

Arjun, Jeff, and Stuart

- Stuart: You said coal and gas are cheaper. They're superficially cheaper, not once you consider externalities. We shouldn't drive less, we shouldn't give up GDP growth...I think we should have the sharing economy
- Arjun: I am for economic growth, I disagree that one of us is right and one of us is wrong. We both have to be right.
 - Driver of our economic growth is cheap energy
 - Go into a slum in Mumbai and compare it to the Bronx. The difference is cheap energy.
 - Big oil companies now model a price on carbon.
 - There is a broad consensus that this needs to be addressed.
 - What's missing: How do you do this while ensuring energy remains cheap?
 - Optimism: reducing the demand for traditional fossil fuels. There is so much that can be done with existing technologies. It's not sexy.
- Jeff: According to studies we've seen, remember Obama put in first CAFE standards since Reagan during economic crisis, if they keep standards in place for ICE, gasoline demand will fall by 30%. Doesn't 350.org say that we need 2/3 of reserves need to be written off?
- Arjun: Even with a significant carbon price, oil and gas will still remain a majority piece of the pie. We spend 0% of our time conspiring to push down alternatives. BP has called for a price on carbon. They've looked into alternative energy investments, but haven't done a significant amount because returns are low.
- Stuart: let's talk about projections and scalability. Projections are based on extrapolation: we know this is going to be wrong. DOE projections are very conservative and wrong. If you get the projections wrong, you get the scaling effect wrong.
- Arjun: There is far less of a divide here than perceived. I want to model how EV's will change oil demand. I'm excited to interact with this type of conversation. I am open to it, as are the oil companies. Oil companies won't champion a \$100/ton carbon tax. You need to engage them behind the scene.
- Audience: When will the CO2 curve start bending?
- Arjun: With \$50/bbl oil, you are less likely to have change. China becoming a larger oil importer than the U.S. will cause them to change. Consumers of oil face subsidies. Eliminate those in emerging markets. The problem is telling folks in India they need to pay 10x more for kerosene so they can have lighting. Everyone except extreme members of Congress wants a price on carbon. The trick is to do that without raising the price on gasoline.
- Audience: Pretend you're India or China government, the snowballing of middle class, how will address growth in demand?
- Arjun: If you're India, make friends with Bangladesh and Pakistan, because they have huge natural gas reserves. If you're China, make friends with Russia. These things take time. For emerging markets, there are major geopolitical issues. Nuclear should play a huge role in these countries, which the U.S. isn't very excited about.

- Stuart: I think if we believe they want the American dream, that might be wrong. Look at current generation, they don't want their own home and car. They want the sharing economy. Autonomous vehicles are coming.
- Jeff: Solar panel prices have fallen 80%. Offshore wind...they're putting up serious scale in Europe. India and China should be something that they should focus on scaling.
- Audience: We've done a lot of research on advanced biofuels for BP and DOE. We agree that the scale of the fuel market and the technologies we are working on are misaligned.
- Arjun: The breakthrough technology comes from independent producers. Alternative supplies for fuels though are very difficult. We could have 50% improvement in fuel economy. I happen to take public transit to work every day. I did sit next to a lady with a bicycle helmet.

Panel: Investment Opportunities in a Sustainable Grid: DG, Distributed Storage, Grid, and Engaged Consumers

Moderator: Jeff McDermott, Managing Partner, Greentech Capital Advisors

- European Grid Investments and Policies that can Encourage Renewable Energy Growth
 - Tim Green, Director, Energy Futures Laboratory, Imperial College London
- Solar as Base Power
 - Nadia Maïzi, Nice Grid Project, and Professor, MINES ParisTech
- New Ultra-high-resolution Measurements to Successfully Integrate Distributed Generation into the Existing Distribution Grid
 - Alex McEachern, President, Power Standards Laboratory; Fellow, IEEE; Convenor, IEC
- Energy Storage as a Foundation for Renewables
 - Janice Lin, Founder and Managing Partner, Strategen Consulting LLC; Co-Founder and Executive Director, California Energy Storage Alliance (CESA); Board of Directors and Chair of the Executive Committee, Global Energy Storage Alliance (GESA)

