

## Headley Germany Trip Report

### Trip Goals

Besides just having the opportunity to see Europe, my main goals of this trip were to see the direction of fuel cell research in Europe, and network internationally with a broader audience of PEM fuel cell researchers. Fuel cells have been in and out of favor in the US, so sometimes it is hard to see whether my research has any long lasting merit. It was really great to see the interest in the hydrogen economy and meet with a number of groups that were very optimistic about the future of hydrogen power generation. Every conference I went to at least mentioned hydrogen fuel cells, and without the skepticism that you often run into in the US. I was able to meet and speak with people that have been advancing the field for years, and get confirmation from them that what I am doing could be very impactful.

I was also hoping to visit a few research centers while I was there, but unfortunately I wasn't able to make that work out. Regardless, it was a great trip and I definitely came back more motivated about my research and with a fresh perspective.

### Conferences Attended

Power-Gen Europe/Renewable Energy World Conference, Cologne, Germany:



This conference was a great primer on the European energy market and challenges they are facing going forward. The attendees consisted of utility managers, power generators, and equipment manufacturers predominantly, so there was some very in depth discussion regarding pricing structures, variability concerns, etc. (You can see the caliber of the booths and attendees in the picture. I definitely felt out of place...)

Europe, Germany in particular, set some very aggressive targets for renewable energy implementation, which is leading to some major concerns in terms of managing variability. I would say this was the main focus of the conference as a whole. A lot of discussions focused on creating a capacity based market structures that would encourage power producers to build plants capable of supplying flexible power for only a few hours a year. The current market structure pays only for generation, and in no way incentivizes when that power is being produced. One of the more interesting talks on pricing structure included an interesting look at the Australian energy market, which has managed to successfully create incentives for flexibility by using a continuous trading model and basically hedging options that leads to guaranteed income for peaking power plants.

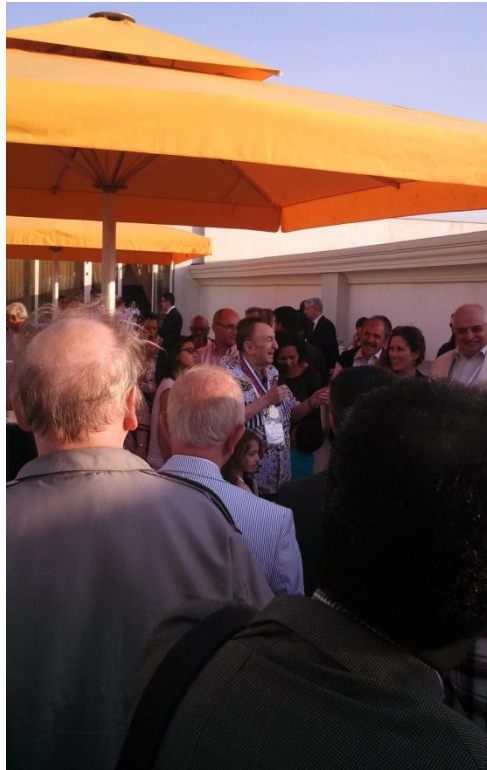
All of these discussions were very eye opening for me in terms of the drastic differences between our energy markets. A big portion of this is the difference in natural gas prices between the US and Europe. Because of the cheap natural gas here, we have something of a natural, inexpensive compliment to increasing renewable energy penetration, but Europe has no such option right now. Interestingly, despite not having an inexpensive flexible generation option, they have plans to install a LOT more renewable energy, hence the general sense of panic coming from the utility presentations at the conference.

There were also a number of presentations covering a wide range of other clean energy topics such as energy storage tech., smart grids, microgrids, hydrogen storage, CCS, etc. I took notes on a number of these presentations and could share more specifics with any IGERT students interested. I would HIGHLY recommend this conference to any fellows making the trip in the future.

