Congratulations to Our German Guests!

"Football is a simple game; 22 men chase a ball for 90 minutes and at the end, the Germans win."
Texans Know Something About Soccer, Too

USA Team Captain: Clint Dempsey

Hometown: Nacogdoches, TX
Today’s Agenda

• 230 pm: Opening remarks and lecture
• 250 pm: Moderated Panel Discussion
  – Ben Paulos (Moderator)
• 450 pm: wrap-up and thanks
• 500 pm: Adjourn
• 530 pm: BBQ dinner at Saengerrunde Hall
  – 1607 San Jacinto Blvd, Austin Texas 78701
Texans Share A Special Kinship With Germans

Dinner Location: 1607 San Jacinto Blvd, Austin Texas 78701
With Many Thanks To Our Sponsors

• Cynthia and George Mitchell Foundation
• Heinrich Boll Foundation
• CleanTX
• UT Energy Institute
An Energy Revolution Is Underway
For the Last Decade, Headlines Have Declared the End of Oil
Today's Headlines are Very Different

March 2013

May 2013
Much of That Surge Is Happening In Texas

• Permian Basin: 1.7 MMBD (headed to 3)
• Eagle Shale Ford: 1.5 MMBD

• German oil production: <0.2 MMBD

Source: BP Statistical Review of World Energy 2012 • Graphic: Michael E. Webber, The University of Texas at Austin
Texas Production Is Visible From Space
The Stars at Night, Are Big and Bright...
Texas Power Sector
There Are Three Grids In The USA: East, West And Texas

Source: DoE
The Texas Electricity Market (ERCOT) Is Large

- ERCOT = Electricity Reliability Council of Texas
- Customer base:
  - 24 million people
  - 85% of Texas Load
  - Retail Competition: 73% of customers
- Generators: 550 EGUs
- Peak demand: 68 GW
  - Capacity: 1 MW ~200 homes in summer, ~1000 homes in spring
- Wind: 12+ GW (#5 in world)

[Source: ERCOT Quick Facts 2014]
The Texas Power Sector Uses A Lot of Natural Gas (and Wind)

![Pie charts showing energy sources in 2014 and energy use in 2013.]

- **2014 Generation Capacity**
  - Natural Gas: 56%
  - Coal: 23%
  - Nuclear: 6%
  - Wind: 14%
  - Hydro, Biomass, Solar and Storage: 1%

- **Energy Use 2013**
  - Natural Gas: 40.5%
  - Coal: 37.2%
  - Nuclear: 11.6%
  - Wind: 9.9%
  - Hydro, Biomass, Solar, Other: 0.9%
Texas Has Multiple Market Structures

• Competitive wholesale (generation) market
  – Market participants: 1100 active entities generate, move, buy, sell or use wholesale electricity
  – Private companies (& some municipally owned utilities)
  – Prices set by the market
    • Energy only (MWh) NOT capacity (MW)
    • Prices set every 15 minutes & day-ahead
    • Other: ancillary services, regulation up, regulation down
    • Other competitive USA markets (PJM, etc.) have a capacity market
  – Natural gas, wind and solar dominate new capacity
  – Bilateral contracts are 95% of energy purchases
  – Prices are negotiated and not necessarily reported

[Source: ERCOT Quick Facts 2014]
Texas Has Multiple Market Structures

• Regulated transmission market
  – Private companies with fixed prices/profits

• Competitive retail market
  – Private companies
  – EXCEPT
  – Municipally-owned utilities have a local monopoly (Austin and San Antonio)
  – Co-Ops have a local (rural) monopoly

[Source: ERCOT Quick Facts 2014]
Texas Market Has Invested In Renewables

• Renewable Portfolio Standards (RPS) in 1999
  – Expanded to 5 GW of renewables by 2015 (2005)
  – Actual: 12+ GW of new renewables at end of 2013
  – Reduced cost for electricity, but increased cost for infrastructure

• State buildout of transmission lines for CREZ (Competitive Renewable Energy Zones) from W. Texas (windy & sunny) to E. Texas (populated)
  – Voltage: 345 kV
  – Capacity: 18+ GW
  – Pricetag: $7B ($270/Texan)
The CREZ Lines Are A Large-Scale Infrastructure Project

[Source: PUCT]
The CREZ Lines Are A Large-Scale Infrastructure Project

[Source: Texas SECO]
Texas Has Much Better Solar Resources Than Germany...
But Much Less Solar Capacity Installed (For Now)
Germany Power Sector
Germany Is At The Heart of The European Energy Markets

• Borders 10 other EU countries with >33 GW interconnect capacity
• Market coupling with France, Benelux and Austria
• Market coupling with Nordic market area expected by 2017
Examples of Market Structures: Germany

• Policy framework for German energy sector
  – Energiewende = Energy Transition

• Key components:
  – Renewable energy: 60% by 2050
  – Energy efficiency: 50% by 2050 (for electricity)
  – Sustainable development
  – Decarbonization: 80-95% reduction by 2050

• Shift: centralized to distributed generation
  – Small cogen & solar PV
Examples of Market Structures: Germany

- Competitive wholesale market
  - Germany: subsidies in utility bill (driving retail electricity prices higher)
  - USA: subsidies in tax bill (driving taxes higher)
- Competitive retail market (900 players & municipalities)
- CO$_2$ emissions increased as coal was added to the system
- Feed-in Tariffs and other policies drive rapid expansion of intermittent renewables (wind & solar)
  - Electricity prices increased
  - Electricity exports increased
  - Grid reliability went down
Germany is the largest electricity market in Europe with a diverse generation mix.

