Prospects of HVDC and FACTS for
Sustainability and Security of Power Supply

Advances in Power System Control, Operation and Management
APSCOM, 8th – 11th of November 2009, Hong Kong

Wilfried Breuer, CEO Power Transmission Solutions
Electrical Energy is the Backbone of today's and tomorrow's Society
Challenges for Electrical Power Transmission and Distribution

- **Need for more Energy**
- **Urbanization**
- **Scarcity of Natural Resources**
- **Environmental Awareness**
- **Open Markets**

**Increased Use of Distributed and Renewable Energy Resources**
- **Capacity Increase and Bulk Power Transmission over long Distances**
- **Distribution within congested Areas / Megacities**
- **Goal: reliable, flexible, safe and secure Grids**

© Siemens AG 2008
## Paradigm shift in power grids: The *New Electricity Age*

<table>
<thead>
<tr>
<th>19th Century</th>
<th>20th Century</th>
<th>21st Century</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsustainable energy system</td>
<td>Unsustainable energy system</td>
<td>Sustainable energy system</td>
</tr>
<tr>
<td><strong>Electrification of society</strong></td>
<td><strong>Extensive generation of electrical energy</strong></td>
<td><strong>Shift to New Electricity Age</strong></td>
</tr>
<tr>
<td>“Age of Coal”</td>
<td>”Age of fossil fuels”</td>
<td>Challenges require rethinking:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.) Demographic change</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.) Scarce resources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.) Climate change</td>
</tr>
</tbody>
</table>

| **“Generation and load closely coordinated”** | **“Generation follows load”** | **“Energy system shifting”** | **“Load follows generation”** |
| Supply island with stochastic load | Integrated network, central generation, load stochastically predictable, unidirectional energy flow | Increasingly decentralized, fluctuating generation | Central + decentralized generation, intelligence with ICT*, bi-directional energy flow |

- Coal, gas, oil, hydro, nuclear
- “clean” coal, gas, nuclear

| **Renewable energy sources** |
| (solar, wind, hydro, biomass), |

*ICT = Information and Communication Technologies*
Prospects of Solar Power from Deserts

Source: TREC - 2007

Trans-Mediterranean Renewable Energy Cooperation

Solar Power Collector Areas for Electricity Demand of:

= Middle-East and North Africa

Source: TREC - 2007
Siemens has a commitment in the DESERTEC Industrial Initiative (DESERTEC II). The objective of this initiative is to develop over the mid-term a technical and economic concept for solar power from Africa. Work will also focus on the clarification of legal and political issues.
Development of **DC Transmission:**

**Worldwide installed Capacity**

Sources: Cigre WG B4-04 2003 - IEEE T&D Committee 2006

- **Worldwide installed HVDC “Capacity”: 80 GW in 2005**
- **This is 1.8 % of the Worldwide installed Generation Capacity**

**How it “started”**
- **1951, Kashira-Moscow, 30 MW**

**Additionally, over 104 GW are expected from China alone by 2020 !**
Example China: >104 GW Transmission Capacity Expansion by 2019

1. Hami – C. China
   800 kV, 6400 MW, 2018

2. Xiangjiaba – Shanghai
   800 kV, 6400 MW, 2011

3. Xiluodu – Hangzhou
   800 kV, 6400 MW, 2015

4. Xiluodu – Guangdong
   800 kV, 6400 MW, 2013

5. Jinsha River II – East China
   800 kV, 6400 MW, 2016

6. Jingping – Sunan
   800 kV, 7200 MW, 2012

7. Jinsha River II – East China
   800 kV, 6400 MW, 2019

8. Jinsha River II – Fujian
   800 kV, 6400 MW, 2018

9. Nuozhadu – Guangdong
   800 kV, 5000 MW, 2015

10. Jinghong – Thailand
    3000 MW, 2013

11. Yunnan – Guangdong
    800 kV, 5000 MW, 2009

12. Hulunbeir – Shenyang
    500 kV, 3000 MW, 2009

13. B2B NE – North (Gaoling)
    500 kV, 1500 MW, 2008

14. Humeng – Jinan (Shandong)
    800 kV, 6400 MW, 2015

15. North Shaanxi – Shandong
    500 kV, 3000 MW, 2011

16. Ningxia – Shandong
    660 kV, 2 x 4000 MW, 2010

17. Baoji – Deyang
    500 kV, 3000 MW, 2010

18. Mongolia – Beijing
    660 kV, 4000 MW, 2010

19. Xiluodu – Hunan
    660 kV, 4000 MW, 2011

20. Irkutsk (Russia) – Beijing
    800 kV, 6400 MW, 2015

* Options for further Projects > 7 GW
Siemens received an order for the world’s first 800 kV UHV DC in China Southern Power Grid.

Siemens – a Leader in Bulk Power UHV DC Transmission Technology

Yunnan-Guangdong

1,418 km
5,000 MW
+/− 800 kV DC

Commercial Operation:
- 2009 – Pole 1
- 2010 – Pole 2

Reduction in CO₂ versus local Power Supply with Energy-Mix

32.9 m tons p.a. – by using Hydro Energy and HVDC for Transmission
HVDC Plus – The Smart Way

- Compact Modular Design
- Lower Space Requirements
- Advanced VSC Technology
HVDC PLUS: Trans Bay Cable Project, USA
Security of Supply for San Francisco Area

Elimination of Transmission Bottlenecks

Transmission Constraints before TBC

Transmission Constraints after TBC

400 MW 88 Kilometers

California

Elimination of Transmission Bottlenecks

... and Dynamic Voltage Support
HVDC Plus ready to go offshore for windpark grid access
Benefits of SVC Radsted – Denmark

and even more – in Future

174,000 tons p.a. – by using Wind Power … and SVC for Voltage Support

Reduction in CO₂
Applications of **MMC Technology**

*(Modular Multilevel Converter)*

**SVC PLUS®**

Advanced **STATCOM**

**Single Units:**

- +/- 25 MVAr
- +/- 35 MVAr
- +/- 50 MVAr

**Up to 4 parallel Units:**

- +/- 200 MVAr
Grid Code Compliance of Green Energy
Greater Gabbard, UK – 3 SVC PLUS Systems

SVC PLUS:
- 3 x ±50 MVAr in parallel
- 132 kV / 13.9 kV

World's largest Offshore Wind Farm

Greater Gabbard
500 MW
140 x 3.6 MW
Vision for Interconnections facilitated by HVDC in Europe

- **Hydro Power in China**
  - Hydro Power > 30...50 GW

- **Renewable Energy in Europe**
  - Wind Power > 20...40 GW
  - Hydro Power > 10...30 GW
  - Solar >10..20 GW
  - Geothermal power from Iceland
  - Pump-storage capacity Scandinavia
  - Hydro power from Eastern Europe

UCTE Grid Access of Renewable Energy is with HVDC Technology feasible!!

- Onshore and offshore Wind power
- Solar-thermal Generation
- Photovoltaic Generation
- Geothermal power from Iceland
- Pump-storage capacity Scandinavia
- Hydro power from Eastern Europe