NACHHALTIGwirtschaften

Internationale Tagung

Sichere Energieversorgung

Strategien und Technologien für die Zukunft

e2050

29. und 30. November 2006
Millenium Event Center, Wien

BUNDESMINISTERIUM für WIRTSCHAFT und ARBEIT

IEA

bmvit

2050

www.e2050.at

Die mittel- und langfristige Sicherstellung unserer Energieversorgung ist eines der zentralen Anliegen des 21. Jahrhunderts. Stark wachsende Energienachfrage auf globalen Märkten, Versorgungsknappheiten und enorme Preissteigerungen bei fossilen Brennstoffen verlangen langfristig tragfähige Lösungen. Erneuerbare Energieträger und Effizienzstrategien gewinnen zunehmend an Bedeutung. Gleichzeitig sind auch weit in die Zukunft wirkende Infrastrukturentscheidungen zu treffen.

Dabei stellen sich Fragen wie: Welche Entwicklungspfade sind wünschenswert? Welche technologischen Optionen sind zu entwickeln? Welche Chancen und Risken sind erkennbar? Zur Klärung solcher Fragestellungen und zur Bereitstellung zukunftsfähiger Technologien und Lösungen wird die Forschung eine wichtige Rolle spielen.

Diese im Rahmen des Strategieprozesses ENERGIE 2050 des Bundesministeriums für Verkehr, Innovation und Technologie durchgeführte Veranstaltung wird sich mit Versorgungssicherheit, neuen Szenarien sowie der Vernetzung globaler, europäischer und regionaler Strategien auseinandersetzen und längerfristige Strategien und Maßnahmen sowie entsprechende Forschungsschwerpunkte diskutieren. Dabei spielen bisher erzielte Ergebnisse aus dem Impulsprogramm Nachhaltig Wirtschaften und Erfahrungen aus internationalen Kooperationen im Rahmen der Internationalen Energieagentur (IEA) eine wichtige Rolle.

Alle Stakeholder mit Bezug zu diesem Thema sind herzlich eingeladen, ihre Zukunftsbilder in den Strategieprozess ENERGIE2050 einzubringen und zukünftige Forschungsfragen mitzugestalten.

weitere Informationen: www.e2050.at

2050

Tagungsprogramm

Mittwoch, 29. November 2006

9:00	**Registrierung und Empfang**
10:00	**Begrüßung** Andreas Reichhardt, Sektionsleiter Innovation und Telekommunikation, Bundesministerium für Verkehr, Innovation und Technologie (BMVIT) Alfred Maier, Sektionschef Energie und Bergbau, Bundesministerium für Wirtschaft und Arbeit (BMWA)

Internationale and Europäische Energieszenarien und -strategien

	Moderation: Michael Hübner, BMVIT
10:20	**Der österreichische Strategieprozess „Energie 2050"** Michael Paula, Energie- und Umwelttechnologien, BMVIT
10:45	**Globale Energieszenarien und Perspektiven zu Energietechnologien** Antonio Pflüger, International Energy Agency, Frankreich
11:10	**Issues for European energy R&D: options, priorities, policies and organization** Heather Greer, Advisory Group for Energy (FP6/7, Euratom), NRL, Ireland
11:35 – 12:00	**Kaffeepause**
	Moderation: Bettina Bergauer-Culver, BMWA
12.00	**Energy Technologies of the Future – R&D Priorities** Richard Doornbosch, OECD, France
12:25	**Globale und österreichische Energieperspektiven bis 2050 und danach - Forschungs- und Investitionsbedarf** Nebojsa Nakicenovic, IIASA, Österreich
12:50	**Diskussion**
13:00 – 14:00	**Mittagsbuffet**

Beispiele Nationaler Energiestrategien

Moderation:
Brigitte Bach, arsenal research

14:00 **Strategic Technology Roadmap in the Energy Field – Energy Technology Vision 2100**
Yasushi Setoguchi, MIZUHO Information and Research Institute Inc., Japan

14:25 **Swedish Energy Strategy 2020**
Lotta Bångens, Chair, Sweden's Energy Advisers, Member of the Commission on Oil Independence, Sweden

14:50 **Diskussion**

15:00 – 15:30 **Kaffeepause**

Risikoanalyse und Versorgungssicherheit

Moderation:
Gerald Vones, BMWA

15:30 **Regionale Aspekte einer (alternativen) Energieversorgung**
Friedrich Schneider, Universität Linz, Österreich

