly significant) and, secondly, on average also lowers costs of electricity balancing (highly significant). Whether this improved efficiency is covering the incremental costs of seven- instead of five-day trading and whether smaller energy exchanges, like the Austrian EXAA, are likely to make the same move remains to be investigated. Furthermore, seven-day trading seems to have a positive effect (even if not statistically significant) on mitigating the Friday-Monday effects on energy exchanges, thus decreasing price volatility on power exchanges. Lastly, the new market design makes the Austrian Green Electricity Settlement Agency systematically understate its forecasts on green power generation (highly significant) versus actual green power production. However, even here the new market design narrowed downed the negative forecasting tendency when compared to the results of the previous market mechanism.

In further research the arrival of seven-day trading shall be analyses on different power exchanges and the impact thereof on different countries in order to determine whether the results of this paper can be repeated in other markets as well.

References


Enhancing the EU’s Energy Supply Security—An Evaluation of the Nabucco Project and an Introduction to Its Open Season Capacity Allocation Process

Matthias Pickl - Franz Wirl

Abstract The Russian dominance of the European Union (EU)’s natural gas supplies has put the independence of the EU at risk. This paper presents an evaluation of the Nabucco gas pipeline project—considered by some to be the most economical link to new natural gas sources—to determine whether it would help the EU to diversify its gas supplies in a cost-effective way, thus improving its energy supply security in future years. Furthermore, an introduction to the Nabucco Open Season Capacity Allocation Process is given.

Applying empirical methods and competitive pipeline benchmarking analysis, three hypotheses related to the Nabucco natural experiment are evaluated, while hypothesis (1) focuses on the strength of demand for the Nabucco pipeline transportation capacities, hypotheses (2) and (3) examine fair usage rights and overall cost effectiveness of this project. Empirical results show that, due to the EU’s increasing long-term gas demand and decreasing indigenous production, there is a strong demand for the Nabucco gas pipeline by gas shippers. Furthermore, the empirical survey reveals that Nabucco provides a fair capacity allocation of fifty percent to third party shippers. Finally, competitive benchmarking shows Nabucco is indeed a cost-effective new pipeline and a link to fresh natural gas sources for Europe.

Based on these results, it is anticipated that “Nabucco” will not only remain the name of a famous opera, but will also become the term associated with one of the most successful energy projects in Europe.

Die Sicherheit der Energieversorgung in der EU – Eine Bewertung des Nabucco Projekts und Vorstellung dessen Open-Season-Auktionsprozesses


1 Introduction and Motivation

The Russian monopoly dominance of the European Union’s natural gas supplies has put the independence of the EU foreign policy at risk (Schafer 2008). Currently, roughly a third of natural gas used in the European Union comes through Kremlin-controlled east-west pipelines (The Economist 2000) and some sources even surmise that half of all the gas the EU imports comes from Russia (Von Hirschhausen et al. 2005; The Economist 2007). Thus the
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3.1. Introduction and Motivation

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ies several times after disputes with transit countries such as Ukraine. This is quite alarming considering that eighty percent of natural gas travelling from Russia to the EU passes through Ukraine (Freifeld, 2009). The Nabucco project might potentially enhance the EU’s energy supply security, one of the top three priorities within the EU (Percebois, 2008), in future years. This paper gives an introduction to and evaluation of the Nabucco project.

The growth in demand for natural gas in the European Union is expected to continue in the next 25 years (BCG, 2005). As can be seen in Figure 1 (left), European gas consumption will grow – largely due to increased gas-fired power generation (Bothe & Lochner, 2008; Kjärstad & Johnsson, 2007) – from approximately 500 bcm in 2005, valued at about USD 100 billion (Schaffer, 2008), to about 816 bcm in 2030 (OME, 2006) representing an average growth rate of 2% per annum.²

![Figure 1: Left: Forecast of Gas Supply Europe (OME, 2006) Right: Forecast of EU Gas Production Decline (IEA World Energy Outlook, 2008)](image)

As the indigenous gas production of the European Union declines (BCG, 2005), a growing gap between gas production and gas demand – as illustrated by Figure 1 (right) – can be expected in the coming years (IEA World Energy Outlook, 2008). This stems from the fact that, at its present rate of consumption, the EU has only a ten-year supply of natural gas within its own borders, making imports of natural gas a necessity (Schaffer, 2008). Thus, increasing gas demands on the one hand paired with decreasing EU production on the other make a strong case for investing in new pipeline infrastructure (Lise & Hobbs & Oostvoorn, 2008; Finon & Locatelli, 2008; Mavrakis & Thomaidis & Ntroukas, 2006).

² Latest estimates by the International Energy Agency (IEA World Energy Outlook, 2009) partly update these demand estimates due to the general economic downturn to a European Union gas demand of about 619 bcm in 2030. However, the general trend for strong growth in gas demand remains.
Therefore, new infrastructure sources have to be established for the EU gas markets to meet the expected future gas demand. At present, there are three main sources of gas for the European Union – the first is Russia, the second is Norway, and the third is Algeria (see Figure 2). According to forecasts for the future EU gas supply, it can be seen that Russia, Algeria and Norway will not only keep their important supply roles but will even see their volumes nearly double by 2030 (BCG, 2005; Kjärstad & Johnsson, 2007).

The Nabucco project, which takes its name from the Giuseppe Verdi opera that the Consortium members attended after their first meeting, represents a new natural gas pipeline that will begin at the eastern border of Turkey and will connect the Caspian Region and the Middle East via Turkey, Bulgaria, Romania, Hungary with Austria and further on with Central and Western Europe gas markets (Nabucco, 2009). The pipeline length will be approximately 3,300 km, stretching from the Georgian/Turkish and/or Iranian/Turkish border to Baumgarten in Austria. Additional feeder pipelines, as outlined in Figure 3 (left), are possible for Iraqi gas (RWE, 2009). Based on technical market studies, the pipeline has been designed to transport a maximum amount of 31 bcm per year (Nabucco, 2009).
Nabucco Shareholders are RWE (Germany), OMV (Austria), MOL (Hungary), Transgaz (Romania), Bulgarian Energy Holding (Bulgaria) and Botas (Turkey). Currently, each shareholder holds an equal share of 16.67% (Nabucco, 2009). Estimated investment costs including financing costs for the complete new pipeline system amount to approximately EUR 7.9 billion (RWE, 2009).

The project has the unique value proposition of encompassing several possibilities for new gas sources to be fed into the pipeline, such as gas from Azerbaijan, Kazakhstan, Turkmenistan, Iran and Iraq. The good news for Europe is that, in contrast to oil, most experts predict that natural gas supplies will increase in future years as there are huge gas reserves available around Europe (European Gas, 2007; Bothe & Lochner, 2008; Kjärstad & Johnsson, 2007). However the challenge is how to transport the gas to the consumers (Bothe & Lochner, 2008). As illustrated by Figure 3 (right), the Nabucco project may be seen as the missing link between giant sources of gas and potential gas consuming markets (BP Statistical Review, 2006). The Caspian Region, the Middle East and Egypt, which hold the largest gas reserves worldwide, play a crucial role in terms of diversification of supply as well as security of supply for Europe (Mavrakis & Thomaidis & Ntroukas, 2006). The opening up of a fourth main supply corridor might be considered the only solution to meet future EU gas demands (BCG, 2005). As such, Nabucco provides a promising beginning for enhancing the EU’s energy supply security in future years (Schaffer, 2008).

The remainder of this paper is structured as follows: Section 2 gives an overview of the hypotheses that are to be examined. Next, Section 3 describes the applied research methodology. In Section 4 the Open Season Capacity Allocation Process of the Nabucco project is outlined. Section 5 presents and discusses results. Ultimately, a conclusion is provided in section 6.

### 3.2. Hypotheses

This paper seeks to investigate three key hypotheses related to the Nabucco pipeline project and its capacity allocation process. While hypothesis (1) focuses on the strength of demand for the Nabucco pipeline, hypotheses (2) and (3) examine fair usage rights and cost effectiveness of this project.
First, we wish to investigate whether the Nabucco gas pipeline can be envisioned to be in strong demand by potential gas shippers. Based on EU gas demand forecasts and expected developments of indigenous gas production (see Section 1), a strong case for demanding new pipeline infrastructure capacity can be expected. Strong demand by potential gas shippers would result in good pipeline capacity utilization on the one hand and, importantly for Europe, would prove that this pipeline is necessary. Analogous to the favourable outcomes of a good initial public offering (IPO) of a company on a stock market, capacity overbooking is expected to occur, pointing at strong demand by shippers. Hence, the first hypothesis claims this formally:

**Hypothesis 1:** The Nabucco gas pipeline capacity is in strong demand by gas shippers.

Next, this paper analyses whether Nabucco provides a fair capacity allocation, not only to shareholder and associated company shippers, but also to external, third party gas shippers. The Inter-Governmental Agreement among the transit countries (IGA, 2009) requires that a minimum of fifty percent of the Nabucco gas-transporting capacities per year are reserved for third party access. Under such circumstances, increasing competition in the gas markets can be achieved (Cremer & Gasmi & Laffont, 2003). Based upon these expectations, the second hypothesis claims:

**Hypothesis 2:** The Nabucco gas pipeline provides a fair capacity allocation for third party shippers that is also used by third party shippers.

Finally, this paper engages in competitive benchmarking of the major pipeline projects under way: Nabucco, South Stream, and Nord Stream (I and II). A comparison of these gas pipeline projects based on publicly-available information on gas supplies, gas markets, transportation capacities, pipeline length, and capital expenditures will provide a like-for-like quantitative comparison. Clearly, a new competitive pipeline would be able to, apart from securing the gas for Europe, also provide competitively-priced gas for European consumers. In anticipation that Nabucco could be a cost-competitive pipeline, Hypothesis 3 states:

**Hypothesis 3:** The Nabucco gas pipeline is a cost-effective way to bring new natural gas to Europe.
3.3. Method

The research methods applied in this paper are manifold. In fact, a combination of natural experiment setting, public data analysis, competitive benchmarking and empirical market survey are applied.

First, the Nabucco project itself serves as an excellent natural experiment (Meyer, 1995) that allows us to analyse the three key hypotheses outlined in the previous section. As has become popular in energy research (Pickl & Wagner & Wirz, 2009; Wu & Lampietti & Meyer, 2004; Asche & Osmundsen & Sandsmark, 2006; Douglas, 2006; Florio, 2007; Bellas & Lange, 2008), an event study is carried out.

Furthermore, publicly available data from different companies’ web sites and other public sources are collected. These data are then analysed using competitive benchmarking (e.g. between the different pipeline projects that are currently in the planning stage).

Finally, an empirical market survey is conducted with 54 potential gas shippers. By inquiring about their potential gas supply and demand in future years, inferences regarding the expected Nabucco pipeline capacity utilization – and hence overall necessity for the Nabucco pipeline for Europe – can be drawn. More specifically, the 54 most likely Nabucco gas shippers (focusing on company size and regional market focus) were selected from a customer-relationship-management (CRM) software. These include the six Nabucco shareholder shippers (see Section 1) and the biggest gas companies within the specific Nabucco regional market focus. Subsequently, the market survey participants were contacted in the period 2008 to 2009 per postal letter including a project introduction and a written questionnaire. Out of these 54 potential Nabucco gas shippers, 21 provided a response whereof 16 furnished sufficiently concrete answers to be included in the evaluation of the market survey. The obtained results were then descriptively analysed using Microsoft Excel. This empirical market survey serves as an important input factor for the upcoming Nabucco open season capacity allocation process.
3.4. The Nabucco Open Season Capacity Allocation Process

Rather than buying and selling gas itself, the Nabucco Gas Pipeline International company is set up to develop, establish and construct the pipeline, and then to rent pipeline transportation capacities on long- and short-term bases to interested shippers (Nabucco, 2009). Hence the gas will be bought, delivered and sold by shippers, who will be purchasing transport capacities to ship the gas to Europe.

In order to allocate gas transportation capacities, a non-discriminatory and transparent open season capacity allocation process – a special form of auction (Haase & Bressers, 2008) – will be carried out in 2010 to allow potential shippers to express their interest in project participation and to make firm bookings (RWE, 2009). Thus, open season is in fact the name of a tender process for pipeline transportation capacity.

The introduction of open season access to pipeline transportation capacity has unlocked two distinctive industries: the natural-gas market, where agents trade natural gas as a commodity, and the market for pipeline transportation services, where agents trade services to ship natural gas through the pipeline networks (Raineri & Kuflik, 2003). This is an important concept that will contribute to a competitive European gas infrastructure market since former contracts were often negotiated bilaterally in non-transparent and less competitive manners (De Joode & Van Oostvoorn, 2007). Following Smith, De Vany and Michaels (1990), the use of “Exchangable Transport Entitlements” – which gives the right to utilize, to lease, or to sell the pipeline capacity in a specific segment for a specific period – makes sure that the (scarce) capacity can be used by those who value it most, with the possibility of being resold in a secondary market (Raineri & Kuflik, 2003). Consequently, gas pipeline transportation becomes a property right, the gas pipeline becomes a transportation right supplier, and the owners of these rights offer transportation capacity (Walls, 1995).