<table>
<thead>
<tr>
<th>Category</th>
<th>Value (2013)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic consumption</td>
<td>528 TWh</td>
<td>No significant change in the last years, slight downward trend; 46% industrial consumers</td>
</tr>
<tr>
<td>Domestic production</td>
<td>596 TWh</td>
<td>56% fossil fuel, 15% nuclear, 9% wind, 5% solar, 15% other</td>
</tr>
<tr>
<td>Interconnection</td>
<td>Net export: 34 TWh</td>
<td>72 TWh of exports; 39 TWh of imports</td>
</tr>
<tr>
<td>Peak demand</td>
<td>87 GW (2011)</td>
<td>Second highest in the EU</td>
</tr>
<tr>
<td>Installed capacity</td>
<td>184 GW*</td>
<td>43% fossil fuel, 7% nuclear, 19% wind, 19% solar, 12% other</td>
</tr>
</tbody>
</table>

*Total installed generating capacity, excluding import capacity on interconnectors.

Germany Is The Largest Electricity Market In Europe With A Diverse Generation Mix

- Installed Capacity 184 GW (2013)
  - Solar 35 GW / Wind 34 GW
    - 47% of installed capacity is based on renewables
  - Gas 27 GW

- New capacity build up in the last 5 years:
  - Solar + 260% / Wind + 34%
  - Gas + 10% (primarily CHP)

- Power Generation 596 TWh (2013)
  - Conventional power generation still dominant with > 75% (449 TWh)
  - Renewables only contributes 147 TWh
    - Wind 53 TWh
    - Biomass 41 TWh
    - Solar 30 TWh
  - Wind / Solar generation share per day / hour primarily depending on weather conditions
German Fuel Choices Have Shifted

Source: Fraunhofer Institute
German Power Sector Trends

• Nuclear: rapid shut down as response to Fukushima
  – Already 8.4 GW offline
  – By 2022, 20.5 GW offline
• Coal: Recent coal (lignite) plants fill some capacity from missing nuclear
• Natural Gas demand:
  – Near term: Pushed off the stack by renewables
  – Long term: Fills in for shutdown nuclear & coal capacity
  – Heavy dependence on natural gas from Russia
Compare and Contrast
Germany and Texas Are Facing Different Issues

• Major Issues:
  – Texas:
    • Growing population and economy
    • Water as a constraint?
    • Too little capacity?
  – Germany:
    • Growing economy
    • Geopolitics as a constraint?
    • Too much capacity?

• Carbon:
  – Texas doesn’t care: CO$_2$ emissions dropping
  – Germany does care: CO$_2$ emissions increasing
USA Pledging to Get Off Foreign Oil Is A Decades-Long, Bipartisan Tradition
Does Germany Have To Worry About Imported Gas?
Germany and Texas Are Facing Different Issues

• Energy Imports/Exports:
  – Texas imports crude oil, exports gas, weak interconnect for electricity
  – Germany imports crude oil & natural gas, exports electricity

• Both grappling with negative prices from renewables
Germany: Early the week of May 6, Renewables Were Small in Total

- Mon, May 6, 2014, 05h00
  - Wind: <0.7 GW
  - Solar: <0.7 GW
  - Hydro: 2.0 GW
  - Biomass: 3.7 GW
  - Conventional: 26 GW
  - Demand: 53.1 GW
- “Renewable power only covered 12% of demand that hour…”

[The German Energiewende, Craig Morris, May 13, 2014]
Germany: Later the week of May 6, Wind & Solar Drove Prices Negative

- Sun, May 11, 2014, 13h00
  - Wind: 21.3 GW
  - Solar: 15.2 GW
  - Hydro: 3.1 GW
  - Biomass: 3.7 GW
  - Conventional: 26 GW
  - Demand: 59.2 GW
  - Export: >10 GW

- “...wind and solar alone made up around 62% of German power demand.”

[The German Energiewende, Craig Morris, May 13, 2014]
Texas: Abundant Wind Caused Negative Prices More Than 8% of the Time (2008–2011)

- Ingredients for negative pricing
  - Wind supply > total demand
  - Transmission constraints
  - Tax credits

[Source: The Northbridge Group via MasterResource]
Texas: After Expanding Transmission Capacity, the Negative Prices Ended
Germans Know Bier Very Well
Texans Know Something About Bier, Too
Michael E. Webber, Ph.D.

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