15:55 **Das sichere Netz – vom Black-out zum Smart Grid**
Dusan Povh, Siemens, Deutschland

16:20 **Enhancing Energy Security and Mitigating Fossil Risk: The Role of Renewables**
Shimon Awerbuch, SPRU Energy Group, University of Sussex, UK

16:45 **Diskussion**

17:00 **Zusammenfassung und Überleitung zum zweiten Veranstaltungstag**
Michael Paula, BMVIT

Donnerstag, 30. November 2006

Entwicklung von Zukunftsbildern „Energie 2050"

Ziel dieses Tages ist es, mit Akteuren aus Forschung und Entwicklung in moderierten Diskussionen wichtige Impulse für den Strategieprozess Energie 2050 zu erarbeiten. In diesem Rahmen können zentrale technologie- und energiepolitische Aspekte sowie künftige Forschungsfragen aktiv mitgestaltet werden.

Moderation:
Heinz Peter Wallner, Kurt Schauer, Wallner & Schauer GmbH

9:30	**Registrierung und Empfang**
10:00	**World Café: Gemeinsame Zukunftsbilder „Energie 2050"** Entwicklung von langfristigen Energieperspektiven
11:30 – 12:00	**Kaffeepause**
12:00	**Stabile Pfade zur Energievision** Entwicklung von Umsetzungsstrategien
13:00 – 14:00	**Mittagsbuffet**
14:00	**Präsentation der Ergebnisse und Abschlussdialog**
15:00	**Ende**

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Der österreichische Strategieprozess „ENERGIE 2050“

Michael Paula

Internationale Tagung: Sichere Energieversorgung - Strategien und Technologien für die Zukunft

Bundesministerium für Verkehr, Innovation und Technologie | 29./30. November 2006 | Innovation und Technologie

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Zentrale Zukunftsfrage: Energie

- **Globales Wachstum führt zu steigenden „Energiehunger“**
- **Umwelt- und Wirtschaftseinfluss durch Klimaveränderung**
- **Steigende Energiepreise** und **mangelnde Versorgungssicherheit**
- **Erhebliche Infrastrukturinvestitionen erforderlich**
  (IEA: bis 2030 16.000 Mrd. US-Dollar weltweiten)
- **Wirtschaftschancen durch Energieinnovationen**

Langfristige Strategie erforderlich für nachhaltige, wettbewerbsfähige und sichere Energie

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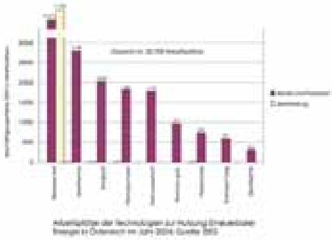
Wirtschaftlicher Erfolg

WKÖ-Studie (Haas/TU-Wien)

- **Umsatz** aus Technologieproduktion **€ 1,46 Mrd**. mit Wertschöpfung von € 1,04 Mrd.
- Beschäftigungseffekt ca. **32.700 Arbeitsplätze** (Produktion: 13.600, Betrieb: 19.100)

Österr. Marktentwicklung Solarthermie (Faninger 2006)

- deutlicher Jahreszuwachs (2005) von +27%
- Exportsteigerung auf 68% (2004 38%)
- In Österreich installierte Kollektorfläche 2005: 240.000 m² (Steigerung 28% geg. 2004)



2004: 32.700 Arbeitsplätze

- **Biomasse**
- **Solarthermie**
- **Wärmepumpen**
- **Kleinwasserkraft**
- **Photovoltaik**
- **Geothermie**

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Perspektive für Österreich

- Die sichere und **nachhaltige Energieversorgung gewinnt stark an Bedeutung**
- Österreich verfolgt **klare Innovationsstrategien** mit Schwerpunkten auf **erneuerbare Energieträger** und **Energieeffizienz** in intelligenten **Systemen**
- **Österreich** steigert seine **Energieforschungsausgaben** und **positioniert sich international mit anspruchsvollen Energie-Innovationen**
- **Innovative Betriebe nützen diese Chance** für ihren Wettbewerbsvorteil und schaffen **beständige Arbeitsplätze** durch globale Marktüberlegenheit