The specific Nabucco open season capacity allocation auction will contain two phases (see Figure 4): In the first phase, the offer is addressed to the shareholders and associated companies for an amount up to 15.5 bcm - fifty percent of Nabucco’s maximum transport capacity (Nabucco, 2009). If capacity commitments of shareholders and associated companies are exceeding the reserved capacity of fifty percent,
these commitments will be reduced and allocated pro rata. In the case that shareholders will commit for less than the reserved fifty percent of transportation capacity in the first open season round, the remaining capacity will be offered in the second open season round.

Figure 4: Phases of the Nabucco Open Season Capacity Allocation Process

In a second phase, Nabucco will offer, as a minimum, the remaining fifty percent – in fact a volume of 15.5 bcm of gas transporting capacity per year is pre-determined for third party access (IGA, 2009) – to external, third party companies in conjunction with shareholders and associated companies, offering them the same conditions and transparency as in the first phase. In this procedure all market participants will have the possibility of securing long-term contracts.

In general, it is foreseen that ninety percent of the overall capacity is reserved for long term transportation contracts (more than 1 year, but typically 25 years). However, ten percent of the maximum transportation capacity shall be reserved for short term contract (ranging from single days up to the maximum of one year) and will be available in the second phase of the open season process (Nabucco, 2009). The entire Nabucco open season capacity allocation process will start in the third quarter of 2010 and last for approximately six months (Nabucco, 2009).

3.5. Results

In order to obtain the results with reference to the first hypothesis – i.e. the Nabucco gas pipeline capacity is strongly demanded by shippers – an empirical market survey was conducted with 54 potential gas shippers. By inquiring about their potential gas supply and demand in future years, statements regarding the expected Nabucco pipeline capacity / volume utilization – and hence overall necessity for the Nabucco pipeline for Europe – can be made. Twenty-one shippers (including the six Nabucco shareholding shippers and 15 third party shippers) showed interest, out of which six-
teen (including the six Nabucco shareholding shippers and 10 third party shippers) gave a sufficiently concrete answer to be included in the evaluation of the market survey on a non-binding basis about their interest in Nabucco pipeline capacities. Figure 5 below illustrates the results of this survey and points out that in every year demand for Nabucco pipeline capacities / volumes is far higher than the actual pipeline capacities / volumes. Depending on whether we look at volumes (in bcm per year) or capacities (i.e. flow rate x distance), between 140% and 460% or between 115% and 375% of the Nabucco gas pipeline is demanded by shippers. Thus, we can conclude that Hypothesis 1 is confirmed and the Nabucco gas pipeline is indeed in strong demand by shippers.

![Figure 5: Demand for the Nabucco Pipeline as Percentage of Volumes and Capacities](image)

The evaluation of the outcomes regarding the second hypothesis – dealing with the question of whether the Nabucco gas pipeline provides a fair capacity allocation to third party shippers – was supported by the aforementioned empirical market survey with potential gas shippers as well. Figure 6 shows the capacity volume responses of the 16 gas shippers (i.e. six Nabucco shareholding shippers and ten third party shippers) that were included in the evaluation of the market survey. It shows that indeed a fair, roughly fifty-to-fifty percentage split of pipeline transportation capacities between shareholding shippers and external, third party shippers can be expected in each year of pipeline operation. Therefore, rather than the pipeline being entirely reserved for gas owned by the pipeline builders, by a non-discriminatory open season approach, the Nabucco project is able to increase competition in the European gas market (RWE, 2009). Hence Hypothesis 2 can be confirmed: the Nabucco gas pipe-
line provides a fair capacity allocation to third party shippers that is also utilized by third party shippers.

Figure 6: Fair Capacity Allocation for Third Party Shippers

Finally, we turn to the evaluation of Hypothesis 3 and its assertion that the Nabucco gas pipeline is a cost-effective way to bring new gas to Europe. Here the results of the competitive benchmarking of the major gas pipeline projects’ under planning – namely Nabucco, South Stream and Nord Stream (I and II) – are provided. The input source for this competitive benchmarking is publicly available information on transportation capacities, pipeline length, and capital expenditures of these pipelines. Figure 7 below summarises these projections:

<table>
<thead>
<tr>
<th>Project</th>
<th>Capacity (bcm per year)</th>
<th>Pipeline Length (km)</th>
<th>CAPEX (EUR bn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nabucco</td>
<td>31,00</td>
<td>3,300,00</td>
<td>8,00</td>
</tr>
<tr>
<td>South Stream</td>
<td>63,00</td>
<td>3,200,00</td>
<td>25,00</td>
</tr>
<tr>
<td>Nord Stream (I &amp; II)</td>
<td>56,00</td>
<td>2,100,00</td>
<td>17,00</td>
</tr>
</tbody>
</table>

Figure 7: Major Gas Pipeline Projects: Capacities, Length, and Capital Expenditures (RWE, 2009; IEA World Energy Outlook, 2009; Reuters, 2007)

To create like-for-like comparisons, a common gas supply start time (i.e. beginning of 2015), a common utilization rate (i.e. 90%), equal relative operational expenditures (i.e. 1.5% of capital expenditures), the same evaluation period of 25 years, and identical financial assumptions (i.e. 100% equity financing, internal rate of return requirements of 11.5%) were chosen (own industry assumptions). For Nabucco and South Stream a common gas source (i.e. Azerbaijan off-shore Caspian Sea gas) is as-
sumed. For Nord Stream (I and II) this is not the case, its inclusion is for transport cost benchmarking purposes only.

Next, to evaluate tariffs and provide for a competitive benchmarking, the following tariff cost functions are applied:

\[
NPV = \sum_{n=0}^{25} \frac{C_n}{(1+r)^n} = 0
\]

with \(C_n\) … Cash flows per period so that

\[
NPV = \sum_{n=0}^{25} \frac{(Tariff_2 \times PipelineCapacity \times UtilizationRate) - CAPEX - OPEX}{(1+r)^n} = 0
\]

with

- Tariff_2 … Total Tariff for the full pipeline distance per 1.000 m³ per year;
- PipelineCapacity … Pipeline specific as per Figure 7 above;
- CAPEX … Pipeline specific capital expenditures as per Figure 7 above;
- OPEX … Operational expenditures at 1.5% of Capital Expenditures;
- UtilizationRate … 90%;
- \(r\) … 11.5%.

and

\[
Tariff_1 = \frac{Tariff_2}{PipelineLength} \times 100
\]

with

- Tariff_1 … Distance-related Tariff;
- PipelineLength … Pipeline specific pipeline length as per Figure 7 above.

Figure 8 shows the results of this competitive benchmarking and indicates that Nabucco is more cost-effective than South Stream, its direct Southern corridor pipeline competitor, for both a distance-related tariff comparison and total tariff comparison. In fact, based on the assumptions taken, Nabucco can be expected to offer a 22% (i.e. distance-related tariff: EUR 2,38 vs. EUR 3,05) to 19% (i.e. total tariff: EUR 78,70 vs. EUR 97,59) lower gas transportation tariff to potential shippers than South Stream. With costs of EUR 25 billion (American Chronicle, 2009; RWE, 2009) Russia’s alternative pipeline across the Black Sea, the South Stream project through Bulgaria, Serbia and Hungary to Austria, or alternatively through Slovenia to Italy (MacDonald, 2008), will not be competitive, as according to analyst views it is too
expensive (The Economist, 2009b). Moreover, it would not diversify Europe’s energy supplies away from Russia. Compared to Nord Stream (I and II), Nabucco is more cost-effective on a distance-related tariff basis (34%, i.e. EUR 2,38 vs. EUR 3,62) and on almost equal conditions in terms of total tariff (i.e. EUR 78,70 vs. EUR 76,01). The minor total tariff surplus comes from the fact that Nord Stream is considerably shorter in terms of pipeline length (2.100 km vs. 3.300 km) than Nabucco. Further separate tariff evaluations of Nord Stream I and II – this pipeline is built in two parallel legs – are provided below. In an overall view, it can be stated that Nabucco provides a 3% lower total tariff (EUR 78,70 vs. average EUR 81,41) and a 55% lower distance-related tariff (EUR 2,38 vs. average EUR 5,3§) when comparing it to the average of South Stream, Nord Stream (I and II), Nord Stream I and Nord Stream II. In any event, neither South Stream nor Nord Stream would diversify the EU’s energy supplies away from Russia.

<table>
<thead>
<tr>
<th>Project</th>
<th>Distance Related Tariff (EUR per 100 km / per 1000 m³ / year)</th>
<th>Total Tariff (EUR for the full pipeline distance per 1000 m³ / year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nabucco</td>
<td>2.38</td>
<td>78,70</td>
</tr>
<tr>
<td>South Stream</td>
<td>3.05</td>
<td>97,59</td>
</tr>
<tr>
<td>Nord Stream (I &amp; II)</td>
<td>3.62</td>
<td>75,01</td>
</tr>
<tr>
<td>Nord Stream 1</td>
<td>6.71</td>
<td>80,49</td>
</tr>
<tr>
<td>Nord Stream 2</td>
<td>7.96</td>
<td>71,54</td>
</tr>
<tr>
<td>Average (without Nabucco)</td>
<td>5.33</td>
<td>81,41</td>
</tr>
</tbody>
</table>

Figure 8: Major Gas Pipeline Projects: Tariff Comparison

The only alternative to new pipelines – increased liquefied natural gas (LNG) imports – seems unpromising. LNG alone, with 55.3 billion cubic meters of imports into Europe in 2008 (E.ON Ruhrgas, 2009) providing just about 10% of overall supplies will not be able to shoulder the increasing gas supply requirements of Europe. In any event, even though substantial decreases are happening, LNG is still more costly than piped gas at distances up to 3,000 to 4,000 kilometres (Kjärstad & Johnsson, 2007).

Hence, the third hypothesis can be confirmed: the Nabucco gas pipeline is a cost-effective way to bring new gas to Europe. In this way, a more competitive European gas market with accompanying lower costs can be expected. This can only benefit European consumers.
3.6. Conclusion

This paper evaluated the Nabucco Project as a major means to enhance the EU’s energy supply security in future years by counteracting the increasing Russian monopolistic dominance of European gas supplies.

Three main research questions were posed, centering on the strength of demand for the Nabucco pipeline (H1), fair access rights (H2), and overall cost effectiveness (H3). All three hypotheses encouragingly point into the envisioned direction: Increasing gas demand and decreasing indigenous production make a new gas pipeline necessary for Europe. The empirical survey demonstrated that the Nabucco gas pipeline is strongly demanded by gas shippers (H1). Furthermore, through its open season capacity allocation process, the empirical survey revealed that Nabucco provides a fair capacity allocation of fifty percent to third party shippers (H2), and that this allocation will be fully utilized, thus enhancing competition. Finally, competitive benchmarking showed that Nabucco is in fact a cost-effective pipeline (H3). Indeed, it is the currently missing link that will provide an economical connection to new natural gas supplies for Europe (BP Statistical Review, 2006; RWE, 2009).

Based on these results, it is anticipated that “Nabucco” will not only remain the name of a famous opera, but will also become the term associated with one of the most successful energy projects in Europe. Previous research has already shown that the “great natural gas pipeline game” can be won (Schaffer, 2008), but only by acting with rapid commitment. Hopefully commerce is not taking back seat to politics (Freifeld, 2009). However, this possible success will still require a lot of work and commitment from the actual participants and Europe itself with strong multilateral direction (Weisser, 2007). Political support already in place in the form of the Inter State Agreement, signed in Ankara on July 13th 2009 between the states of the Nabucco transit countries (IGA, 2009), is a good step in the right direction to harmonizing the legal framework by granting stable and equal transport conditions for all partners and customers. Nabucco is the only pipeline project currently under consideration with such an agreement in place. Now that this agreement is in place, “this pipeline is inevitable rather than just probable”, as European Commission President José Manuel Barroso put it in July of last year (Freifeld, 2009).
The undertaken empirical market survey serves as an important input factor for the actual Nabucco open season capacity allocation process to be carried out in the third and fourth quarter of 2010. In further research, the results of this open season capacity allocation process will be analysed in detail.

References


4. Paper 3 – Auction Design for Gas Pipeline Transportation Capacity – The Case of Nabucco

This Paper is at the time of submission of this dissertation under second stage review by an International Journal and was presented at the 11th IAEE European Energy Conference (International Association of Energy Economics, Energy Economy, Policies and Supply Security: Surviving the Global Economic Crisis) in Vilnius / Lithuania in August 2010.

Abstract

As a response to the Russian dominance of the European Union’s (EU’s) natural gas supplies and the combination of the EU’s increasing gas demands and decreasing indigenous gas production, major gas pipeline projects are currently under way in order to enhance the security of the EU’s energy supply. Oftentimes to raise financing and to allocate gas transportation capacities special forms of auctions are carried out to allow gas shippers to make firm bookings.

In recent years, auctions have emerged as one of the most successful allocation mechanisms in microeconomic theory. However, different auction design allocation mechanisms can lead to different outcomes making the choice of auction design a decisive one, especially for divisible-good auctions. This paper seeks to give a formulation of an optimal auction design for gas pipeline transportation capacity. Specifically three different allocation mechanism designs are tested: (i) Biggest Net Present Value Contract Allocation; (ii) Pro Rata Allocation; and (iii) Allocation per Optimization. In addition, the Nabucco Gas Pipeline Project is taken as a case study to experimentally and empirically show the results of such auction designs.