#### International Conference on Clean Energy, Istanbul Turkey:

This conference was far more academic in nature. Researchers from universities worldwide attended the event to cover a wide range of clean energy related topics. This conference was particularly useful for me because there were a lot of fuel cell researchers that attended, so it turned out to be a good networking opportunity for me. One particularly good talk was by Kevin Kendall from the University of Birmingham who worked on productizing fuel cell vehicles and I

was able to speak with him to discuss research and the fuel cell initiatives in Europe, which was great.



(This was a very laid back conference. The picture here is from one of the mixers early on in the event. The older chap in the middle is Dr. Verziroglu after receiving a lifetime achievement award. I met many of the people I explored Istanbul with at this event)

Besides, I attended presentations covering a wide range of topics from solar pond thermal storage to hydrogen storage in porous media. It was great to be able to see so many different technologies presented in one place and make contacts from so many different locations (Canada, Israel, Turkey, and a few US universities as well).

I feel I should mention the company Bilfinger somewhere in this report as well. They had a presentation at EVERY conference that I attended in Europe, and seem to be a strong clean energy research presence in many areas. At this conference, they presented some work on a demand side management system that could drastically improve variability concerns in the grid. They also fund research on carbon capture, power-to-liquids, and fuel cell systems amongst other topics. They would be worth looking out on future trips.

I also presented at this conference, and my work seemed to be well received. I was able to exchange information with the fuel cell research group from the Middle East Technical University who were particularly interested in my modeling techniques. Hopefully, we will be able to leverage that into some sort of collaboration in the future. All told though, I would not

necessarily recommend this conference. There were a lot of good presentations, but probably just as many bad ones. Also, towards the end of the conference, a lot of presenters did not bother to show up (busy sightseeing more than likely; Istanbul is incredible). I did manage to have a good experience here, but more in terms of the connections than the conference itself, which was not particularly well organized.

IGSSE Forum, Burghausen, German:



(This is from outside the monastery that we toured where they had the closing reception)

This event was great! It was a good way to get to know a lot of the graduate students from TUM and build friendships that otherwise would not have been possible. I definitely think this should be high on the list for all future fellows making the trip. Given that it was very difficult to contact any of the TUM professors to setup lab tours, being able to meet with the graduate students directly was great. The event had some interesting talks, and it was a decent way to see the breadth of research being done at TUM. The activity/presentation itself was somewhat odd, but led to some really good conversations with the German engineers and architecture students regarding differences in our energy systems, governments, ideologies, etc. As someone that wanted to better understand the European energy system and how they have been directing their research/funds, this kind of authentic parlay was one of the highlights of the trip for me.



TUM Lab Tours, Munich, Germany:



(This is one of the wind tunnel facilities at TUM that Victor showed me. They have a number of pretty impressive wind tunnel setups, and I just happened to come by while they were running a test, which was pretty cool to see).

Thanks to some of the connections that I made during the IGSSE Forum, I was able to connect with a few of the grad students for tours of their facilities. Victor Stein was kind enough to show me through the Engineering section of the Garching Campus, and Christoph Schaffer showed me through the Physics department. Both visits were great and very informative. Particularly, the tour of the Physics department was useful to me. Christoph himself works on organic solar cells, but it just so happened that a few of the other people on his floor worked on PEM fuel cells that I was able to speak with for a bit. For people going next year, I have Victor and Christoph's contact information (as well as a few others from TUM) and perhaps they could help with getting people in touch with the TUM groups.

European Fuel Cell Forum, Lucerne, Switzerland:

This event happens annually, switching its focus between SOFC and PEM fuel cells year to year. Somewhat unfortunately for me, this year was centered around SOFC rather than PEM

technology, but the talks were still very informative and quite a few concepts transpose to PEM technology that I was able to learn about. Particularly, there were some interesting talks regarding accelerated aging tests of membranes that I think could have some real merit in the PEM realm. I also met more fuel cell researchers from the University of Birmingham to discuss some of their work. It was certainly a good event for anyone in the fuel cell area,



(The booth shown here was predominantly comprised of companies sponsored by Bilfinger. All of them are marketing some cutting edge technologies for commercial use in some fashion. One in particular you can see here is a SOFC all-in-one module for remote power generation. This was for pretty low power stuff, but still pretty interesting to see something like that actually in field use.)