Notes

- Jeff: I'm incredibly excited to have this deep knowledge of expertise here. As Arjun is saying, the demand side is where there is a lot of low hanging fruit. Where is their value creation for investors and consumers? Let's start in Europe, they're 5 years ahead of the U.S. in terms of the energy transition. E.ON has split in two and have one new division on renewables and distributed generation competing against their legacy business.
- Tim: The issue is around intermittency. It's the ultimate, perishable good. Europe pulls on geographical diversity when they're reaching high penetrations. So usually, you can deal with surplus via exports, though sometimes wind in Germany is correlated with wind in Denmark. Ireland is starting to building more transmission to interconnect to mainland? The flexibility in demand is what we know will play a huge role, but how will that be brought to bear? We don't understand enough about the human factors for charging vehicles and cooling homes. We need a market mechanism to help. Storage

will of course be part of the picture. So it's all of the above, but the problem gets harder as penetration increases.

- Nadia: The question is to understand how high penetration of intermittent solar will impact the grid. Our project in the south of France has many experiments. The problem of EDF, the distribution system operator, was to assess at what level of penetration the voltage will be lower or higher than recommended limits. This is an optimization problem. Consumers don't yet understand benefits of smart meters and connected batteries. First, we have to redesign the social scale and the technical scale. There is cheap nuclear power, and consumers are therefore not price driven. They have no idea how much they're paying.
- Alex: We are thinking in huge terms. Artists making huge murals, and I'm happy making nicely sharpened pencils. We make instruments for measuring what's going on in the grid with high precision and high resolution. Storage now for instant delivery is the rotational inertia of all of the generators. PV and Storage is all DC energy and they're switched to AC with inverters. One power quality issue we are seeing in Germany is tremendous increase in high frequency emissions that are causing capacitors to catch fire here and there. As we add more wind and solar that are unstable second to second, we are getting variations in voltage at time scales that are very quick. We believe that we can put a lot more on the grid than we thought if the inverters are programmed correctly. Our standards laboratory is growing very fast, and we need growth capital \$5m.
- Janice: Voltage sags and power quality...Storage is a very broad asset class. The challenge is one of market design. Investors need a way to get paid. Bankable revenue streams are not there yet for storage. This is changing. For 1-2s voltage sags, a flywheel company sweetspot is <5s response. Can we put it in a microgrid? Can we put it in a wind turbine? But how would wind developer get paid for this? Does smoother output improve effective capacity or reduce time to interconnection? Storage exists for many applications, and our perennial challenge is monetizing those applications with market design.
- Jeff: REV in NY... What are the real incentives to be an efficient consumer? Everyone got excited with Google buying Nest and Dropcam. What about time of use pricing? Can you get consumer behavior to change?
- Tim: It is difficult to realize where the value is for storage. Our network operators can't own storage and can only own generation. But that means the value for storage is hard to realize. Flip the paradigm for responsive consumption. The UK will go to half-hourly pricing for retail level. Recruiting people for trials, but they're already well disposed. So how do scale beyond the trial and have external validity? How do you engage them without them needing to watch a meter at home? They need to set it and forget it.
- Jeff: The hope is that the Europeans and Californians can have the culture here. NY'ers: Fuhhgettaboutit.
- Nadia: The project tried to find a solution to get people more informed. They tried to develop a visualization tool. There was a big energy-related fire, but if consumption had been lower, maybe that fire would not have happened. Can we communicate this to consumers? Even if you're in favor of renewable energy, you still need to worry about power quality.