Results show that a trade-off between revenue optimization and fair and transparent allocation can be observed: Allocation per Optimization is the favourable auction design when revenue maximization is more important than fair and transparent allocation. On the other hand, Pro Rata Allocation is the auction design to be chosen when fairness and transparency of allocation are considered most central.
4.1. Introduction and Motivation

As a response to the Russian monopolistic dominance of the European Union’s natural gas supplies (Schaffer, 2008) and the combination of the European Union’s increasing gas demands and decreasing indigenous gas production (IEA World Energy Outlook, 2008 & 2009), major gas transportation pipeline projects are currently underway in order to enhance the EU’s energy supply security, one of the top three priorities within the EU (Percebois, 2008), in future years. Rather than buying and selling gas itself, many gas pipeline companies are set up to develop and construct pipelines, and to rent its transportation capacities on long- and short-term basis to interested shippers. The financing by banks of any pipeline requires the contractual commitment from shippers to pay for gas shipments over an extended period of time (Marks, 2009; Tye & Garcia, 2007). In order to obtain these commitments and allocate these gas transportation capacities, special forms of auctions (Haase & Bressers, 2008) are carried out to allow potential shippers to express their interest in project participation and to make firm bookings. Auction theory has attracted enormous attention in the last few years (see Klemperer, 1999, 2000, and 2002 for a review of auction theory). Its emergence as one of the most successful development in microeconomic and game theory in the last decades has led to the award of the Nobel Price in Economics to Vernon Smith in 2002 for his tests of different auction forms (Stockholm Nobel Price Announcement, 2002; Smith, 1965; Smith 1976a; Smith 1976b; Copping, Smith & Titus, 1980). Theoretical and empirical research shows that from an economic perspective, auctions are an appropriate mechanism for allocation as they tend to be beneficial with regards to price determination, distributional and efficiency goals, and revenue maximization (Klemperer, 2004; Milgrom, 2004). However, different auction designs and allocation mechanisms can lead to different outcomes. Therefore the choice of auction rules is a decisive challenge (Ockenfels, 2009) and determining success factor for each particular auction. This especially holds true for auctions for divisible goods that are at risk of yielding significantly lower overall revenues than ordinary one-item auctions (Wilson, 1979).

Therefore, this paper sets out to provide a mathematical formulation of alternative auction designs for gas pipeline transportation capacity. Furthermore, the Nabucco Gas Pipeline Project – by some named the most economic link to new gas (Pickl & Wirl, 2010; RWE, 2009) and certainly one of the most prominent energy projects ever
– is taken as a case study to experimentally and empirically show the results of such alternative auction designs. These results lead to a conclusion of a potentially optimal auction design considering particular defined auction goals.

The remainder of this paper is structured as follows: Section 2 provides a background on general auction theory and its application to energy markets. Section 3 gives an overview of the applied research methods in this paper. Next, Section 4 outlines the Nabucco auction design: the strategic auction goals are introduced, the auction process is described, the empirical market-survey received bids are presented and alternative capacity allocation designs are devised. Section 5 presents and discusses results of the alternative auction allocation designs. Ultimately, a conclusion is provided in section 6.

4.2. Background

According to general auction theory, auctions are traditionally classified into four types (Stockholm Nobel Price Announcement, 2002). In an English auction, bidders announce their bids sequentially and in an increasing manner until no higher bid is received by the auctioneer. This is also called an open ascending price auction. In a Dutch or descending auction, a high first bid is announced by the auctioneer and is gradually lowered until some bidder chooses to bid. In the other two classical auction forms, all bidders simultaneously submit their bids in sealed form and the unit for sale is allocated to the highest bidder (Stockholm Nobel Price Announcement, 2002). In the first-price sealed bid auction, this bidder pays his or her bid to the seller; while in the second-price sealed bid auction – also known as Vickrey auction (Blume et al., 2009; Chen, 2007; Milgrom, 1989; Vickrey, 1961) – the winning bidder pays only the second highest bid. Under the Vickrey auction, bidders have a dominant strategy to truthfully report their values to the auctioneer (Kwasnica et al., 2005). An additional type of auction is the Walrasian auction in which the auctioneer takes bids from both buyers and sellers and then progressively either raises or drops prices depending on the received bids (Sun & Yang, 2009; Shneyerov, 2002; Ermoliev & Michalevich & Nentjes, 2000; Smith, 1965). The Walrasian auction concludes when supply and demand balance (Jaffe & Walker, 1983).
In liberalized energy markets, the use of auctions represents an important development in the regulation of the formerly publicly owned energy utilities (Porter, 1995; Cameron & Cramton & Wilson, 1997). They offer the prospects of achieving optimal, or near-optimal, allocation of existing capacities and a price mechanism for establishing whether new investment is needed (Porter, 1995). In addition, these auctions are also Pareto-optimal thus directly improving welfare in the sense that the (scarce) unit for sale is expected to be allocated to users, whose bids reveal that they place the greatest value on it (Hawdon & Stevens, 2001) with the possibility of being resold in a secondary market (Raineri & Kuflik, 2003).

Yet, for all their positive promises in practice many auctions have disappointed, especially as complex problems bedevil auctions of dearer goods (The Economist, 2002) and fungible commodities (Vickrey, 1961) like also gas pipeline transportation capacities.

Auctions for gas pipeline transportation capacities, often termed open seasons, are in fact a special form of an auction (Haase & Bressers, 2008). The here presented Nabucco auction mechanism may come closest to an English auction – where, under some of the proposed allocation mechanism designs (see Section 4.5), the highest present contract value bidders get selected - and a Walrasian Auction (for tariff adaptation when supply and demand balance). Even sealed first price bid auctions could be thought of to have common features in the sense that only one bid is submitted per shipper and competitors cannot directly see them. More specifically, the Nabucco auction design, in its full complexity, is a sequential (non-binding, binding, shareholder/non-shareholder), three dimensional (distance, flow rate, years, note: tariff is fixed), multi-attribute (reverse flow, exit/entry points phases), first price (i.e. first revenue) auction with multiple winners. The tariff charged is the one that is concluded when a balance between supply and demand is achieved.

Further special features include a non-binding auction phase for informational purposes. An important aspect of any market is the information available to participants. Especially in auctions information can play a crucial role (Porter, 1995). If revenue raising is an objective, all information possessed by the seller should be published (Hawdon & Stevens, 2001). The social and private costs of information imperfection are compounded in strategic settings, where participants may exploit informational asymmetries. If one buyer has access to information superior to that of rivals informa-
tional rents may be obtained and as the results are not zero-sum, inefficiencies may result (Porter, 1995). Therefore, Nabucco’s non-binding auction phase serves an important informational purpose. It shall be noted that – while some researchers argue in favor of the provision of asymmetric information to bidders (Hagedorn, 2009; Bergemann & Pesendorfer, 2007) – for the Nabucco auction design the same symmetric information level has to be made available to all bidders for non-discriminatory reasons.

An additional specific feature of the Nabucco auction design is that not the highest bidder in terms of transportation price is selected, but – as in fact the distance related tariffs are predetermined and equal for all bidders (see Pickl & Wirl, 2010) – allocation to a set of bidders (i.e. the winners’ set) takes place according to one of the allocation mechanism designs proposed in Section 4.5. As such an often documented problem in auctions – the winners curse, in which large numbers of bidders generate more aggressive biddings and result in bankruptcies and negative profits of the (single) auction winner (Holt & Sherman, 1994; Kagel & Levin, 1986; Milgrom, 1982; Capen & Clapp & Cambell, 1971) – are not valid for this auction design as in fact there is a set of auction winners (i.e. the allocation outcome winners) comparable to Wilson’s eminent paper on auctions of shares (1979).

4.3. Method

The research methods applied in this paper are manifold. In fact, a combination of empirical market survey of auction volumes and bid patterns, mathematical formulation of allocation mechanism design and experimental testing of auction allocation is carried out.

First, the potentially optimal auction design is mathematically formulated to achieve its strategic goals. In this way this paper follows eminent auction theory papers such as Vickrey (1961), Wilson (1979), Chao and Wilson (2002), Ledyard et al. (2002), Rajnish & Shmuel (2002), Sunnevag (2003), Kwasnica et al. (2005), Parkes and Kalagnanam (2005), and Hagedorn (2009). In the course of doing so different allocation mechanism designs are proposed.

Next, an empirical market survey is conducted with 54 potential gas shippers to investigate the expected auction volumes and bid volume patterns. More specifically,
the 54 most likely Nabucco gas shippers (chosen based on company size and regional market focus) were selected from a customer-relationship-management (CRM) software. These include the six Nabucco shareholder shippers and the biggest gas companies within the specific Nabucco regional market focus. Subsequently, the market survey addressees were contacted in the period 2008 to 2009 per postal letter including a project introduction and a written questionnaire. Out of these 54 potential Nabucco gas shippers, 21 provided a response whereof 17 furnished sufficiently concrete answers to be included in the evaluation of the auction volumes and bid patterns.

Finally, the different proposed allocation designs are experimentally tested using the auction volumes and bid patterns from the empirical market survey. That is we use the test bed approach of experimental economics (Kwasnica et al., 2005). The use of laboratories as test beds for complex auctions in complex environments began with Ferejohn et al. (1979), Smith (1979), Grether et al. (1981), and Rassenti et al. (1982). This methodology has proven to be successful in providing guidance for the design of a variety of implemented auctions (Plott, 1997; Ishikida et al., 2001; Ledyard et al., 1997). The outcomes are evaluated on three grounds: revenue raising potential / efficiency, fairness and transparency. This experimental testing serves as an important input factor for the upcoming Nabucco Capacity Auction and resembles a real life auction application as in Porter (1995) and Loxley & Salant (2004). As has become popular in energy research (Pickl & Wagner & Wirl, 2009; Wu & Lampietti & Meyer, 2004; Asche & Osmundsen & Sandsmark, 2006; Douglas, 2006; Florio, 2007; Bellas & Lange, 2008), an event study is presented.

### 4.4. Designing the Nabucco Auction

#### 4.4.1. Strategic Objectives and Performance Measures

When developing and choosing an auction design, a range of evaluation criteria may be used and, in general, trade-offs between these measures can be expected (Kwasnica et al., 2005; Pekec & Rothkopf, 2003). Following the strategic objectives of the Nabucco project (Nabucco, 2009), the different experimental designs (see section 4.5) shall be evaluated on three grounds: revenue raising potential/efficiency, fairness and transparency.
Revenue raising maximization is an obvious choice where the auction designer happens to be the seller of the item to be auctioned (Kwasnica et al., 2005). Revenue raising potential/efficiency in this paper is measured by three criteria:

The first is maximum annual revenue efficiency calculated as per the following formula:

\[
E_{\text{max}} = \max \frac{\text{AllocatedCapacity}_t}{\text{Total PipelineCapacity}_t}
\]

\[t = \{1, \ldots, 25\}\]

with

- \text{AllocatedCapacity}_t \ldots \text{the allocated capacity in year } t;
- \text{Total PipelineCapacity}_t \ldots \text{the total Nabucco pipeline capacity of } 31 \text{ bcm per year } t;

Note: 25 years is taken as the evaluation period of the pipeline;

Note: As the transport tariff is constant it is not included in this formula.

The second is average annual revenue efficiency computed by:

\[
E_\varnothing = \frac{\text{AllocatedCapacity}_i}{\text{Total PipelineCapacity}_i} \cdot \frac{1}{25}
\]

\[t = \{1, \ldots, 25\}\]

with

- \text{AllocatedCapacity}_i \ldots \text{the allocated capacity in year } i;
- \text{Total PipelineCapacity}_i \ldots \text{the total Nabucco pipeline capacity of } 31 \text{ bcm per year } i;

Note: 25 years is taken as the evaluation period of the pipeline;

Note: As the transport tariff is constant it is not included in this formula.

The third is total foregone revenue captured by:

\[
\text{Rev}_{\text{tot}} = \sum_{i=1}^{25} (\text{Total PipelineCapacity}_i - \text{AllocatedCapacity}_i) \cdot \text{Tariff}
\]

with

- \text{AllocatedCapacity}_i \ldots \text{the allocated capacity in year } i;
- \text{Total PipelineCapacity}_i \ldots \text{the total Nabucco pipeline capacity of } 31 \text{ bcm per year } i.
- \text{Tariff} \ldots \text{the transport tariff for the full pipeline distance per } 1.000 \text{ m}^3 \text{ per year.}

Note: 25 years is taken as the evaluation period of the pipeline.
In general, here it is not the absolute value we place the emphasis on, but the relative performance measure across the different proposed auction designs.

Next, the fairness and transparency evaluation criteria stem from the European Union energy policy aim to reach non-discriminatory access to pipeline infrastructure for third party shippers (EU Gas Directive, 2003; EU Gas Regulation, 2005; Cremer & Gasmi & Laffont, 2003). Fairness and appearance of fairness are important in auctions to ensure that all potential bidders have an equal chance (Rothkopf & Park, 2001). Fairness and transparency of non-discriminatory access to the Nabucco pipeline infrastructure by the allocation mechanism experimental designs in this paper are measured by three indicators:

The first is the total portfolio size of awarded bidders. The closer this number is to the number of participating bidders (see Section 4.4) the fairer is the allocation mechanism’s experimental design.

\[ Total\ PortfolioSize_{of\ Awarded\ Bidders} = \sum_{i=0}^{Number\ of\ Participating\ Bidders} Q_i \]

with

\( Q_i \) … Decision 0 or 1 of whether to allocate the respective bidder or not.

