IGERT
Integrative Graduate Education and Research Training

Sustainable Grid Integration of Distributed and Renewable Resources

The University of Texas at Austin
Cockrell School of Engineering

Trip Report

Author:
Thomas Deetjen
Department of Mechanical Engineering

Supervisor:
Dr. Michael Webber

August 11, 2015
1. Introduction

With support from my IGERT fellowship, I traveled to Europe from May 18 through June 27, 2015 in order to gain a better understanding of the European and German perspective on energy. While most of my time was spent in Munich as a guest researcher at the Technical University of Munich, I was able to attend a conference, visit some interesting energy-related sites, and present my current research work at two universities. This Trip Report is in chronological order. It highlights my academic and travel experiences, and my thoughts on what I have learned from this trip.

As stated in my research trip application, my objectives for this trip were to:

- Improve my understanding of Europe’s and Germany’s energy grid and energy policies
- Learn how Germany views its current power grid situation. Understand the social and political sources of the German renewable energy culture and the technical outlook on the price, reliability, and renewability of Germany’s power grid
- Improve my understanding of the European and German perspective on the American power grid and American energy culture
- Apply this new knowledge towards my research on sustainability in the Texas power grid
- Build strong connections with TUM faculty and graduate students
- Receive feedback and a European perspective on my research projects by presenting at conferences and on the TUM campus
- Practice my German language skills, particularly my technical vocabulary and literacy

I was able to achieve all of these objectives on my trip to varying degrees. My understanding of the European energy market and culture has greatly improved, and it will inform my future research work at the University of Texas.
2. May 18 – May 22
European Energy Market Conference
Lisbon, Portugal

My trip began in Lisbon where I attended the 2015 European Energy Market Conference. The three-day conference covered a broad array of topics and gave me a great introduction to the European view on energy. Each day began with key note speakers who discussed regulatory constructs, market structures, and environmental implications that are important for considering the trajectory of the European energy market. Subsequent breakout sessions allowed students and faculty to present their work to the other attendees.

![Figure 1: Me in Lisbon, Portugal for the European Energy Markets conference.](image)

This structure allowed me to gain a broad understanding of the European energy market from the key note speakers and to learn about ongoing research projects that are more closely related to my interests in renewable energy integration and electricity markets.

After the conference was over, I had the impression that Europe tends to prioritize social needs and reforms over economics more often than in the Texas. They often use regulatory requirements and market incentives to promote carbon dioxide emissions reductions and increased levels of renewable energy. In fact, their 20/20/20 plan is built around greenhouse gas reduction, renewable energy generation, and energy efficiency goals. Their promotion of
these goals has created a heavily subsidized, expensive, and clean energy market. This challenges the Texan perspective that prioritizes economics and says that renewable energy and greenhouse gas reductions are worthwhile if they make economic sense. Rather than trust government regulations and incentives to promote the best energy technologies, Texans would probably lean more towards changing our energy market structures to correctly value emissions externalities and allowing market structures to do the rest.

This European prioritization of clean energy goals above economics was apparent in many of the student presentations. Much of their research work envisioned solutions with little economic potential. This contrast between Texas and Europe which I was introduced to at this conference became a common theme of the discussions I had during my trip, and is an important distinction for understanding the difference between our policies and markets.

Another important facet of the European energy perspective is the necessity of compromise and cooperation. The EU has little real power or influence related to the different countries’ energy markets, so any new initiatives must be agreed on voluntarily. To complicate things, European culture is much less cohesive than American culture and the cultural boundaries to collaboration are more pronounced. The cooperation between countries that has been achieved in the energy and environmental sectors, while not ideal, is impressive. It seems like the difficulty of gaining consensus creates strong support for the initiatives that actually do get passed.

These two underlying perspectives have helped me understand why Europeans have so much frustration towards the United States’ lack of leadership in these areas. Europeans, especially Europeans in my generation, seem to have difficulty understanding a system that is so strongly geared towards free markets, and they find our lack of cohesive energy policy laughable.

Regardless of which perspective is more successful, the themes I picked up from this conference at the beginning of my trip were an important foundation for other lessons I would learn during my time abroad.