- Janice: There is a huge opportunity in aggregation at the intersection of storage and DR. Americans don't like to wear sweaters. The challenge is that you can't always count on the load to drop. Integrating DR with storage means that it is very reliable and dispatchable. An individual consumer won't do that with the utility, but an aggregator will. Long-term contracts for dispatchable DR under approval now to satisfy local capacity requirements in southern California.
- Jeff: Storage for large C&I customers is a very nice opportunity. Can you comment?
- Janice: SGIP is funded through rates. From an investors standpoint, this is very bankable. Buy-down incentives to reduce cost of DG and energy storage. There is \$400m available. Now storage is being deployed behind the meter. The primary application is to reduce demand charges. The deal in Southern California is a utility scale procurement for capacity, so can't also be eligible for SGIP. I'm not sure if that makes sense. But yet, both are very financeable and bankable projects.
- Alex: We are at a university. We are trying to change consumer behavior. We need advertisers, artists, filmmakers, and behavior psychologists.
- Susty: WattTime was started at a hackathon here between a computer scientist and a behavioral economist!
- Audience: Now there is a standard for variable speed chillers in buildings. This seems to be very effective way to change behavior...with a standard. Maybe you don't need to actual behavior change. My question to investors: when you propose a project for a customer, do you look at bringing facility up to code or do you look at making it more efficient? You need a standard option and a high efficiency option.
- Alex: The energy costs of the building are only 1% of the operational costs.
- Tim: We have building standards and mandates. In London, there are businesses that change lighting. They talk to landlord and take care of anything. Give an ROI that is very attractive.
- Audience: I'm an obstetrician. Half of pregnancies are unintended. Family planning is the most cost effective carbon cut. Whether it's mitigation in the north or adaptation in the south, let's use family planning.
- Janice: I appreciate that comment. You don't need to be an artist or a family planner to be effective. We need to discuss these things in a simple way so the average person can understand. Jerry Brown has done amazing things, and he's just a person like you and me. You are an agent of change. Energy storage is like making jam. When we have excess fruit, we make jam, and it becomes much higher value. Guess how many advocacy groups for storage in AZ? Zero. But consumers advocated for it there.
- Audience: Brian, MechE working on AJP with Granholm. Where does the policy come in? Easiest policies to get through government with high ROI to get energy storage on the grid.
- Tim: That presupposes storage is the answer. It's one of the answers.

Student panel:

Cathy: vertical learning

URAP program: undergraduate research assistant program

Katie: Alison and I talked this fall. I was in her shoes not long ago. It's very daunting at the time, but being able to share my experience was really valuable so that Allison could know what opportunities are out there.

Allison: Being part of BEREC, I reach out to someone on leadership team and ask them about their path. They've been generous in their help and support. Being part of that network has helped me a lot.

Sasha: I've reached out to the School of Journalism for mentorship and they are all

Cathy: We have porosity, move across disciplinary boundaries.

What gaps?

Sasha: We need more training for scientists to write narratives and stories about their work. That expertise exists, but students need help finding it.

Allison: For people don't know how to start making connections, it can be overwhelming. We need to help people take that first step. The energy engineering major is new. The first majors are graduating this spring. Over time, a support network will grow. But now, it's so new that there are opportunities to refine that program.

Michael: I would like to see more abundant funding for undergraduate research in the summer.

Katie: When I first got to Berkeley, I had trouble keeping track of all the events on energy and climate. We need better coordination and a better forum. BEREC and BECI will work on a master calendar.

Mohini: I agree with Allison. There are lots of opportunities, how do you choose between them? We need some more guidance.

Global: capacity to communicate these issues, public perception on climate. Difficulties...

Sasha: We need to communicate what people are already doing, what impact it is having, and what co-benefits. John Harte, Tanya D, and I co-created a class called "Early Solutions", with a number of our stories published in Grist.

Michael: I resonated with focusing on solutions. My goal with the grid video game is to focus on solutions and experimenting. We need to frame it in a playful way to start, to engender optimism and cooperation.

Allison: My parents are book designers. A big challenge is communicating things in every day examples and in terms people understand. I didn't understand what a climate scientist was before I got into energy. Talking to people of all ages and demographics and focusing on how it is interdisciplinary it allows me to connect with a lot of people.

Katie: I've always lived in the Bay Area. We need more training in talking to people who don't understand these opportunities.

If you could tackle any problem, what would it be and what solution would you promote?

Mohini: I have been reading about solutions for powering villages in India. Address clean energy needs and other development needs.

Allison: Bringing energy solutions where they lack energy access is very relevant, and very important to tackle.

Michael: I really want to help people see themselves as participants in the energy system. This huge grid...it's almost spiritual. We are all connected. People need to know when energy is expensive and when it's abundant. We need to embrace that we are all in this together, and we can't always use all that we want.

Sasha: We are truly interconnected with future generations. We are also priveleged and big GHG emitters. We need to take the power we have and advocate for the powerless, the ones without a voice, who will be impacted on climate change.

Katie: I would like to get into the demand side management space to help integrate renewables.