The second is portfolio efficiency measured by the total portfolio size of awarded bidders as a fraction of participating bidders as outlined by the following formula:

\[ Portfolio\ Efficiency = \frac{Total\ PortfolioSize_{of\ Awarded\ Bidders}}{Number\ of\ Participating\ Bidders} \]

The closer this second fairness evaluation criterion number is to 1 the better is the allocation mechanism experimental designs.

The third fairness and transparency evaluation criterion is a qualitative performance measure and is evaluating whether the respective allocation mechanism experimental design is discriminating any particular bidder group with regards to any specific bidder group characteristic and whether it provides for a transparent way of allocation that can easily be understood and strategically assessed by bidders.

The remaining strategic auctions goals such as arriving at a competitive tariff (i.e. the transportation tariff is pre-determined at the beginning of the auction and then
adapted to bid volume depending on capacity utilization), seller return on equity, short term capacity reservations, and creditworthiness of the bidders (which is important for any successful auction, since if a winning bid were to prove unsupportable by the bidder, the auction would have to be held again (Hawdon & Stevens, 2001)) shall be mentioned here, yet are not evaluated separately for the purposes of this paper.

4.4.2. A Process Description of the Nabucco Auction

Rather than buying and selling gas itself, the Nabucco Gas Pipeline International company is set up to develop, establish and construct the pipeline, and to rent pipeline transportation capacities on long- and short-term basis to interested shippers (Nabucco, 2009). Hence the gas will be bought, delivered and sold by shippers, which will be purchasing transport capacities to ship the gas to Europe.

In order to allocate gas transportation capacities a non-discriminatory and transparent open season capacity allocation process – a special form of auction (Haase & Bressers, 2008) – will be carried out in 2010/2011 to allow potential shippers to express their interest in project participation and to make firm bookings (RWE, 2009). Thus open season in fact is the name of a tender process for pipeline transportation capacity.

The introduction of open season access to pipeline transportation capacity has unlocked two distinctive industries: the natural-gas market, where agents trade natural gas as a commodity, and the market for pipeline transportation services, where agents trade services to ship natural gas through the pipeline networks (Raineri & Kuflik, 2003). This is an important concept that will contribute to a competitive European gas infrastructure market since former contracts were often negotiated bilaterally in non-transparent and less competitive manners (De Joode & Van Oostvoorn, 2007). Following Smith, De Vany and Michaels (1990) the use of “Exchangable Transport Entitlements” – which give the right to utilize, to lease, or to sell the pipeline capacity in a specific segment for a specific period – makes sure that the (scarce) capacity can be used by those who value it most, with the possibility of being resold in a secondary market (Raineri & Kuflik, 2003). Consequently, gas pipeline transportation becomes a property right, the gas pipeline becomes a transportation right supplier, and the owners of these rights offer transportation capacity (Walls, 1995).
The specific Nabucco Open Season Capacity Allocation Process will contain two distinct phases – open season for shareholders and open season for third parties – each with two sub phases – a non-binding phase (to minimize risks and to get a better feeling for the market and maximize the provision of information (Porter, 1995) and a binding phase (see Figure 1)):

<table>
<thead>
<tr>
<th>Phase 1:</th>
<th>Open Season for Shareholders</th>
<th>Non-binding phase</th>
<th>Commitment</th>
<th>Assessment, allocation</th>
<th>Long Term Transportation Agreements (LTTAs)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Phase 2:</th>
<th>Open Season for Third Parties</th>
<th>Non-binding phase</th>
<th>Information Period</th>
<th>Commitment</th>
<th>Assessment, allocation, LTTAs</th>
</tr>
</thead>
</table>

Figure 1: Phases of the Nabucco Open Season Capacity Allocation Process (see Pickl & Wirl, 2010).

In the first phase, the offer is addressed to the shareholders and associated companies for an amount up to 15.5 bcm per year - fifty percent of Nabucco’s maximum transport capacity. This first phase starts with a non-binding phase that, apart from a participation fee, does not carry any firm commitment to enter into a gas transportation contract. However, shippers have to take part in the non-binding open season in order to be allowed to take part in the binding open season round. The idea of the methodology is that shippers can not apply separately for the binding round in order to treat all shippers equally. Given bids by shippers during the non-binding round can not be reduced for the binding round in terms of capacity. Otherwise the shippers will lose their participation fee. Shippers, nonetheless, are allowed to confirm or even to increase their bid in the binding round. Shippers will get their participation fee refunded in case they are selected for the binding open season phase and they confirm/increase their non binding bid or if they are not selected to participate in the binding open season round.

The non-binding phase is followed by a commitment phase, an assessment and capacity allocation procedure as well as the conclusion of the respective Long Term Transportation Agreements.

If capacity commitments of shareholders and associated companies are exceeding the reserved capacity of fifty percent, these commitments will be reduced and allocated as per a pre-defined allocation mechanism. In case shareholders will commit
for less than the reserved fifty percent of transportation capacity in the first open season round, the remaining capacity will be offered in the second open season round.

In a second phase, Nabucco will offer, as a minimum, the remaining fifty percent – in fact a volume of 15.5 bcm of gas transporting capacity per year is pre-determined for third party access by the Inter State Agreement between the Nabucco transit countries – to external, third party companies, also including Nabucco shareholders, offering them the same conditions and transparency as in the first phase. In this procedure all market participants will have the possibility of securing long-term contracts. Similar to the first phase, also this second phase includes a non-binding phase.

In general, it is foreseen that ninety percent of the overall capacity is reserved for long term transportation contracts (more than 1 year, but typically 25 years). However, ten percent of the maximum transportation capacity shall be reserved for short term contracts (ranging from single days up to the maximum of one year) and will be available in the second phase of the open season process.

The entire Nabucco open season capacity allocation process will start in late 2010 / early 2011 and will last for around six months. The specific tariff range mechanism – Nabucco will publish the tariff in a 3-tier approach – is presented in Figure 2. The final tariff is concluded in a Walrasian auction mechanism when final demand is known and balances with supply (Jaffe & Walker, 1983; Sun & Yang, 2009; Shneyerov, 2002; Ermoliev & Michalevich & Nentjes, 2000; Smith, 1965).

Figure 2: Tariff Range Mechanism.
4.4.3. Mathematical Formulation of Bidders Optimal Bidding Strategy

Rather than providing a fully general framework, in this paper we will focus on the most prominent factors of the particular designs we evaluate. Before mathematically formulating the auctioneer’s optimal capacity allocation rule, the bidders’ optimal bidding strategy shall be outlined. Due to the inherent design complexity – and therefore partial impossibility to show the true optimal bidding strategies that lead to an equilibrium – this is done in a simplified manner.

First a bidder would maximize his/her expected profits (E) that are constructed by subtracting the transport tariff (t) that he/she has to pay from the price differential of his/her gas purchasing price – the upstream price for gas (up) – and his/her gas selling price – the downstream price of gas (dp) – and multiplying it by his/her gas volume (F, i.e. total flow of the pipeline).

\[
b_i \rightarrow E((up - dp) - t) \cdot F \sum_{\gamma=1}^{n} \frac{b_i}{b_{\gamma}}
\]

\[
\max \pi_i = E((up - dp) - t) \cdot F \frac{b_i}{\sum_{\gamma=1}^{n} b_{\gamma}}
\]

Next, the individual bidder’s volume transported (vi) becomes subject to the allocation mechanism process of the auctioneer and the maximum available capacity of 31 bcm per year.

\[
v_i = \max \left\{ b_i, \sum_{\gamma=1}^{n} b_{\gamma} \right\}
\]

\[
v_i = \left\{ \frac{b_i}{\sum_{\gamma=1}^{n} b_{\gamma}} \leq \frac{if}{\sum_{\gamma=1}^{n} b_{\gamma}} \right\} 31
\]

Finally, the bidder would convert the bid to his/her risk appetite of being allocated by introducing a particular utility function.

Theoretically to reach an equilibrium and to maximize overall pipeline revenues, truthful revelation should be a dominant strategy for every bidder/player (Hobbs et al., 2000). On the other hand, it shall be noted that strategic bidding behaviour might even have the potential to hurt the revenue outcome of the overall pipeline. It can
even lead to collusion, for example by smaller bidders. Therefore, it might be better not to encourage such strategic bidding behaviour altogether.

4.4.4. Empirical Market Survey – Received Bids

In order to obtain the expected auction volumes and bid volume patterns, an empirical market survey was conducted with 54 potential gas shippers. Out of these 54 potential Nabucco gas shippers, twenty-one shippers (including the six Nabucco shareholding shippers and fifteen third party shippers) showed interest whereof seventeen furnished sufficiently concrete answers to be included in the evaluation of the auction volumes and bid patterns. Figures 3 and Table 1 illustrate the results of the received bids (in Figure 4 actual company names are disguised for confidentiality purposes). Figure 3 points out that in every year demand for Nabucco pipeline capacities is higher than the actual pipeline capacities (i.e. depending on whether we look at volumes (in bcm per year) or capacities (i.e. flow rate x distance), between 140% and 460% or between 115% and 375% of the Nabucco gas pipeline is demanded by shippers). This expected overbooking makes a capacity allocation to selected bidders necessary.

![Figure 3: Empirical Market Survey – Demand/Received Bids for the Nabucco Pipeline as Percentage of Volumes and Capacities (see Pickl & Wirl, 2010).](image-url)
Next, the experimental designs for capacity allocation shall be introduced. Different allocation mechanism designs are proposed and tested by the test bed approach of experimental economics (Kwasnica et al., 2005). Specifically, three different allocation mechanism designs are tested: i) Biggest net present value contract allocation; ii) Pro rata allocation; and iii) Allocation per optimization. The outcomes of these three different allocation mechanism designs are then evaluated on three grounds – revenue raising potential/efficiency, fairness and transparency – with the general goal to award the auction item (i.e. pipeline transportation capacity) to the collection of bidders that would yield the best combination of revenue maximization while maintaining fairness and transparency of allocation.

4.4.5.1. Experimental Design 1 – Biggest Contract Allocation

The first allocation mechanism experimental design is biggest net present value contract allocation. Here, in principle, the auction design uses a straightforward allocation rule: Award the auction item (i.e. pipeline capacity) to the highest value bid (measured in EUR value of the contract value on a net present value basis) until no
further bid fits within the capacity limits of the Nabucco pipeline (i.e. 31 bcm per year).

This means that the ranking of the bids is done per net present value which for each individual bid is calculated as per the following formula:

\[
NetPresentValue_{\text{per Bid}} = \sum_{t=1}^{25} \frac{Rev_t}{(1 - r)^t}
\]

with

- \( Rev_t \) … the Total Revenue resulting from Tariff times Volume in every year \( t \);
- \( r \) … the discount rate set at 10%.

Note: That it is assumed that each bidder books the total pipeline distance.

This experimental design follows the ideas of general auction theory where in an English Auction setting (Stockholm Nobel Price Announcement, 2002) the highest bidder auction participant gets awarded.

4.4.5.2. Experimental Design 2 – Pro Rata Allocation

The next allocation mechanism experimental design is pro rata allocation. In this case, the auction design – in the presence of an overbooking – utilizes the allocation rule of awarding the auction item (i.e. pipeline capacity) to each bidder on a pro rata basis (i.e. if a bidder bids for an annual maximum capacity of \( x \) bcm, the total annual maximum bids accumulate to \( y \) bcm, and the pipeline has a capacity of 31 bcm, the specific bidder gets a capacity of his/her period bid times 31 divided by \( y \) bcm allocated).

This means that in fact every bidder is awarded a piece of the auctioned pipeline capacity. In this sense this allocation mechanism is in line with the European Union energy policy aim to reach non-discriminatory access to pipeline infrastructure for third party shippers (EU Gas Directive, 2003; EU Gas Regulation, 2005; Cremer & Gasmi & Laffont, 2003). Specifically, under this allocation mechanism each bidder is allocated a capacity according to the following formula in each period \( t \):

\[
allocation_{\text{bidder } i} = \text{bidvolume}_{\text{bidder } i} \cdot \frac{\max \text{capacity}}{\max \sum_{i=1}^{n} \text{bidvolume}_{\text{bidder } i}}
\]

with
bidvolume_{bidder_i} \ldots \text{the bid volume of bidder } i \text{ in a specific year } t; \\text{maxcapacity} \ldots \text{the capacity constraint of 31 bcm of the pipeline per year.}

4.4.5.3. Experimental Design 3 – Allocation per Optimization

The third allocation mechanism experimental design implements an allocation per optimization. In this design, the allocation imperative is to award the auctioned Nabucco pipeline transportation capacity to the collection of bids that would yield the highest total revenue for the auctioneer. In detail, the following allocation procedure applies:

First each bidder bids for a volume transported \((v)\) and a particular year when the gas is to be transported \((t)\). The distance of the pipeline is not considered as it does not affect the allocation mechanism since the constraint is on the way of the pipeline (i.e. you just lose on the way).

\[
b_i = (v_i, t_i)
\]

Next, the items are awarded to the collection of bids that would yield the highest total revenue: An optimization operations research algorithm is checking and comparing all possible combinations of bids until an optimum solution with the highest total revenue is filtered out. Therefore, we solve the following allocation problem:

\[
\text{max } NPV = \max \sum_{i=1}^{n} NPV(b_i)
\]

so that:

\[
\sum_{i=1}^{n} v_{it} \leq 31 \forall t
\]

which represents the capacity constraint of 31 bcm of the Nabucco pipeline per year.