The conference also broadened my understanding of electricity markets and the complications of renewable energy integration. I learned about the successes and failures of European energy market design, the difficulty with correctly remunerating electricity generation capacity, important considerations for modeling electricity markets, and other research-oriented lessons that are immediately applicable to my work. These lessons rounded out my experience at the conference, and I left Lisbon with a better understanding of the European perspective on energy, new knowledge about energy research, and some ideas on how I can apply this knowledge to my own research and opinions about energy stewardship.
During the last year, I befriended two German exchange students while they were visiting the University of Texas at Austin. Both of these students are advised by Professor Thomas Hamacher at the Technical University of Munich, and I was invited to work out of their research office while I was in Munich. Working at this office every day provided me with many opportunities to talk with other students and professors about the projects they are working on and to see how I could apply their research methodologies to my own work. Below is a summary of the students and professors I met with during my time in Munich:

**Figure 2: Hiking in the Alps near Munich, Germany.**

Professor Thomas Hamacher: Professor Hamacher hosted me in his research office space during my stay in Munich. He has been with TUM for some years and recently became the director of the Munich School of Engineering, a collaborative group made up of many professors and researchers around the university. His research group focuses on energy modeling, micro-grids, and islanded electricity systems in developing countries. I enjoyed going hiking with him and his wife one Saturday, and we had many good discussions about German and European energy perspectives. He has invited me
to work with a TUM master’s student to continue building ties between UT and TUM, and has offered to host me again in the future if I decide to come back.

Matthias Hueber: Matthias is a 4th year PhD student in Professor Hamacher’s research group. He collaborates with mathematicians to expand the theory behind unit commitment and dispatch modeling to correctly account for generator ramping capabilities. He also collaborates with engineers to improve a unit commitment and dispatch model of the European electricity market. Matthias’ research work is similar to my own, and I enjoyed hearing how he improved his electricity model. I am considering similar methodologies as I improve my own model.

Laura Stolle: Laura is a master’s student who works with Matthias Hueber. She helped Matthias improve his unit commitment and dispatch model of Europe by improving the representation of the European transmission network. This was accomplished by breaking Europe into hundreds of zones, and using DC electric theory to approximate the size and resistance of the transmission capacity running between each of the zones. Her work is very interesting to me. I will be reading through her master’s thesis as I consider strategies for representing electricity transmission in my own model.

Dominic Hewes: Dominic is a PhD student in a different TUM department. He has worked with Matthias Hueber on some of his projects, but focuses more on the electricity calculations used in transmission modeling. Dominic is building a model capable of 10 ms dynamic simulations of electricity flow through a network. He hopes to use this model to see how renewable energy locations within a grid affect the stability of the grid and to estimate where new transmission should be added. His work is interesting to me because it looks at renewable energy at the distribution level, which is a good shift in perspective from the transmission level difficulties with which I am familiar.

Magdalena Dorfner: Magdalena is 1st year PhD student in Professor Hamacher’s research group. She has a background in analyzing the uncertainty in unit commitment and dispatch electricity market modeling. Her current work involves the simultaneous optimization and iteration of multiple electricity models from different geographic areas and she plans on looking at how solar panel locations and orientations and wind turbine sizes influence the electricity market. Magdalena had some helpful comments on how I could account for scarcity prices in my own electricity model. She is also interested in visiting UT Austin in the next couple of years.

Henry Martin: Henry is a new master’s student at TUM. He has taken a number of classes on data processing and electrical transmission and is looking for a project to apply these skills to as he decides on his master’s thesis. Magdalena Dorfner recommended that he ask me about potential collaboration opportunities since he is interested in visiting UT Austin, and Professor Thomas Hamacher is interested in
supporting this arrangement. I am hopeful that this opportunity will come to fruition. It is a good example of the collaboration that TUM hopes to encourage with UT Austin.

Johannes Dorfner: Johannes is 4th year PhD student in Professor Hamacher’s research group. His work involves creating models that separate cities into nodes and connections in order to observe how heat, electricity, and distributed energy flows in a distribution network based on the locations and magnitudes of demands in the network. He hopes this model can be used by distribution network operators to identify transmission constraints in their networks. He made some good suggestions of software and techniques that I can use to search for trends in some of the data that I am working with in my own work.

Wishva Solanga: I heard Wishva give a master’s thesis presentation about design criteria for electricity markets with high shares of renewable energy. He used the merit order effect to show that renewable energy sources depress the profitability of other generators by shifting the merit order curve. He also observed the effects of FITs, FIPs, Quotas, and other renewable energy incentive structures and suggested that intra-day trading may be a better way for renewables to bid into the electricity market rather than competing in the day-ahead market used by thermal generators.
Dr. Vicky Cheng: Dr. Cheng is a research associate who joined TUM a couple of years ago. She has a background in energy and transportation modeling at the city level. Her new focus is on building an electricity and heat model of Munich which incorporates building energy consumption estimation models and the electricity and heat distribution networks utilized by the Munich municipal utility. The goal of this model is to help inform better policy decisions about urban development projects around Munich. We had a good discussion about the possibility of using heating and cooling storage as proxies for electricity storage.