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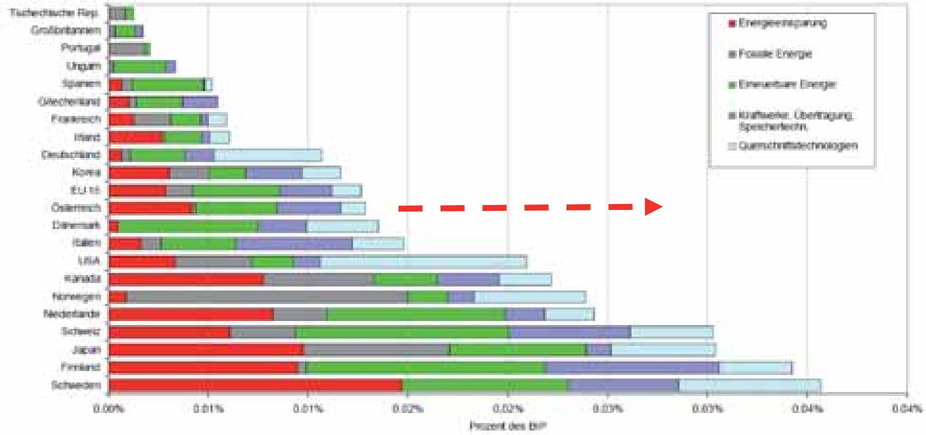
Nichtnukleare Energieforschungsausgaben / BIP



Nichtnukleare Energieforschungsausgaben der öffentlichen Hand bezogen auf das BIP, 2004
(Quelle: Web-Datenbank der IEA, Österreichische Energieagentur)

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Angestrebt:

- Deutliche Erhöhung der Forschungsmittel
- Misionsorientierte F&E –Programme
- Verstärkte internationale Kooperationen
- Längerfristige Planungshorizonte - mehrjährige Leitprojekte
- Aufbau von Forschungsinfrastruktur
- Effiziente Transfer- und Implementierungsstrategien

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Energieforschungsprogramm e2050

„Energie für die Zukunft"

Missionsorientiertes F&E-Programm 2007-2010

(Innovative und strategische Komponente)

- **Langfristige Perspektive**
- **Strategische und**
- **technologiebezogene Fragestellungen (auch langfristige)**

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Programmausrichtung

Energiesystem umfassend berücksichtigt

mit Fokus auf:

Erneuerbare Energie und

Energieeffizienz in

intelligenten Energiesystemen

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Energie und Gesellschaftsentwicklung

Strategischer Themenschwerpunkt

- **Bewertung von langfristigen Technologieoptionen und ihrer Umwelt- und Klimarelevanz**
- **Versorgungssicherheit; Bewertung von Risken etc.**
- **Gesellschaftsvisionen/Lebensstile, Nutzerverhalten und Energiebedarf**
- **Soziale und strukturelle Innovationen als Vorraussetzung für erfolgreiche Implementierung**
- **Kostenwahrheit und Transparenz beim Einsatz von öffentlichen Mitteln** etc.

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Technologiebezogene Themenschwerpunkte

 **Energiesysteme und Netze**

 **Biogene Brennstoffproduktion** (Biobased Industry)

 **Energie in Industrie und Gewerbe**

 **Energie in Gebäuden**

 **Energieeffizienz und Endverbraucher**

 **Fortg. Verbrennungs- und Umwandlungstechn.**

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Energiesysteme und Netze

Technologiebezogener Themenschwerpunkt

- Strom- und Gasnetze, Systemoptimierung, Lastausgleich
- Regionale Wärme- und Kältenetze
- Intelligente Integration von dezentralen Energieerzeugern
- Energieregionen, Multifunktionale Energiezentren
- Energiespeicher-Technologien
- Dezentral einsetzbare Erzeugungstechnologien

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Biogene Brennstoffproduktion

Technologiebezogener Themenschwerpunkt

- Biotechnologische Herstellungsverfahren (Biogas, Bioethanol,...)
- Chemische und thermische Herstellungsverfahren (Pyrolyse, Umesterung, thermische Vergasung, katalytische Verfahren,...)
- Koppelverfahren mit stofflicher Nutzung (Bioraffinerien)

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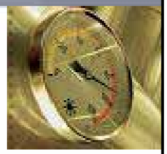
Energie in Industrie und Gewerbe
Technologiebezogener Themenschwerpunkt



- Wärmeintegration und Systemoptimierung
- Erneuerbare Energie für Prozesswärme und Kälteerzeugung
- Neue Produktionsprozesse und energiesparende Verfahrenstechnologien (zB. Membranverfahren statt thermischer Trennung)
- Energiesparende Steuer-, Regelungs- und Antriebstechnik