This experimental design is inspired by the very first research on auctions – in fact the very first academic paper (Friedman, 1956 & 1957) on auctions presents a decision theory model in the area of operations research (Rothkopf, 2007; Myerson, 1981) – and incorporates the operations research idea of optimization.
4.5. Results

Results show that the Nabucco auction design, in its full complexity, is a sequential (non-binding, binding, shareholder shipper/non-shareholder shipper), three-dimensional/multi-attribute (distance, flow rate, years, note: tariff is fixed), and partly first price (i.e. first revenue) auction, with multiple winners. Similar to a Walrasian auction the tariff charged is the one that is concluded when supply and demand balance. For deciding on the optimal auction design for determining the most beneficial set of auction winners three different allocation design mechanisms are proposed. Rather than focusing on the full complexity of the auction framework, the proposed auction designs are evaluated according to the main strategic objections and performance measures as outlined in Section 4.1.

Results regarding the first allocation mechanism experimental design – biggest net present value contract allocation – in Figure 4 show that according to this experimental design a limited revenue raising potential/efficiency and limited fairness of allocating bidders can be observed, while transparency is given. Figure 4 illustrates graphically that by this allocation mechanism clearly the pipeline capacity of 31 bcm per year is not reached at all by the proposed auction. More specifically, the revenue efficiency reaches a maximum of 84% (in the years 4 to 20) and reaches a modest average of 73%. By that – and assuming a pipeline tariff of EUR 78.70 (see Pickl & Wirl, 2010) per 1.000 m3/year – a total revenue of on average mEUR 656 per year or bEUR 16.4 over 25 years, that theoretically would be possible if the pipeline was fully utilized – is not realised. These results best illustrate the potentially detrimental outcomes of auctions for divisible goods (Wilson, 1979). Furthermore, fairness in terms of allocating bidders cannot be observed: Firstly, only four (AlphaGas, BurnNG, CaspGas, and DistriGas) of the 17 bidders are allocated/awarded. Hence a portfolio efficiency of modest 0.24 can be observed. Thirdly, clearly the big bids (and hence the big companies) are favored by this allocation mechanism.
Results with regards to the second allocation mechanism experimental design – pro rata allocation – are summarized in Figure 5. It is shown that this experimental design yields comparable outcomes in terms of revenue raising potential/efficiency and transparency, but better results of fairness of allocating bidders when compared to the first allocation mechanism. In particular, the revenue efficiency reaches a higher maximum of 96% (in the year 5), but a lower average revenue efficiency of only 70%. This results in – assuming the same pipeline tariff of EUR 78.70 (see Pickl & Wirl, 2010) per 1,000 m3/year – a total revenue inefficiency of on average mEUR 740 per year or bEUR 18.5 over 25 years.

On the other hand, in terms of fairness of allocating bidders major improvements can be determined: First of all, the total portfolio size of awarded bidders reaches 17 (meaning that all bidders get a share of the auctioned pipeline transportation capacity). This translates to an optimum portfolio efficiency of 1. Finally, as every bidder gets allocated by this allocation mechanism, no discrimination of any particular bidder group with regards to any specific bidder group characteristic can be observed. Transparency of allocation is equally present as under the first auction design.
Results regarding the third allocation mechanism experimental design – allocation per optimization – are presented in Figure 6. From the graphical representation it becomes clear that this experimental design yields by far the best outcomes in terms of revenue raising potential/efficiency of all allocation mechanisms: Specifically, the revenue efficiency reaches the maximum of 100% in 6 years (i.e. in year 8 to 13) and a superior average revenue efficiency of 88%. This results in – assuming the same pipeline tariff of EUR 78.70 (see Pickl & Wirl, 2010) per 1.000 m3/year – a total revenue inefficiency of on average mEUR 288 per year or bEUR 7.2 over 25 years, in fact coming as close as possible to the theoretical optimum.

In terms of fairness of allocating bidders the allocation per optimization mechanism fairs far better than the biggest contract allocation mechanisms, but in contrast to the pro rata allocation not all bidders get awarded. In detail, the total portfolio size of awarded bidders reaches 10 (i.e. NatGas, PortGas, AlphaGas, JGas, GasTrad, FinGas, Q-Gas, DistriGas, CaspGas, and MiddleEuGas) of the 17 bidders. This represents a portfolio efficiency of 0.59. Finally, no discrimination of any particular bidder group with regards to any specific bidder group characteristic can be observed. On the other hand, this allocation mechanism does not allow for bidders to act strategi-
cally as an optimum bidders’ strategy for becoming allocated can not be pre-analysed at all as true transparency is given, but not easily assessed.

4.6. Conclusion

This paper comes as a response to the many gas transportation pipeline projects currently under way which, to obtain financing by banks, often run special forms of auctions. In these auction processes potential shippers express their interest in project participation and make firm bookings for pipeline transportation capacities.

This paper is inspired by on the one hand the general emergence of auctions (Klemperer, 2004; Milgrom, 2004) and on the other by their associated properties that can lead to different outcomes and make the choice of auction rules a decisive challenge (Ockenfels, 2009). Specifically this paper tested three different allocation mechanism designs: i) biggest net present value contract allocation; ii) pro rata allocation; and iii) allocation per optimization in order to determine an optimal auction design considering particular defined auction objectives.

The results of experimentally testing these auction designs with the bid volume patterns of an empirical market survey show that the different auction design allocation
mechanisms demonstrate diverging trends. Table 2 summarizes the findings: a trade-off between revenue optimization (i.e. in the interest of the pipeline owner) and fair and transparent allocation design (i.e. wished for by regulators to achieve third party access and competition) can be observed. Results show that: (i) biggest net present value contract allocation yields weak outcomes in terms of both pipeline revenue raising potential and fairness of allocation. Only transparency is satisfactorily maintained in this design; (ii) pro rata allocation yields optimal fairness of bidder allocation and transparency and comparable results in terms of revenue raising potential as biggest net present value contract allocation: and (iii) allocation per optimization by far leads to the best results in terms of revenue maximization, and improvements of a fair allocation compared to the biggest net present value contract allocation. On the other hand, transparency of allocation is found to be insignificant as this allocation mechanism does not allow for bidders to act strategically as an optimum bidders’ strategy for becoming allocated can not easily be pre-analysed. In conclusion, allocation per optimization is the favourable auction design when revenue maximization is more important than fair / transparent allocation. On the other hand, pro rata allocation is the auction design to be chosen when fairness and transparency of allocation dominates pure revenue raising potential.

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Table 2: Overview of Results and Conclusion - The choice of auction design has implications and trade-offs.

As a limitation it shall be mentioned that this auction design paper assumes that the choice of the auction allocation design does not impact the strategic bidding behavior of the bidding shippers. In fact, it is implied that all bidders bid according to the optimal strategy outlined in Section 4.3. and that this results in the received bids as outlined in Section 4.4.. In future research, however, it shall be investigated how the actual choice of the auction allocation design impacts the strategic bidding behavior of bidders.
Earlier research has shown that Nabucco could become the term associated with one of the most successful energy projects in Europe (Pickl & Wirl, 2010). Carefully designing its auction design can additionally contribute to making this happen. In future research the real life Nabucco Capacity Auction will be carried out and the results of its auction design presented to the energy research community.

References


Pickl, M., Wirl. F. (2010). Enhancing the EU’s Energy Supply Security – An Evaluation of the Nabucco Project and an Introduction to its Open Season Capacity Alloc-


5. References


6. Annexes

6.1. Dissertation Summary in German Language


Die zweite Publikation analysiert das Nabucco Gas Pipeline Projekt – von manchen als kosteneffizienteste Verbindung zu neuem Gas bezeichnet – um festzustellen, ob es für die Europäische Union zur kosteneffizienten Diversifizierung ihrer Gaslieferun-


6.2. Expose – Registration of PhD Topic
Anmeldung des Dissertationsthemas - Exposé

Angaben zur Person
Matrikelnummer: 0025756
Zuname: Pickl
Vorname: Matthias

Exposé zu der auf Formular SL / D1 genannten Dissertation

Kurzbeschreibung des beantragten Dissertationsthemas (in Deutsch und/oder Englisch) - Angabe von geplanten Methoden, verwendeten Verfahren, verwendeter Literatur, ecc; ca. 250 – 300 Worte (sollte der Platz nicht ausreichen, verwenden Sie bitte die Rückseite des Formulars oder ein Beiblatt):


The first paper deals with the impacts of 7-day-trading on the Austrian electricity market. The applied methods include an empirical survey, a natural experiment evaluation and econometric analysis.

The second paper investigates the energy supply security of the European Union, the demand for the Nabucco Gas Pipeline Project, and the favorability of the Nabucco Gas Pipeline Project versus other pipeline projects. An empirical survey is carried out and econometric analysis is applied.

The third paper analyses the optimal auction design for gas pipeline transportation capacity. A combination of three research methods is applied: mathematical formulation, experimental testing, and empirical auction surveying.

The utilized literature covers the major international energy journal. A brief selection of the utilized literature is provided as an attachment.

Unterschrift der Dissertantin / des Dissertanten

Datum 10/03/2010

[Signature]
6.3. PhD Grades
Matrikelnummer: 0025756

Geburtsdatum, SVNr: 22.12.1980, 1343221280
Studierendenstatus: ordentlich
Staatsbürgerschaft: Österreich
Geschlecht: männlich
Zulassungsnachweis: Inl. postsekund. Bildungseinr., 26.05.2003

Herr
Mag. Matthias Pickl
Wagramerstraße 25/2/15
1220 Wien

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### Sammelzeugnis

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Datum: 16.09.2010
Die Studienprüfer:
Univ.-Prof. Mag. Dr. Brigitte Kopp

Zur besseren Übersicht wurden die aktuellsten Leistungen mit einem Stern (*) markiert.

**Noten:**
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Die Studienprüfung:
Univ.-Prof. Mag. Dr. Brigitte Kopp

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Conference Review Process and Impact Analysis

Call for papers: a huge success
Mar 19, 2010

IAEE’s Rio 2010 International Conference’s Call for papers proved itself a huge success. Over 415 papers were sent from 37 different countries! Brazil was the country with the greatest amount of papers (160), followed by the United States (44) and Germany (37). The papers were blind reviewed by at least two reviewers, which proved the robustness of the evaluation process. Unfortunately the conference organization was not able to accept all papers, as the possible slots are too little in number.

The conference will give 325 authors the opportunity to present their thoughts on Energy Economics. The hottest conference themes will be Energy and the Environment, Energy Policy, Implementing Renewable and Energy Modeling all having around 30 accepted papers. We congratulate the selected authors and encourage those who were not accepted to keep sending their work to other IAEE conferences.

The paper receiving system is already working, we remind you to send your paper until April 15th! Authors must register themselves until April 15th in order to guarantee that their papers will be properly inserted into the concurrent sessions.

Query: iaee conference: all
Summary:
Papers: 239  Cites/paper: 2.82  h-index: 11  AWCR: 103.27
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10th IAEE EUROPEAN CONFERENCE

7-10 September 2009 in Vienna, Austria

Energy, Policies and Technologies for Sustainable Economies

Conference Programme

SESSION 7-VI: WIND POWER AND ELECTRICITY MARKETS
- Geheime Ratstube | Thursday | 13:45-15:30

- Matthias Pickl (UNIVERSITY OF APPLIED SCIENCES KUFSTEIN), Erich Wagner (ENERGIEALLIANZ), Franz Wirl (UNIVERSITY OF VIENNA): THE IMPACT OF INTRODUCING 7-DAY-TRADING ON THE AUSTRIAN ELECTRICITY MARKET

Austrian Association for Energy Economics

AAEE
Overview

The Friday-Monday effect in stock and other exchange markets is a well-documented phenomenon linked to the interruption of the usual flow of information during weekends. In the case of electricity markets, this information break is of particular concern for day ahead trading auctions. The reasons are that weather forecasts become increasingly unreliable with the forecast horizon (three days on any Friday in a 5-days trading regime) but are crucial to predict demand and even more crucial renewables (e.g., wind energy). In the beginning of October 2008, the seven-day electricity trading mechanism was introduced on the European Energy Exchange to create a more efficient continuous market that offers trading participants the possibility of enhanced portfolio optimization. Simultaneously, the Austrian Green Electricity Settlement Agency (OEMAG) decided to allocate green electricity production forecasts on a daily basis to reduce prediction uncertainties which were rising recently due to the growing wind power generation share. This institutional change provides a unique real-world experiment how continuous trading enhances the efficiency of markets in particular of electricity markets. Of course these efficiency gains must be weighed against the costs of setting up and running trading all 7 days.