I also gave a presentation to Professor Hamacher’s group. I discussed the Texas electricity grid, my current research results, and future research ideas. I enjoyed sharing my work with them, and received some great feedback that will help me in the future.

Figure 4: I present my current research to Professor Hamacher and his research group.

During my time in Munich, I was also able to attend a session of the TUM Speaker Series put on by the TUM Business Club in which a topic is debated by a number of industry leaders. I listened to Robert Flaeching from the Saudi Arabian Economic Advising Office, Phillippe Boisseau from Total, Ulrike Andres from TAL trans-alpine pipeline, and Thomas Raffeiner from Mobility House discuss the future of electricity generation. The debate centered on the necessity of clean energy and how quickly and feasibly it can be incorporated. Thomas Raffeiner suggested that the major problem with current policy is that it fails to correctly price the externalities.
associated with electricity generation. If carbon emissions, land degradation, and pollution were correctly taxed or priced, then the cost of renewable energy would already be at a competitive price. Phillippe Boisseau agreed on principal, but commented that the debate on how to price these externalities was far from reaching a consensus, and even if the correct externality prices could be applied to the market immediately, it would take decades before the manufacturing sector could grow and produce enough renewable energy hardware to beginning satisfying the new demand. This debate confirmed some of the thoughts I have had about the incorrect valuation of electricity generation, but was also a good reminder that the economies and industrial sectors which create renewable energy technologies need time to scale their operations.

Munich was a wonderful city to base my operations from. It is often described by the locals as the largest village in Germany, insinuating that, while Munich has a large population, it has the feel of a small village in many aspects. I agree with this perspective and found the city to be welcoming, cozy, natural, and not overly crowded. The history and architecture around the city are impressive, and the walkability and ease of using the public transportation made it very easy to get around. I especially enjoyed the parks in the city – the English Garden, Flaucher Park, and the Nymphenburg Palace Gardens. I would definitely consider returning to Munich for a prolonged stay if it becomes an option for me in the future.
I spent a weekend in Austria in order to visit the Krameterhof sustainable farm in Ramingstein. The original owner of the farm has written a few of my favorite farming books, and I enjoyed touring the farm with his son, who currently owns Krameterhof.

Figure 5: Krameterhof sustainable farm in Ramingstein, Austria.

Agriculture is an important user of raw materials, electricity, water, and energy throughout the world. While modern industrial farming has become an intense user of all these inputs, the “permaculture” method developed at Krameterhof farm aims to utilize organic natural cycles to make better use of natural resources. The farm is situated on a steep alpine slope with limited water resources and a longer winter than the valley below. While the tracts of land surrounding the farm have mostly been given up to timber farming, Krameterhof farm utilizes a number of techniques to profitably produce vegetables, meat, and even a rare root used for producing an alcoholic beverage. The farm is designed to capture the small water flow from a few natural springs and spread it out over as much of the land as possible. This is accomplished by creating a number of terraced pastures with numerous small ponds. As the water flows from higher
elevation ponds, across the farm, to lower elevation ponds, it irrigates the land and provides an aerated water infeed for the fish populations being raised there. Additionally, the farm has installed some microturbines to convert energy from the flowing water into electricity. This electricity source produces all of the electricity necessary to run the farm, while locally harvested firewood provides the necessary heating energy for the farm to operate. I was surprised by the natural beauty of this farm when compared to the industrial agricultural operations I am used to seeing. Krameterhof has found a way to profitably run a farm without using industrial methods which increase costs and can have a deleterious effect on the environment. They are promoting a viable alternative to industrial agriculture.

Figure 6: The generator room of the Walchensee hydropower plant near Munich, Germany.

On my way to visit Krameterhof, I stopped for a couple of hours to see one of the original hydropower facilities in Germany – the Walchensee Powerplant. The hydropower plant is located in between a high alpine lake and lower lake in the adjacent valley, thus utilizing a natural mountain dam. A low-grade tunnel connects the upper lake, the Walchensee, to a valving station which throttles the water flow down six large pipes to the valley below. At the bottom of the mountain, the generation facility utilizes four 18 MW Francis turbines and four 13 MW Pelton wheels for a total capacity of 124 MW. It was completed in 1924 and, due to its history, proximity to Munich, visitors center, and attractive buildings, is a real gem of German renewable energy accomplishment.
5. June 9 – 15
    Personal Travel
    Hungary, Austria

In the middle of June, I was able to take a short trip with my wife, Katie, and two of our friends, Paige and Travis. We rode a sleeper train to Budapest where we spent three days. Budapest has a troubled history of many invaders and lost wars, which gives an air of pessimism to the locals. A bright spot in their history is 1896, when they were a part of the Austro-Hungarian Empire and used a brief period of wealth to fund a massive building project to celebrate the millennial founding of the city. Demonstrative of the profligate spending, they not only built the winning design for the Hungarian Parliament building, but constructed the second and third place designs as well. During this time, Budapest built the first European subway system, the third European movie theater, and a host of beautiful buildings around the city.