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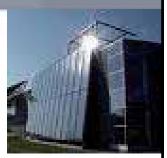
Energie in Gebäuden
Technologiebezogener Themenschwerpunkt



- Energieversorgung und -management großer Gebäude
- Ganzheitliche Sanierung und Intelligente Gebäudehüllen
- Gebäude als Energieproduzenten
- Innovative Klimatisierung und Kühlung
- Industrielle Fertigung von Gebäuden

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Energie und Endverbraucher

Technologiebezogener Themenschwerpunkt

- Intelligente Technologien für Endverbrauchsprodukte
- Geräteentwicklung und Ecodesign
- Least-Cost-Strategien (Verbraucherverhalten, *sustainable consumption*,…)
- Energieeffizienz von IT-Anwendungen

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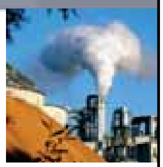
Fortgeschrittene Verbrennungs- und Umwandlungstechnologien

Technologiebezogener Themenschwerpunkt



- Effiziente Umwandlungstechnologien
- Verbesserte Verbrennungsprozesse
- CO2 Abscheidung und Speicherung
- (Clean) Coal Technologien

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Energy 2050 – Vienna
Issues for European Energy R&D:
Options, priorities, policies, organisation

Dr Heather Greer
NRL Ireland
Advisory Group on Energy, FP6/7/Euratom
29th November 2006

Advisory Group on Energy (AGE)

- Covers FP and Euratom
- Non-representative of MSs, but…
- Representative voice of energy RTD actors
- Nominated by Commission, appointed by Commissioner for Research
- Independent advice
- Influence? None other than what the AGE creates

2

FP6 AGE

Four published reports:

- **"Key Tasks for Future European Energy R&D (2 vols – 2005, 2006)**
- **"Towards the European Energy Research Area" (2005)**
- **"Transition to a Sustainable Energy System for Europe: The R&D Perspective" (2006)**

***Austrian member*: Prof Gerhard Faninger**
Institut für interdisziplinäre Forschung und Fortbildung

3

FP7 AGE

- **First (partial) meeting: July 2006**
- **First full meeting: Oct 2006**
- **First task: opinion on FP7 work programme**
- **Now formulating a programme for FP7/Euratom AGE**
- **Likely to build on strategic focus from FP6**

***Austrian member*: Dr Josef Spitzer, Joanneum Research**

4

This presentation….

1. EU/EC level: recent developments, some trends and projections, and some worrying ‘disconnects’
2. Views on priority R&D fields for short, medium and long terms
3. Organisation and funding issues: a new paradigm for EU energy research?
4. Some closing personal comments

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6

Recent EU developments - policies

- Common policy approach to energy:
  - Security of supply (= Nat gas from Russia!)
  - Shared approach to taxation measures (sustainability)
  - Competitiveness an issue of increasing concern
- Raising the visibility of energy issues in Europe

7

Proposed activities include:

- Regular Strategic EU Energy Review
- Action Plan on Energy Efficiency (objective: 20% improvement in EE by 2020) (*accelerated action*)
- Renewable Energy Road Map
- Strategic Energy Technology Plan
- Common *external* energy policy

8

The EC: …Urgency… Scale…

- "Europe must act urgently: it takes many years to bring innovation on stream in the energy sector" (Green Paper - March 06)
- "A common approach, articulated with a common voice, will enable Europe to lead the search for energy solutions" (Barroso, May 06)
- "…The EU will need to reduce its CO2 emissions by at least 50% over the next decades…. we are beginning to realise the magnitude and the urgency of this problem" (Piebalgs, May 06)

9

Yet….

1. EU-25: In 2000, the second highest CO_2 emitter from FF only (16.0% of global)
2. Primary energy imports 50%; "on present trends", by 2030:
   - 90% dependent on imports for oil
   - 80% dependent on imports for Nat Gas
3. Likely range of EU GHG emissions to 2025: -1% to +39% (mid-point: +20%)

10

Yet…. *(Contd)*

4. At the least, a high probability of maximum global oil production in the short term (from 2010 – 2020), while…
5. …Global oil demand must be expected to grow at a high rate over this time…
6. But important modelling exercises don't reflect this (e.g. POLES Ref. Scenario: 60 years reserves at current production - EOR to increase recoverable reserves from 1,700Gbl (2001) to 2,500Gbl (2050) – 50% increase!
7. Demand for electricity will continue to grow (global projection: +45% by 2030); Europe too…. And H2….EVs?