More precisely, this paper analyses the impact of the newly introduced 7-day electricity trading mechanism on the Austrian renewable electricity market. Specifically, it is investigated whether the daily trading on electricity exchanges, like the German EEX, and the daily green electricity allocation by the Austrian Green Electricity Settlement Agency (OEMAG), as envisioned, indeed lead to (i) a reduction of the green electricity production forecasting uncertainties and (ii) a generally more efficient electricity market with accompanying lower costs. Furthermore, we analyse whether (iii) 7-day trading helps to mitigate the Monday effect that is often observed on exchanges. Finally, we investigate whether or not (iv) the underlying market design might tempt OEMAG to systematically increase its forecasts on green power generation, because its remuneration exceeds the costs of buying any shortfall in the market.

Methods

The decisions to trade electricity and allocate green electricity production daily from Monday to Sunday, rather than only from Monday to Friday, serve as an excellent natural experiment that allows us to analyse the impacts of an exogenous variation in market settings on the Austrian renewable electricity market. That is, as has become popular in energy research, some kind of event study is applied.

The analysis is performed by applying statistical and econometric methods in SPSS to a unique data set containing time series of green power allocation from “other renewables” (not “small hydro”) balancing deviation and balancing prices in the APG control area of eastern Austria. Additionally, we use data from the European Energy Exchange to analyse electricity prices. The period analysed comprises the six months from October 2008 to March 2009.
Results
Preliminary results tend to confirm expected outcomes: Firstly, results show that the new market design reduces forecasting uncertainties by 26.27% (highly significant) and, secondly, on average also lowers costs of electricity balancing (highly significant). Whether this improved efficiency is covering the incremental costs of seven- instead of five-day trading and whether smaller energy exchanges, like the Austrian EXAA, are likely to make the same move remains to be investigated. Furthermore, seven-day trading seems to have a positive effect (even if not statistically significant) on mitigating the Friday-Monday effects on energy exchanges, thus decreasing price volatility on power exchanges. Lastly, the new market design makes the Austrian Green Electricity Settlement Agency systematically underestimate its forecasts on green power generation (highly significant) versus actual green power production. However, even here the new market design narrowed downed the negative forecasting tendency when compared to the results of the previous market mechanism.

Conclusions
In conclusion the new market mechanism of 7-day electricity trading seems to improve availability of renewable electricity (and presumably also demand) which should make the market more efficient: At least the three hypothesis as envisioned appear to point into this direction. Whether this improved efficiency is covering the incremental costs of 7- instead of 5-day trading and whether smaller energy exchanges, like the Austrian EXAA, are likely to make the same move, remains to be investigated.

References
This is to certify that Matthias Pickl presented the paper entitled

Enhancing the EUs energy supply security - an evaluation of the Nabucco Project

at the 33rd Annual Conference of the International Association for Energy Economics (IAEE), 06–09 June 2010, Rio de Janeiro, Brazil.

José A. Scaramucci
General Conference Chair
ENHANCING THE EU’s ENERGY SUPPLY SECURITY –
AN EVALUATION OF THE NABUCCO PROJECT AND AN INTRODUCTION TO ITS
OPEN SEASON CAPACITY ALLOCATION PROCESS

Overview
The Russian monopolistic dominance of the European Union’s natural gas supplies has put the independence of the EU foreign policy at risk (Schaffer, 2008). Currently roughly a third of European Union gas uses comes through Kremlin-controlled east-west pipelines (The Economist, 2009) and some sources even reckon that half of all the gas the EU imports come from Russia (Von Hirschhausen & Meinhart & Pavel, 2005). Thus Europe may in many respects be seen as a captive market, largely dependent on pipeline supply from Russia (European Gas, 2007). In addition, the Kremlin has in recent years several times abruptly cut off gas deliveries after disputes with transit countries such as Ukraine. This is quite scaring considering that eighty percent of natural gas from Russia travels to Europe through Ukraine (Freifeld, 2009). This paper shall give an introduction to and overview of the Nabucco project – by some named the most economic link to new gas (RWE, 2009) and even baptised the project of the century (Ozkan, 2009) – which might potentially enhance the EU’s energy supply security, one of the top three priorities within the EU (Percebois, 2008), in future years. Furthermore, an introduction to the Nabucco Open Season Capacity Allocation Process is given.

Applying empirical methods and competitive benchmarking analysis four hypotheses related to the Nabucco natural experiment are evaluated: while hypotheses (1) and (2) focus on the strength of demand for the Nabucco pipeline, hypotheses (3) and (4) examine fair usage rights and overall cost effectiveness of this project.

Hypothesis 1: A new gas pipeline enhances the European Union supply security for natural gas.
Hypothesis 2: The Nabucco gas pipeline capacity is strongly demanded by gas shippers.
Hypothesis 3: The Nabucco gas pipeline provides a fair capacity allocation for third party shippers.
Hypothesis 4: The Nabucco gas pipeline is a cost effective way to bring new gas to Europe.

Methods
The research methods applied in this paper are manifold. In fact a combination of natural experiment setting, public data analysis, competitive benchmarking and empirical market survey are applied. First, the Nabucco project itself serves as an excellent natural experiment (Meyer, 1995) that allows us to analyse the four key hypotheses outlined in the previous section. As has become popular in energy research (Pickl & Wagner & Wirl, 2009; Wu & Lampietti & Meyer, 2004; Asche & Osmundsen & Sandmark, 2006; Douglas, 2006; Florio, 2007; Bellas & Lange, 2008), an event study is carried out. Furthermore, publicly available data from different companies’ web sites and other public sources is collected. This data is then analysed using competitive benchmarking (e.g. between the different pipeline projects that are currently in the planning stage). Finally, an empirical market survey is conducted with 54 potential gas shippers. By inquiring their potential gas supply and demand in future years, inferences regarding the expected Nabucco pipeline capacity utilization – and hence overall necessity for the Nabucco pipeline for Europe – can be drawn. This empirical market survey serves as an important input factor for the upcoming Nabucco open season capacity allocation process.

Results
Four main research questions are posed centering on the strength of demand for the Nabucco pipeline (H1 and H2), fair access rights (H3) and overall cost effectiveness (H4). Initial results show that all four hypotheses encouragingly point into the envisioned direction: Increasing gas demand and decreasing indigenous production make a new gas pipeline necessary for Europe (H1). Next, the empirical survey demonstrated that the Nabucco gas pipeline is strongly demanded by gas shippers (H2). Furthermore, through its open season capacity allocation process, the empirical survey revealed that Nabucco provides a fair capacity allocation of fifty percent to third party shippers – that is also utilized – thus enhancing competition. Finally, competitive benchmarking showed that Nabucco is fact the most cost effective pipeline (H4). Indeed, it is the so far missing link and most economic connection to new gas for Europe (BP Statistical Review, 2006; RWE, 2009).
Conclusions

Based on these results it can be hoped for that Nabucco will not only remain a famous opera, but turns into one of the most successful energy projects for Europe. Already previous research showed that the “great natural gas pipeline game” can be won (Schaffer, 2008), but only by acting with rapid commitment. It shall be hoped that commerce is not taking back seat to politics (Freifeld, 2009). However, this possible success will still require a lot of work and commitment from the actual participants and Europe itself with strong multilateral direction (Weisser, 2007). Political support already in place in form of the Inter-Governmental Agreements – signed in Ankara on July 13th 2009 – between the governments of the Nabucco transit countries (IGA, 2009) seem a good start into the right direction to harmonize the legal framework by granting stable and equal transport conditions for all partners and customers. Now that there is an agreement in place, “this pipeline is inevitable rather than just probable”, as European Commission President José Manuel Barroso put it in July this year (Freifeld, 2009).

In further research the results of the actual open season capacity allocation process shall be analysed in detail. The undertaken empirical market survey presented here serves as an important input factor for the Nabucco open season capacity allocation process to be carried in the third and fourth quarter of 2010.

References


Certificate of Attendance

11th IAEE European Conference

Energy Economy, Policies and Supply Security: Surviving the Global Economic Crisis

25-28 August 2010, Vilnius, Lithuania

organized by
International Association for Energy Economics
Lithuanian Association for Energy Economics
Lithuanian Energy Institute

This is certify that

Matthias PICKL
University of Vienna

participated in the Conference and presented the paper

"Optimal Auction Design for Gas Pipeline Transportation Capacity – the Case of Nabucco"

David Williams
Executive director, IAEE

Jurgis Vilemas
General Conference Chair
Matthias Pickl¹, Franz Wirl², Yuri Yegorov³

OPTIMAL AUCTION DESIGN FOR GAS PIPELINE TRANSPORTATION CAPACITY – THE CASE OF NABUCCO

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Overview
As a response to the Russian dominance of the European Union’s natural gas supplies, major gas transportation pipeline projects are currently under way [1] in order to enhance the EU’s energy supply security, one of the top three priorities within the EU [2], in future years. Rather than buying and selling gas itself, many gas pipeline companies are set up as pure midstream gas players: they develop and construct pipelines, and as a requirement to obtain financing, rent transportation capacities on long- and short-term basis to interested shippers. In order to allocate gas transportation capacities special forms of auctions are carried out to allow potential shippers to express their interest in project participation and to make firm bookings. In recent years, auctions have emerged as one of them most successful allocation mechanisms in microeconomic theory and game theory. From an economic perspective, auctions are an appropriate mechanism for allocation as they tend to be beneficial with regards to distributional and efficiency goals [3 and 4]. However, different auction designs and allocation mechanisms can lead to different outcomes. Therefore the choice of auction rules is a decisive one [5]. This paper shall give a mathematical formulation of an optimal auction design for gas pipeline transportation capacity. Furthermore, the Nabucco Gas Pipeline Project – considered by some to be the most economical link to new natural gas sources – is taken as case study to experimentally and empirically show the results of such auction design.

Methods
The research methods applied in this paper are manifold. In fact, a combination of empirical market survey of auction volumes and bid patterns, mathematical formulation of allocation mechanism design and experimental testing of auction allocation is carried out.
First, potentially optimal auction designs are mathematically formulated to achieve its strategic goals. In this way this paper follows eminent auction theory papers such as [6, 7, 8, and 9]. In the course of doing so different allocation mechanism designs are proposed.
Next, an empirical market survey is conducted with 54 potential gas shippers to investigate the expected auction volumes and bid volume patterns. More specifically, the 54 most likely Nabucco gas shippers (focusing on company size and regional market focus) were selected from a customer-relationship-management (CRM) software. Contacted shippers include the six Nabucco shareholder shippers and the biggest gas companies within the specific Nabucco regional market focus. Subsequently, the market survey participants were contacted in the period 2008 to 2009 per postal letter including a project introduction and a written questionnaire. Out of these 54 potential Nabucco gas shippers, 21 provided a response whereof 17 furnished sufficiently concrete answers to be included in the evaluation of the auction volumes and bid patterns.
Finally, the different proposed allocation designs are experimentally tested using the auction volumes and bid patterns outcomes of the empirical market survey. That is, we use the test bed approach of experimental economics. The use of laboratory as a test bed for complex auctions in complex environments began with [10, 11, 12, and 13]. The outcomes are evaluated on two grounds: revenue raising potential and fairness. This experimental testing serves as an important input factor for the upcoming Nabucco Capacity Auction and resembles a real life auction application as in [14] and [15].

Results
Results show that the Nabucco auction design is a sequential (non-binding, binding, shareholder shipper / non-shareholder shipper), four-dimensional/multi-attribute (tariff, distance, flow rate, years), and partly first price (i.e. first revenue) auction, with multiple winners. Similar to a Walrasian auction the tariff charged is the one that is concluded when supply and demand balance. The optimal auction design for determining the most beneficial set of auction winners is selected based on four different allocation design mechanisms. Preliminary results show that (i) allocation based on “highest individual revenue” yields the weakest outcomes in terms of both total pipeline revenue raising potential and fairness. Second (ii) allocation based on a mixture of first assigning “highest individual revenue” bids combined with after a certain cap assigning “lowest individual revenue” bids reaches more favourable outcomes on both evaluation criteria than (i). Pure “optimization” (iii) leads to the best results in terms of revenue maximization, but falls short of a fair and transparent allocation design. Finally, “pro rata” allocation outcomes (iv) have an advantage of transparency and simplicity and can result in efficient allocation in the case of truth revealing bidders. However, strategic players under certain incentives might submit not truth revealing bids, and this case is still under evaluation.

Conclusion
This paper shows that different auction designs and allocation mechanisms can lead to different outcomes therefore making the choice of auction rules a decisive one. Clearly a trade-off between revenue maximization (i.e. in the interest of the pipeline owner) and fair and transparent allocation design (i.e. wished for by regulators to achieve third party access and competition) can be observed. In future research the real life Nabucco Capacity Auction will be carried out and the results of its auction design presented and analysed.

References
6.5. Additional Book Chapter
Chapter Contribution to upcoming book on Cost Effectiveness Analysis

Book Chapter Title:
Cost Effectiveness Analysis of International Gas Pipeline Projects

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PREPARED FOR:
Nova Science Publishers, Inc.