![Figure 7: Traveling with my wife and friends in Budapest, Hungary.](image)

After visiting Budapest, we rented a car and did a driving tour of Austria. Visiting a famous Benedictine abbey, a ruined castle, alpine villages, and the Salzburg fortress were some of the highlights of this trip. My favorite activity was hiking to the top of the mountain which overlooks the old salt-mining village of Hallstatt. The hiking, scenery, and slow-paced culture of the Austrian countryside were refreshing, and I hope to return some day.
After traveling through Austria, I had a quick turnaround in Munich. During this time, I went on a field trip with many of the members of Professor Hamacher’s research group to Wildpoldsried, Germany. Wildpoldsried is internationally known as an energy efficient village. They utilize wind turbines, solar PV panels, distribution-level battery storage, energy efficiency programs, and an agricultural waste digester which produces biogas to be burned in the village’s district heating boilers. All of the projects have been funded by a combination of bank financing and citizen investments. The 2,500 citizens have invested almost 50 million Euro in these energy initiatives.

Wildpoldsried is no different from other German villages in its access to natural resources and financing. What sets it apart is its strong energy-conscious leadership and citizens. The local sustainability effort is led by a municipal government which prioritizes energy efficiency and renewable energy generation in all of its buildings and organizes efforts between village leaders and citizens. Wildpoldsried is an interesting example of how sustainability can be achieved on a community level. There are many lessons to learn from its success.
7. June 18 – 21
   Visiting Friends
   Jena & Hennef, Germany

During my final week in Europe, I visited some friends on my way to the University of Duisberg-Essen. I studied German language in Bonn, Germany during the summers of 2008 and 2009, and became close friends with my host family, Barbara and Friedhelm, and the youth pastor of their church, Sebastian.

![Figure 9: My friend, Sebastian, and I hiking near Jena, Germany.](image)

I traveled to Jena, Germany to meet Sebastian, his wife, and new child who I had not met before. Afterward I traveled to Hennef, Germany to spend some time with Barbara and Friedhelm who have transitioned from a house full of highschool- and college-aged children to being empty-nesters and grandparents. I really enjoyed spending some time with these old friends and was glad that my IGERT trip gave me the opportunity to see them.
My last stop in Europe was Essen, Germany to visit the research group of Christoph Weber at the University of Duisberg-Essen. I met Professor Weber last spring at an electricity conference in Austin, Texas. We interacted some via email and a phone call, and he invited me to visit him in Essen when he learned of my trip.

Essen is in the heart of the Ruhr valley – the birthplace of the German industrial revolution and an important center of coal mining and heavy manufacturing. I learned much about the history of the Ruhr area by visiting the Ruhr museum, a natural history museum housed in the historic Zollverein coal mine and coking facility. The museum has many excellent exhibits about the history of the Ruhr valley, and much of the industrial equipment from the coking facility has been left intact as a tribute to the area’s industrial importance and a museum of how a coking facility looked and operated.

During my visit to the University of Duisberg-Essen, I was able to give a presentation of my research, answer questions from Professor Weber’s graduate students, and hear about their research projects. Professor Weber’s group is a combination of economics and engineering
students. They focus on creating market models of the energy sector. I learned about their work in demand management in distribution grids, planning uncertainty, market model theory, and other interesting projects. They gave me good feedback on my own presentation and I left the university with some new ideas on how to improve my work and a new interest in keeping up with the work produced by their research group.
9. Conclusions

Overall, my trip to Germany was very productive. I learned a great deal about European energy, both from a formal, conference-type setting, and from discussions with new friends. Europeans view energy, government, and economy differently than we do in the US, and it is necessary to understand the differences in our viewpoints if we want to effectively work with them towards a cleaner energy future. The lessons I have learned during this trip will help me in the future as I work towards that goal.

I was also able to make many new friends and connections during my time in Munich and Essen, and I am excited about continuing to develop those relationships. Relationships are the foundation of any sort of collaboration between universities and cultures, and I believe I will have opportunities to work with these people in the future. I hope that my future interactions with them will continue to shape my understanding of European energy perspectives and how we can work towards a more sustainable energy system.

I greatly appreciate the financial support from the NSF IGERT program at the University of Texas which allowed me to have this experience. The lessons I learned and friendships I made on this trip will continue to influence my career for many years.