11

Yet…. *(Contd)*

8. Ageing European energy system:

   €1,000,000,000,000 investment needed by 2025, much of it to meet baseload

9. But the technologies we need aren't ready yet, and significant market share takes decades

12

Europe stirs…

- In fact, the Commission has been pushing the agenda *hard* since FP5…
- And recent events are driving a common overall energy policy approach…
- But will the Euro-Russian accord plus easing oil prices slow this again?
- A *few* MSs are driving their energy/GHG agenda
- But still an absence of *strategy* at EU level…..

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Is energy R&D *really* important in EU?

FP	Energy budget as % of total FP budget
1	66%
2	50%
3	23%
4	22%
5	18%
6	11.6%
7	4.6% (7.25% of Cooperation budget)

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Is energy R&D *really* important in EU?

EU level:

- FP6 Thematic Progr Energy: €424 M
- FP7 Thematic Progr Energy: €341 M

Member State level:

- Though it may now be steadying out, *EU (EU-15) Government energy R&D expenditures have been in decline since 1982 (adjusted to 2000 prices)*

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Initial comments (FP7)

- **Portfolio approach of FP7 seems inevitable and strategically appropriate**
- **Proposed Work Programme for FP is (fairly) comprehensive… and it covers (almost) all AGE concerns**
- **But wait a while for complaints about shortage of funds…**
- **Strategic element remains largely *ad hoc***

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Prioritising – strategic issues

- **Required: a long term vision and quantitative/qualitative objectives for a "sustainable energy system"**

  ["Sustainability" including environmental, economic, social dimensions]
- **Both transformation and transition**
- **Identifiable 'pathways to sustainability'**
- **Long term fuel availability**
- ***Parallel* focus: immediate-short, medium, long, and very long term horizons**

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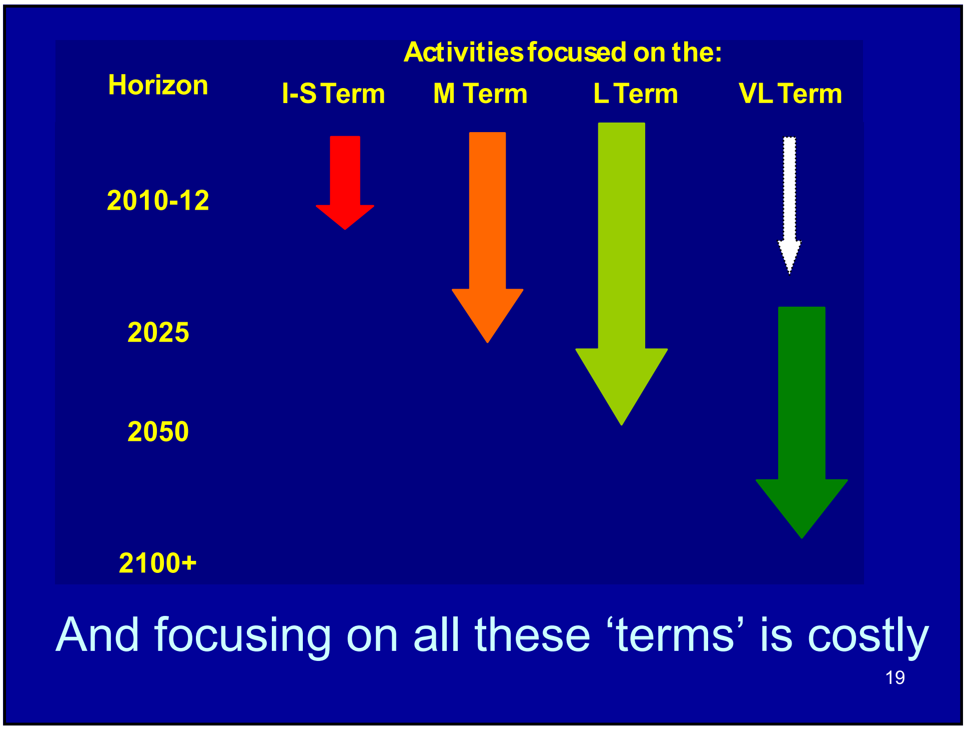

Overall strategic energy R&D focus in the

I-S Term

- Energy efficiency a key competitive advantage in all markets (stimulate ‘virtuous R&D circle’)
- Radical efficiency breakthroughs
- Established RE technologies fully cost competitive
- Demand reduction