September 2010
# Table of Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>3</td>
</tr>
<tr>
<td>1. Introduction</td>
<td>4</td>
</tr>
<tr>
<td>2. Method</td>
<td>8</td>
</tr>
<tr>
<td>3. Investigated Pipelines</td>
<td>10</td>
</tr>
<tr>
<td>4. Results</td>
<td>15</td>
</tr>
<tr>
<td>5. Conclusion</td>
<td>18</td>
</tr>
<tr>
<td>References</td>
<td>19</td>
</tr>
</tbody>
</table>
Abstract

With the long-term market outlook for increased global gas demand, major gas pipeline projects are planned for the future in order to enhance the security of energy supplies around the world. In fact an estimated 140 billion USD are predicted to be spent on pipeline construction in the period 2010 to 2012 as world gas demand is expected to grow 1.5%-2.0% per year through 2030.

Gas pipeline projects are predominantly regulated natural monopolies and as a result are generally subject to regulatory oversight. At the same time as the process of liberalization of global energy markets progresses, cost effectiveness of these often competing pipeline projects is crucial in order to provide competitive transport tariffs for potential shippers.

This chapter presents a new methodological framework for defining cost effectiveness of international gas pipeline projects. The proposed methodological framework improves to fulfill the goal of cost effectiveness by linking cost to the length of pipelines.

The proposed methodological framework is then applied to actual data. The major pipeline projects currently under way are benchmarked against each other. The developed framework makes a comparison of these gas pipeline projects possible based on publicly-available information on gas supplies, gas markets, transportation capacities, pipeline length, and capital expenditures and provides for a like-for-like quantitative comparison. In this way a benchmark for defining cost-effectiveness of any international pipeline project is determined. This will assist in evaluating cost effectiveness of international gas pipeline projects and will further pave the way for natural gas to become the major bridge energy source of the near future.
1. Introduction

As a consequence of the long-term market outlook for increased global gas demand (Bothe & Lochner, 2008; Kjärstad & Johnsson, 2007; OME, 2006), a plethora of gas pipeline projects are at various stages of planning. Investments in pipeline construction in the period of 2010-2012 are estimated at 140 billion USD (see Figure 1). This increased interest in pipeline development raises the important question of how to determine or estimate cost-effectiveness of international gas pipeline projects. Indeed, as the liberalization process of global energy markets progresses forward, one of the main determining factors in the outcome of competition between some pipeline projects (Jamasp & Pollitt, 2008; Cremer & Gasmi & Laffont, 2003) is projects’ transport tariffs cost-effectiveness.

Figure 1: Estimated USD 140 billion pipeline investment - Period 2010 to 2012 (European Gas Conference, 2010)

In Europe this development is even more severe: On the one hand the growth in demand for natural gas is expected to continue in the next 20 to 25 years (BCG, 2005). As can be seen in Figure 2 (left), European gas consumption will grow – largely due to increased gas-fired power generation (Bothe & Lochner, 2008; Kjärstad & Johnsson, 2007) – from approximately 500 bcm in 2005, valued at about USD 100 billion (Schaffer, 2008), to about 816 bcm in 2030 (OME, 2006). This translates to an average growth rate of 2% per annum.¹ On the other hand, as the indigenous gas production of the European Union declines (BCG, 2005), a growing gap between gas production and gas demand (see right side of Figure 2) – can be

¹ Latest estimates by the International Energy Agency (IEA World Energy Outlook, 2009) partly update these demand estimates due to the general economic downturn to a European Union gas demand of about 619 bcm in 2030. However, the general trend for strong growth in gas demand remains.
expected in the coming years (IEA World Energy Outlook, 2008). This stems from the fact that, at its present rate of consumption, the EU has only a ten-year supply of natural gas within its own borders, making imports of natural gas a necessity (Schaffer, 2008). Thus, increasing gas demands on the one hand paired with decreasing EU production on the other makes a strong case for investing in new pipeline infrastructure (Lise & Hobbs & Oostvoorn, 2008; Finon & Locatelli, 2008; Mavrakis & Thomaidis & Ntroukas, 2006).

In Europe, the major playing field for new pipelines is the so-called Southern Corridor to the gas rich Caspian regions. Here, the main gas pipeline projects include Nabucco, South Stream, Interconnector Greece-Italy (IGI) and Trans Adriatic Pipeline (TAP). These projects may be considered as the missing link between vast sources of gas and potential gas consuming markets (BP Statistical Review, 2006). The Caspian Region, the Middle East and Egypt, which hold the world’s largest gas reserves, play a crucial role in terms of diversification of supply as well as security of supply for Europe (Mavrakis & Thomaidis & Ntroukas, 2006). The opening up of a fourth main supply corridor – might be considered as one solution to meet future EU gas demands (BCG, 2005). As such, these projects might provide a promising beginning for enhancing EU’s energy supply security in future years (Schaffer, 2008). These Southern Corridor pipelines (for a geographical overview please refer to Figure 3) – together with the Nord Stream project – will be utilized to develop a new methodological benchmark framework for assessing cost-effectiveness for gas pipeline development projects.

Figure 2: Left: Forecast of Gas Supply Europe (OME, 2006)  
Right: Forecast of EU Gas Production Decline (IEA World Energy Outlook, 2008)

At present, there are three main sources of gas for the European Union: Russia, Norway, and Algeria (BP Statistical Review, 2007; Kjärstad & Johnsson, 2007)
It is widely accepted that the main reason for the battle over pipeline transit routes (American Chronicle, 2009) is the Russian monopolistic dominance of the European Union’s natural gas supplies that has put the independence of the EU foreign policy at risk (Schaffer, 2008). Currently, roughly a third of the natural gas consumed by the European Union is delivered through the Russian-controlled east-west pipelines (The Economist, 2009); some sources even surmise that half of all the gas the EU imports comes from Russia (Von Hirschhausen & Meinhart & Pavel, 2005; The Economist, 2007). Thus the EU may, in many respects, be seen as a captive market, largely dependent on Russian gas supplies (European Gas, 2007). In recent years, the Kremlin has abruptly cut off gas deliveries several times after disputes with transit countries such as Ukraine. This is quite alarming considering that eighty percent of natural gas travelling from Russia to the EU passes through Ukraine (Freifeld, 2009). The new pipeline projects might potentially enhance the EU’s energy supply security, one of the top three priorities within the EU (Percebois, 2008). This chapter then also provides a new framework for determining the cost-effectiveness of international gas pipeline projects in doing so.

Section 2 of this chapter describes the applied research methodology and introduces the methodological framework for defining cost effectiveness of international gas pipeline projects. In Section 3 the
investigated pipelines are introduced. Section 4 presents and discusses results. Concluding remarks are provided in Section 5.
2. Method

A new methodological framework for defining cost effectiveness of international gas pipeline projects will now be introduced. By establishing a competitive benchmark the term “cost-effectiveness” is defined in the area of international gas pipeline projects, and a cost benchmark comparison of gas pipelines is then made possible. In addition, the proposed methodological framework facilitates the useful linking of cost-effectiveness by to pipeline length.

Competitive benchmarking is established by applying the proposed methodological framework to actual data. The major gas pipeline projects under planning in the EU (i.e., Nabucco, South Stream, Nord Stream (I and II), Interconnector Greece-Italy (IGI) and Trans Adriatic Pipeline (TAP)) are investigated in terms of cost-effectiveness – and serve as excellent natural experiments case studies (Meyer, 1995). As has become popular in energy research (Pickl & Wagner & Wirl, 2009; Wu & Lampietti & Meyer, 2004; Asche & Osmundsen & Sandsmark, 2006; Douglas, 2006; Florio, 2007; Bellas & Lange, 2008), a type of an event study with actual data is carried out.

The methodological framework – inspired by a previous publication (Pickl & Wirl, 2010) but extended for additional pipelines – for this cost effectiveness benchmarking exercise will now be outlined in detail. First, the input source for this competitive benchmarking utilizes publicly available information on transportation capacities, pipeline length, and capital expenditures for these pipelines. Figure 4 below summarises these projections.

<table>
<thead>
<tr>
<th>Project</th>
<th>Capacity (bcm per year)</th>
<th>Pipeline Length (km)</th>
<th>CAPEX (EUR bn)</th>
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<tr>
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<td>31,00</td>
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<tr>
<td>TAP</td>
<td>10,00</td>
<td>520,00</td>
<td>1,50</td>
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Figure 4: Major Gas Pipeline Projects: Capacities, Length, and Capital Expenditures (RWE, 2009; IEA World Energy Outlook, 2009; Reuters, 2007)

In addition, publicly available data from different companies’ web sites and other public sources are collected. These data are then analysed using competitive benchmarking (e.g., between the different pipeline projects that are currently in the planning stage).

To create like-for-like comparisons, a common gas supply start time (i.e. beginning of 2015), a common utilization rate (i.e. 90%), equal relative operational expenditures (i.e. 1.5% of capital expenditures), the same evaluation period of 25 years, and identical financial assumptions (i.e. 100% equity financing,
internal rate of return requirements of 11.5%) were chosen (own industry assumptions). Furthermore, for Nabucco, South Stream, IGI and TAP a common gas source (i.e. Azerbaijan off-shore Caspian Sea gas) is assumed. For Nord Stream (I and II) this is not the case for geographical reasons (see Figure 8 in next Section) – its inclusion is for transport cost benchmarking purposes only.

In the next step, to evaluate tariffs and provide for a competitive benchmarking, the following tariff cost functions methodology is applied:

$$NPV = \sum_{n=0}^{25} \frac{C_n}{(1 + r)^n} = 0$$

with $$C_n$$ … Cash flows per period so that

$$NPV = \sum_{n=0}^{25} \frac{(Tariff_2 \times PipelineCapacity \times UtilizationRate) - CAPEX - OPEX}{(1 + r)^n} = 0$$

with

- Tariff_2 … Total Tariff for the full pipeline distance per 1,000 m³ per year;
- PipelineCapacity … Pipeline specific as per Figure 4 above;
- CAPEX … Pipeline specific capital expenditures as per Figure 4 above;
- OPEX … Operational expenditures at 1.5% of Capital Expenditures;
- UtilizationRate … 90%;
- $$r$$ … 11.5%.

and

$$\frac{Tariff_1}{PipelineLength} \times 100$$

with

- Tariff_1 … Distance-related Tariff;
- PipelineLength … Pipeline specific pipeline length as per Figure 4 above.

By this method a benchmark for defining cost effectiveness of any international gas pipeline project is determined. The next section describes the investigated pipeline projects in more detail.
3. Investigated Pipelines

This section features a description of the pipelines that are included in the cost-effectiveness benchmarking. In general, the investigated pipelines include the major gas pipeline projects currently under planning in Europe – namely Nabucco, South Stream, Nord Stream (I and II), the Interconnector Greece-Italy (IGI) pipeline and the Trans Adriatic Pipeline (TAP). All these pipelines might potentially enhance the EU’s energy supply security, one of the top three priorities within the EU (Percebois, 2008), in future years.

These projects may be seen as the missing link between giant sources of gas and potential gas consuming markets (BP Statistical Review, 2006). Especially, the Caspian Region, the Middle East and Egypt, which hold the largest gas reserves worldwide, play a crucial role in terms of diversification of supply as well as security of supply for Europe (Mavrakis & Thomaidis & Ntroukas, 2006). The opening up of a fourth main supply corridor – next to Russia, Norway, and Algeria – might be considered as one solution to meet future EU gas demands (BCG, 2005). However, an important criterion for these pipelines to become reality is cost effectiveness.

Figure 5 below illustrates the envisioned geographic locations of these pipeline projects. In general, the introduction of open access to pipeline transportation capacity has unlocked two distinctive industries: the natural-gas market, where agents trade natural gas as a commodity, and the market for pipeline transportation services, where agents trade services to ship natural gas through the pipeline networks (Raineri & Kuflik, 2003). This is an important concept that will contribute to a competitive European gas infrastructure market since former contracts were often negotiated bilaterally in non-transparent and less competitive manners (De Joode & Van Oostvoorn, 2007). Following Smith, De Vany and Michaels (1990), the use of “Exchangable Transport Entitlements” – which gives the right to utilize, to lease, or to sell the pipeline capacity in a specific segment for a specific period – makes sure that the (scarce) capacity can be used by those who value it most, with the possibility of being resold in a secondary market (Raineri & Kuflik, 2003). Consequently, gas pipeline transportation becomes a property right, the gas pipeline becomes a transportation right supplier, and the owners of these rights offer transportation capacity (Walls, 1995). Subsequently each pipeline will be briefly described in a short paragraph.
The Nabucco project, which takes its name from the Giuseppe Verdi opera that the Consortium members attended after their first meeting, represents a new natural gas pipeline that will begin at the eastern border of Turkey and will connect the Caspian Region and the Middle East via Turkey, Bulgaria, Romania, Hungary with Austria and further on with Central and Western Europe gas markets (Nabucco, 2010). The pipeline length will be approximately 3,300 km, stretching from the Georgian/Turkish and Iraqi/Turkish border to Baumgarten in Austria. Additional feeder pipelines are also possible (RWE, 2009). Based on technical market studies, the pipeline has been designed to transport a maximum amount of 31 bcm per
year (Nabucco, 2010). Nabucco shareholders are RWE (Germany), OMV (Austria), MOL (Hungary), Transgaz (Romania), Bulgarian Energy Holding (Bulgaria) and Botas (Turkey). Currently, each shareholder holds an equal share of 16.67 % (Nabucco, 2010). Estimated investment costs including financing costs for the complete new pipeline system amount to approximately EUR 7.9 billion (RWE, 2009).