#### Overview/Recommendations for future trips:

All told, the experience was great. I was able to see how different the European/German system is and really see how my research could impact the world as a whole. That being said, it was still rather difficult to build connections with TUM directly. Outside of the people that I formed connections with during the IGSSE Forum, it was nigh impossible to get in touch with anyone at the university or surrounding research centers (despite multiple emails and a string of attempted phone calls in poor German). If we could have some sort of direct contact at TUM that could help to setup lab tours and trips to some of the research centers in the area, it would go a very long way to improve the TUM connection. Definitely, all future participants should try to go to the IGSSE Forum, but beyond that, it would have been good to have some sort of liaison to help with setting up correspondence at TUM. For instance, in my case, I was able to make some

friends at the IGSSE, but they didn't work in my field, so the lab tours I was able to go on, while informative, were not extremely useful for building connections in my field directly. Long story short, a central contact at TUM that could point us to the right people/bring attention to our emails would greatly improve the Munich section of the trip.

Regardless, the trip was a fantastic experience, and extremely enriching personally and professionally. I think it is somewhat easy just to get used to the energy concerns in the states and assume that they are pretty universal, but seeing the challenges that Europe is facing helped me to put my research into a global perspective. Particularly in the hydrogen storage/generation fields, there is a lot more interest in Europe and a lot more people interested in my work. I hope that I will be able to collaborate with some of the people that I met sometime in the future. Thank you IGERT for the trip of a lifetime!

#### Sidebar (sightseeing):

Besides the professional goals, I just wanted to see as much of Europe as I could squeeze in. I quickly realized just how tall an order that really was, and there was so much to see just around Germany, heck in Munich even. I also wanted to meet some new people, and definitely made a lot of friends that I hope I will have the chance to see again someday. In Istanbul, I met Stefan (from Cologne, who oddly enough said basketball was his first sport) and Mark (from Israel, but oddly enough had been at the PowerGen conference as well) and got to tour a lot of the city with them. In Munich, I met Erwin (a "squirrely" Honduran that loves metal music), went to a music festival with Christoph (physics major at TUM) and his girlfriend Evie, suffered through a few crushing losses for the Brazilian squad with Gaetano, and went to a beer garden with Victor and his girlfriend (who is hoping to make a trip to Austin at one point). I can't even describe how great it was to be able to befriend so many people from so many backgrounds and share stories. I also got to know some of the other IGERT fellows better, and only wish we had all been in the same place at the same time more often.

Also, just seeing the history and culture of Europe was awe-inspiring. I took a ridiculous number of pictures from every museum, art gallery, and city we visited and I still feel like I didn't even capture half of what we saw during the trip. Besides the conference cities, which were amazing to tour in their own right, we also went to Salzburg, hiking in the Alps (with Bonnie), Dachau, London, and got to make a whirlwind tour of Zurich on the way back from the Fuel Cell Forum. I think I will save most of the pictures for the actual trip presentation, but I will share one from the highlight of the trip. I just so happened that it saved a few hundred dollars from the plane flight to leave on the 14<sup>th</sup>, though we were originally intending to leave the 12<sup>th</sup>. Thank God that was the case, because we were able to be in Munich on the night that the Germans won the World Cup because of the change. We went with Erwin to watch the game, and got to be part of the impromptu parade that sprang up down the street afterwards.





My wife missed her flight the next morning (she got upgraded to first class for the 10 hr flight though, so not so bad), and I narrowly caught mine, but it was worth it to be a part of the city-wide celebration.