Societal participation:
- Incr. understanding
- Commitment

M Term

- ‘Sustainability’ a key competitive advantage in all markets
- Deploy most efficient available technologies
- Develop required energy system infrastructures
- Accelerate development of “+ Gen.” technologies
- World-leading R&D infra- structures
- World-leading CoEs
- Build competence/ capacity

L Term

- Long term sustainability a pre-requisite in all markets
- Accelerate R&D focused on proof of concept and pilot
- Plan for post-pilot activities

20

FP7: The elephant not in the room

Fission reactor research:

- **Nuclear power *will* be in the mix, like it or not**
- **Offers pathway to sustainable energy if**
  - **Fuel utilisation is increased greatly**
  - **New fuel cycles reduce quantity/ toxicity of waste products**
  - **Waste disposal/recycling are addressed**

21

Generation IV needs public funds

- **Recent modelling (SAPIENTA) shows Gen. IV is especially sensitive to R&D funding:**
  - **Zero-GERD scenario: G.IV costs in 2050 double and G.IV fails in the market**
  - **High-GERD scenario: G.IV gains 50% more share than in the Reference Scenario**

22

Conversion technologies: heat/power

- Renewables, ‘clean’ coal and nuclear will ‘slug it out’ in the market
- But the ZEP’s aim is a commercial product by 2020
- Global demand for coal? (Heat…Power…CTL)
- And nuclear build capacity is severely constrained and needs time
- And EU-level fission reactor research support is zero
- A sizeable window of opportunity for RES!
- Expect emphasis on community-scale biomass for heat and power

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Energy for transport

- Expect hydrocarbons to dominate for decades
- Thus *all* measures to reduce private/ freight transport emissions/use
- Accelerate uptake/devt of high-efficiency ICEs/hybrid drives
- Maximise BTL penetration; accelerate 2nd Generation biofuels/fuel from waste streams/integrated biorefineries
- H2/FC & EV options: *both need high-temperature source + infrastructure!*

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Energy for transport *(Contd)*

- Watch out for biofuel/mass feedstock constraints (*enter GTL, CTL*)
- European biocrop infrastructure will require integrated policy and extensive R&D
- Speculative R&D needed on biofuel production – enzymes, photoferment-ation…
- It would be a pity if small-scale electricity storage were ignored…

25

Energy for transport *(Contd)*

- Incentives and regulation can boost efficiency and low-emission technologies, but…
- …in the long run the market will decide between biofuel/FF ICEs and hybrids, H2/FC, and electric vehicles
- There will at least be niche markets for all – *well, maybe…*
- Expect new entrants and new market segments/structures in the transport industry

26

End use efficiency

- **Potential is massive, but requires massive multi-stranded policy support to stimulate ongoing R&D**
- ***All* sectors**
- **FP7 emphasis on industrial process R&D for step-change efficiency improvement is necessary and welcome**
- ***EU-level research should: focus on large-potential topics; breakthroughs; competitiveness; supporting policy***

27

Carbon Capture & Storage

- **Extensive short and long term research programme still needed**
- **Environmental, regulatory, legal issues to be resolved**
- **Public acceptability may turn out to be a hidden trip-wire**
- **Is CCS our latest comforting bedtime story?**
- **Shall we say that widespread CCS will be a ‘transition technology’?**

28

Societal and even cultural issues

- Political short-term-ism leads at best to public confusion; at worst, to complacency
- Issues include:
  - Understanding & informed opinions
  - Understanding that abundant, clean, affordable energy must have ‘costs’
  - Commitment to ‘clean’ choices & lines of behaviour
  - Lifestyle and values
  - Cooperative & collaborative approaches
- R&D needs; FP7 emphasis welcome

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RE R&D priorities – overview *(1)*

- Wind energy: cost reduction & scale; reliability & remote applications; predictability
- Solar low-temp: efficiency & cost reduction; applications (industry; desalination)
- Solar high-temp: extensive, including capital/operating cost reduction, materials/components, demonstration/ applications

30

RE R&D priorities – overview *(2)*

- Solar PV: Strategic Research Agenda; breakthrough R&D needed to achieve mass-producible low-cost film
- Biomass: All stages of supply chain; operating cost reduction; efficiency (gasification); demo/scale-up
- Biofuel: Gen 1: cost reduction; Gen 2: lignocellusosic feedstock & syngas to liquid; biorefinery devt.
- Ocean energy: Prove potential