The South Stream pipeline project is Russia’s alternative pipeline project and by some seen as rival to the planned Nabucco pipeline. It will go across the Black Sea, and then through Bulgaria, Serbia and Hungary to Austria, or alternatively through Slovenia to Italy (MacDonald, 2008) extending over approximately 3,200 km. Project owners of this pipeline are Gazprom (Russia) and ENI (Italy). Furthermore EDF is expected to join this consortium in future. Based on industry information, the pipeline is planned to transport up to 63 bcm of gas annually. With that it is the biggest of all investigated pipeline projects. With costs of EUR 25 billion (American Chronicle, 2009; RWE, 2009), it is claimed to be not cost competitive, as according to analyst views it is too expensive (The Economist, 2009b). Moreover, as a Russian project it would not diversify Europe’s energy supplies away from Russia.

Nord Stream stands for another new natural gas pipeline project that will link Russia and the European Union via the Baltic Sea (see Figure 8). With 2,100 km in total length – and major portions of it offshore – it will be, when finished, the longest sub-sea pipeline in the world. The plan for the offshore pipeline is to build two parallel legs (Nord Stream I and II) each with capacity of 27.5 bcm per year for a total transportation capacity of up to 55 billion cubic metres of gas each year. Nord Stream is a joint venture of five companies. Gazprom holds a 51 percent stake in the joint venture. BASF SE/Wintershall Holding and E.ON Ruhrgas each hold 15.5 percent, and Gasunie and GDF Suez each have a 9 percent share (Nord Stream, 2010). Total pipeline costs are estimated to amount to EUR 17.0 billion (IEA World Energy Outlook, 2009; Reuters, 2007).
The Interconnector Greece-Italy (IGI) – also referred to as Poseidon project (IGI, 2010) – is a planned natural gas pipeline for the transportation of natural gas from the Caspian region to Italy. It is a part of the Interconnector Turkey–Greece–Italy (ITGI) pipeline system starting from Karacabey (Turkey), going over to Komotini (Greece), and from there passing the Ionian Sea to reach Otrantro in Italy (see Figure 9). The IGI pipeline will extend over approximately 807 km. Its project owners – the Italian firm Edison and the Greek Public Gas Corporation DEPA will spend EUR 1.1 billion to transport estimated 10 bcm on an annual basis to Europe.

Finally, the Trans Adriatic Pipeline (TAP) – as per Figure 10 – is a proposed pipeline project to transport natural gas from the Caspian and Middle East regions starting from Thessaloniki in Greece, through Albania and the Adriatic Sea to its Brindisi in Italy (TAP, 2010). The project is designed for a transportation capacity of 10 bcm annually. The shareholders of the Trans Adriatic Pipeline project include the Swiss EGL, the Norwegian Statoil and the German E.ON Ruhrgas. EGL and Statoil both own 42.5% in the project, while E.ON Ruhrgas holds a 15% share. The 520 km long pipeline will cost estimated EUR 1.5 billion.
Figure 10: Trans Adriatic Pipeline (TAP) Project (RWE, 2009)
4. Results

This chapter section presents the results of the pipelines’ cost effectiveness benchmarking and hence of defining cost effectiveness of international gas pipeline projects. Recalling section 2, the input source for this competitive benchmarking is publicly available information on transportation capacities, pipeline length, and capital expenditures of these pipelines. Figure 11 below restates these projections in a summarised form:

<table>
<thead>
<tr>
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Figure 11: Major Gas Pipeline Projects: Capacities, Length, and Capital Expenditures (RWE, 2009; IEA World Energy Outlook, 2009; Reuters, 2007)

To create like-for-like comparisons, a common gas supply start time (i.e. beginning of 2015), a common utilization rate (i.e. 90%), equal relative operational expenditures (i.e. 1.5% of capital expenditures), the same evaluation period of 25 years, and identical financial assumptions (i.e. 100% equity financing, internal rate of return requirements of 11.5%) were chosen (own industry assumptions). Furthermore, for the pipeline projects Nabucco, South Stream, IGI and TAP a common gas source (i.e. Azerbaijan off-shore Caspian Sea gas) is assumed. For Nord Stream (I and II) this is not the case for geographical considerations (see Figure 8 in Section 4), its inclusion is for transport cost benchmarking purposes only.

Next, to evaluate tariffs and provide for the competitive benchmarking and cost effectiveness evaluation, the tariff cost functions as outlined in Section 2 are applied: In this way a cost effectiveness benchmark for a distance related tariff and a total tariff is established.

Figure 12 shows the results of this competitive benchmarking of all pipelines under review and indicates the cost effectiveness benchmark for a distance related tariff and for a total tariff. Computed as the average of all pipeline tariff cost functions the cost effectiveness benchmark comes to EUR 4,69 (per 100 km / per 1.000 m³ / per year) for the distance related tariff and EUR 85,48 (for the full pipeline distance per 1.000m³ / per year) for the total tariff. A truly cost effective pipeline clearly meets both of these tariff benchmarks.
The results show that, under the stated assumptions, the Nabucco pipeline would reach a distance related tariff of EUR 2.38 (per 100 km / per 1,000 m³ / per year) and a total tariff of EUR 78.70 (for the full pipeline distance per 1,000 m³ / per year). The South Stream project would arrive at a distance related tariff of EUR 3.05 (per 100 km / per 1,000 m³ / per year) and a total tariff of EUR 97.59 (for the full pipeline distance per 1,000 m³ / per year). For Nord Stream the cost function computation yield a distance related tariff of EUR 3.62 (per 100 km / per 1,000 m³ / per year) and a total tariff of EUR 76.01 (for the full pipeline distance per 1,000 m³ / per year). Separate cost effectiveness results are provided for the different pipeline legs of Nord Stream I and II. The Interconnector Greece-Italy (IGI) shows a distance related tariff of EUR 2.90 (per 100 km / per 1,000 m³ / per year) and a total tariff of EUR 90.00 (for the full pipeline distance per 1,000 m³ / per year). Finally, the Trans Adriatic Pipeline (TAP) would have to charge a distance related tariff of EUR 6.20 (per 100 km / per 1,000 m³ / per year) and a total tariff of EUR 104.00 (for the full pipeline distance per 1,000 m³ / per year) to meet the like-for-like internal rate of return assumptions.

So which of these pipelines meet the cost effectiveness benchmark? As stated before a fully cost effective pipeline clearly has to satisfy both tariff benchmarks: distance related tariff and total tariff. This is the benchmark for defining cost effectiveness of an international pipeline project according to this book chapter. Figure 13 below indicates that distance related tariff cost effectiveness is meet by 4 out of 5 investigated pipeline projects: Nabucco, South Stream, Nord Stream and the Interconnector Greece-Italy (IGI) pipeline. The Trans Adriatic Pipeline (TAP) fails the distance related tariff cost effectiveness criterion. When looking at the total tariff cost effectiveness only Nabucco and Nord Stream are cost effective. South Stream with costs of EUR 25 billion (American Chronicle, 2009; RWE, 2009), Russia’s alternative pipeline across the Black Sea, the South Stream project through Bulgaria, Serbia and Hungary to Austria, or alternatively through Slovenia to Italy (MacDonald, 2008), will not be cost effective and therefore not competitive, as according to analyst views it is too expensive (The Economist, 2009b). Moreover, it would not diversify Europe’s energy supplies away from Russia. Also the Interconnector...
Greece-Italy (IGI) pipeline and the Trans Adriatic Pipeline (TAP) are not total tariff cost-effective. Therefore – when reviewing both distance related and total tariffs – only two of the major gas pipeline projects currently under planning in Europe are cost effective: the Nabucco project and Nord Stream.

Figure 13: Cost Effectiveness – Both Distance Related and Total Tariff Criterion only met by Nabucco and Nord Stream

Compared to Nord Stream (I and II), Nabucco is more cost-effective on a distance-related tariff basis (34%, i.e. EUR 2.38 vs. EUR 3.62) and on almost equal conditions in terms of total tariff (i.e. EUR 78,70 vs. EUR 76,01). The minor total tariff surplus comes from the fact that Nord Stream is considerably shorter in terms of pipeline length (2.100 km vs. 3.300 km) than Nabucco. From a strategic point of view for Europe it shall furthermore be mentioned that in any event, neither South Stream nor Nord Stream would diversify the EU’s energy supplies away from Russia.

The only true alternative to new pipelines – increased liquefied natural gas (LNG) imports – seems unpromising. LNG with 55.3 billion cubic meters of imports into Europe in 2008 (E.ON Ruhrgas, 2009) is currently just providing about 10% of overall supplies. While import capacities might not be the main constraining factor for LNG, it will certainly not be able to shoulder the increasing gas supply requirements of Europe by itself. In any event, even though substantial decreases are happening, LNG is still more costly than piped gas at distances up to 3.000 to 4.000 kilometres (Kjärstad & Johnsson, 2007).

Therefore, all pipelines achieving the outlined cost effectiveness benchmark of EUR 4,69 for the distance related tariff and EUR 85,48 for the total tariff can be named gas pipeline that transport new gas to Europe in a cost-effective way. In this way, a more competitive European gas market with accompanying lower costs can be expected. This can only benefit European consumers.
5. Conclusion

A new methodological framework for assessing the cost effectiveness of international gas pipeline projects was presented and discussed. Market developments (i.e., increasing global gas demand, a plethora of pipeline projects under planning, and the thus far lack of a cost-effectiveness benchmarking framework) necessitate the development of such a tool to further pave the way for natural gas to become the major bridge energy source of the near-future.

The proposed methodological framework for assessing the cost effectiveness of international gas pipeline projects includes two criteria: i) a distance related tariff benchmark and ii) a total tariff benchmark. After outlining the methodological framework the tool was applied to actual data of five major pipelines under planning in the EU: Nabucco, South Stream, Nord Stream, the Interconnector Greece-Italy (IGI) pipeline and the Trans Adriatic Pipeline (TAP). These were assessed utilizing publicly available information on transportation capacities, pipeline length, and capital expenditures and by creating like-for-like assumptions in terms of gas supply start time, gas source, utilization rates, operational expenditures, evaluation periods, and financial assumptions.

The outcomes show that when considering both the distance related tariff benchmark and the total tariff benchmark only two of the major gas pipeline projects (the Nabucco project and Nord Stream) currently under planning in Europe are indeed cost effective. As the liberalization of global energy markets progresses, increasing pipeline-to-pipeline competition (Jamasb & Pollitt, 2008) should only result in the construction of cost-effective gas pipelines. It was demonstrated that the new methodological framework presented here can assist in evaluating the cost effectiveness of any given international gas pipeline project.

It should be noted that the current methodology does not account for accessibility and exploration costs of the gas supply side, which are considered to be exogenous parameters. Naturally, these parameters have an impact on the overall economics of any pipeline project and are needed for complete netback calculations (Reuters, 2010). The exclusion of these parameters from the current analysis is partially mitigated by assuming a common gas source for the calculations. Nevertheless, the author hopes that the presented methodological framework can become the tool of choice for assessing cost-effectiveness of any given international gas pipeline project.
References


## 6.6. Curriculum Vitae

### PERSONAL INFORMATION

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### SUMMARY

Matthias Pickl is an energy industry manager and energy markets researcher. He studied business administration at the Vienna University of Economics and Business (2000 - 2003). Next, he worked as a commercial project manager / representative of the local Permanent Establishment on a power plant construction project in Greece (VA Tech / Siemens, 2003 - 2005). In this period he also completed a part-time MBA at the ACT American Graduate School (Boston, Massachusetts). From 2005 to 2009 Mr. Pickl was a Regional Commercial Manager (General Electric) in Milan / Italy and Vienna / Austria with a focus on modelling and negotiating gas power plant service agreements with energy corporations all over Europe. Since April 2009, Mr. Pickl is an Associated Professor (FH) for Energy Management at the University of Applied Sciences in Kufstein. Since November, 2009 Mr. Pickl is a Gas Capacity Trading Manager for Nabucco Pipeline International responsible for the preparation of a EUR 60 billion auction. He is a PhD candidate of Energy Economics at the University of Vienna (expected Graduation End of 2010).

### EXPERIENCE

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<th>Company</th>
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<tr>
<td>Manager – Capacity Trading</td>
<td>Nabucco Gas Pipeline International</td>
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<td>Associated Professor (FH) for European Energy Management</td>
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<tr>
<td>Regional Commercial Manager Central &amp; Eastern Europe</td>
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</tr>
<tr>
<td>Research Assistant</td>
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<tr>
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<tr>
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<td>Sept 02 - Dec 02</td>
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### EDUCATION

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<tr>
<td>Master of Business Administration (MBA)</td>
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</tbody>
</table>

LANGUAGES & DISTINCTIONS

Languages:  
- German (native)  
- English (excellent)  
- Italian (fluent knowledge)  
- Spanish (basic knowledge)  
- Greek (basic knowledge)  
- Russian (basic knowledge)  

PhD:  
- Grade Point Average of 1,0 (Very Good); Publications in International Journals.

MBA:  
- John Pappajohn MBA Student of the Year Award for Academic Excellence, Scholarship Recipient for Distinguished Academic Achievements.

Magister:  
- Placed in Center of Excellence; Award of Two Merit-Based Scholarship, Completion of Studies in 6 Semesters.

Publications