31

FP6 AGE & FP7/Euratom WP

- Very close correspondence between AGE unanimous recommendations and the proposed WP for FP7
- *BUT:*
  - AGE wanted a four-fold increase in budget
  - AGE believe a major EU initiative (JTI, MS participation, risk-reduction) on fission reactor, fuel cycles, waste reduction/recycling not only makes sense, but is essential
  - AGE believes rapid progress towards more JTIs is needed (though costly…)

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Organisation & Funding (Overview)

- Energy technology R&D has a particular need for ERA principles
- Pooled MS/EU funding and risk-reduction will be needed in a *number* of fields of energy R&D (ERA-NETs can help substantially)
- Better organisation of crosscutting R&D funding *must* happen in FP7
- We need world-leading energy R&D infrastructures and Centres of Excellence

34

Is progress sufficient?

- Strong progress since 2000
- European Commission have driven the agenda, *but*
- Engagement by most Member States lacks conviction and urgency
- Requires strong top-down approach *as well as* bottom-up
- *Still* a gross absence of strategy at EU and most MS levels – even an absence of data!

35

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1. EU/EC level: recent developments, some trends and projections, and some worrying 'disconnects'
2. Views on priority R&D fields for short, medium and long terms
3. Organisation and funding issues: a new paradigm for EU energy research?
4. Some closing personal comments

36

Some (mostly) personal comments

- **Who is *really* aware of the "magnitude and urgency" of the problems we face**
- **Without strong MS political commitment, we will fail. We may anyway**
- **We simply cannot afford *not* to pursue all options – particularly not one as potentially important as fission**
- **Changing the way we do energy R&D in Europe is as important as the R&D itself**

37

Finally…

- ***"Our problems today result from a lack of commitment to energy R&D in the past. We cannot now afford to repeat this mistake. There is no time to spare."***

European Commission, "Transition to a Sustainable Energy System for Europe: The R&D Perspective", Summary report by the Advisory Group on Energy, 2006

38

Energy 2050 – Vienna
Issues for European Energy R&D: Options, priorities, policies, organisation

Dr Heather Greer
NRL Ireland
Advisory Group on Energy, FP6/7/Euratom
29th November 2006

References

1. Boumert Kevin & Jonathan Pershing, "Climate Date: Insights and Observations", Washington DC: Pew Center on Global Climate Change, Dec 2004, p23.
2. European Commission, "Doing More With Less: Green Paper on Energy Efficiency", DG TREN, 2005, p5.
3. European Commission, "World Energy, Technology and Climate Policy Outlook - 2030" (WETO), 2003.
4. European Commission, "Energy Futures: The role of research and technological development", DG Research (SES), 2006.
5. "Annual Energy Outlook", Energy Information Administration, 2006.
6. European Commission, "Green Paper: A European Strategy for Sustainable, Competitive and Secure Energy", March 2006, p3.
7. European Commission, "Key Tasks for Future European Energy R&D: A first set of recommendations by the [FP6] Advisory Group on Energy", Vols 1 & 2, 2005 & 2006.

40

References *(Contd)*

8. European Commission, "A Vision for Zero Emission Fossil Fuel Power Plants", DG Research, Report by the Zero Emission Fossil Fuel Power Plants Technology Platform (ZEP), 2006.
9. Personal communication with Dr Pascal Columbani.
10. Nuclear Energy Institute, "Status Report, Nuclear Power 2006: Briefing for EFCOG", August 31, 2006.
11. "The Acquisition of Westinghouse", presentation by Atsutoshi Nishida, President & CEO, Toshiba, February 8, 2006.
12. "Extensive Cooperation based on Self-Reliance – The Choice of China's Nuclear Power Development", China National Nuclear Corporation, Chen Hua, Dept of Nuclear Power, March 2006.
13. European Commission "Towards the European Energy Research Area", Recommendations by the ERA Working Group of the [FP6] Advisory Group on Energy, 2005.
14. European Commission, "Transition to a Sustainable Energy System for Europe: The R&D Perspective", Summary report by the Advisory Group on Energy, 2006.

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Notes

- Slide 10: EU was also second highest to US (26.8%) in terms of cumulative emissions (1950-2000) of CO_2 from FF & cement production, at 22.2% of world CO_2 emissions.
- Slide 11: C. Campbell's extensive database suggests that global oil production will reach a maximum within the coming years, if not already. Total (France): Top level report suggests 2020 a possibility under pessimistic assumptions.

  All projections are for a continuing increase in world FEC – e.g. from about 10,000Mtoe today to about 17,000 in 2030 , a 70% increase

  EU increase is much more modest, but still an increase.

  In fact, the EOR (Enhanced Oil Recovery) assumption is essential in order to close the gaps for 2050 within the Reference Scenario. *To date*, EOR has not prevented oil production plateaux and decline in 53 oil-producing regions/major fields.
- Slide 23: The sources referred to make clear the magnitude of the gap between the nuclear industry capacity and the likely demand in the mid and maybe the short terms. It is not planned that Toshiba Westinghouse will allocate significant, if any, capacity to new nuclear build in Europe.

  Locally based use of biomass CHP/DH for industry, commerce and the residential and other sectors not only represents an efficient (from a total systems and a conversion efficiency point of view), but also represents a desirable drive towards individual and group participation in energy provision and use.

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Notes *(Contd)*

- Slide 34: Assuming Technology Platforms' outputs lead to a much more closely planned and coordinated approach to developing technologies towards deployment, this in turn will demand a more coordinated European/MS approach to R&D programmes and particularly pooling of EU and MS funds to achieve ambitious objectives. And energy research is characterised by the scale, duration and risk associated with many fields.

  For a detailed treatment of the organisational, structural and funding issues, see European Commission "Towards the European Energy Research Area", Recommendations by the ERA Working Group of the [FP6] Advisory Group on Energy, 2005.
- Slide 35: Examples of lack of data include (a) an absence, despite several efforts, of reliable and up to date information on national energy R&D policies, programmes and resources; and (b) a lack of independent data and analysis in relation to oil and natural gas reserves (the "Observatory" established in DG TREN recently may address the latter).

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Energy Technologies of the Future and R&D priorities

Arsenal Research, Energy 2050 Conference
29 November 2006

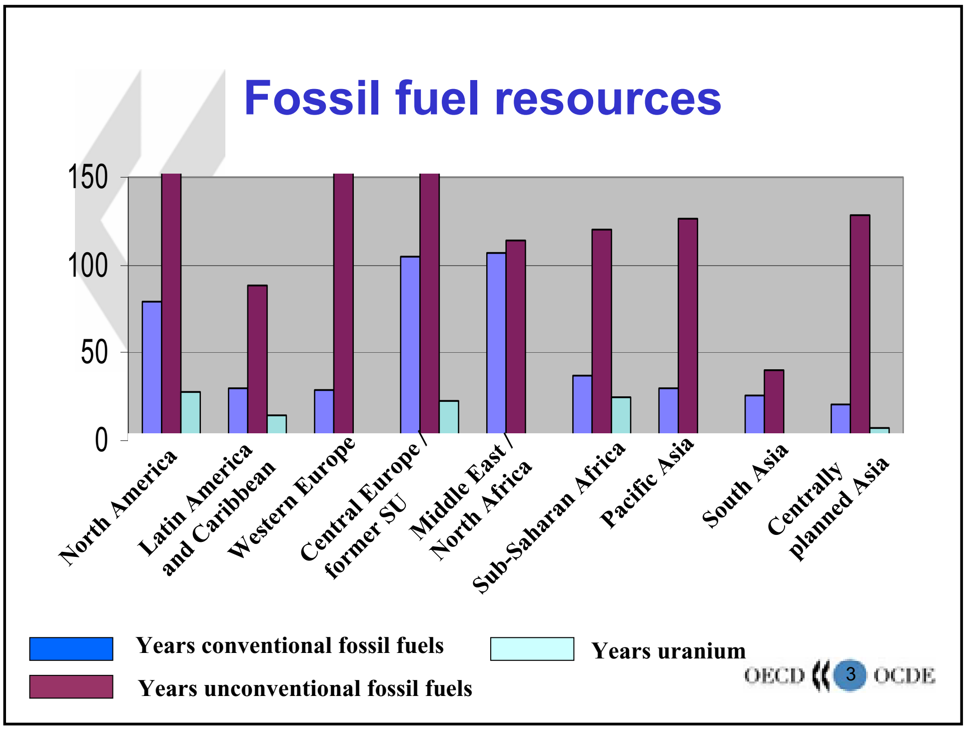
Richard Doornbosch
Principal Advisor
OECD Round Table on Sustainable Development
www.oecd.org/sd-roundtable → meeting papers

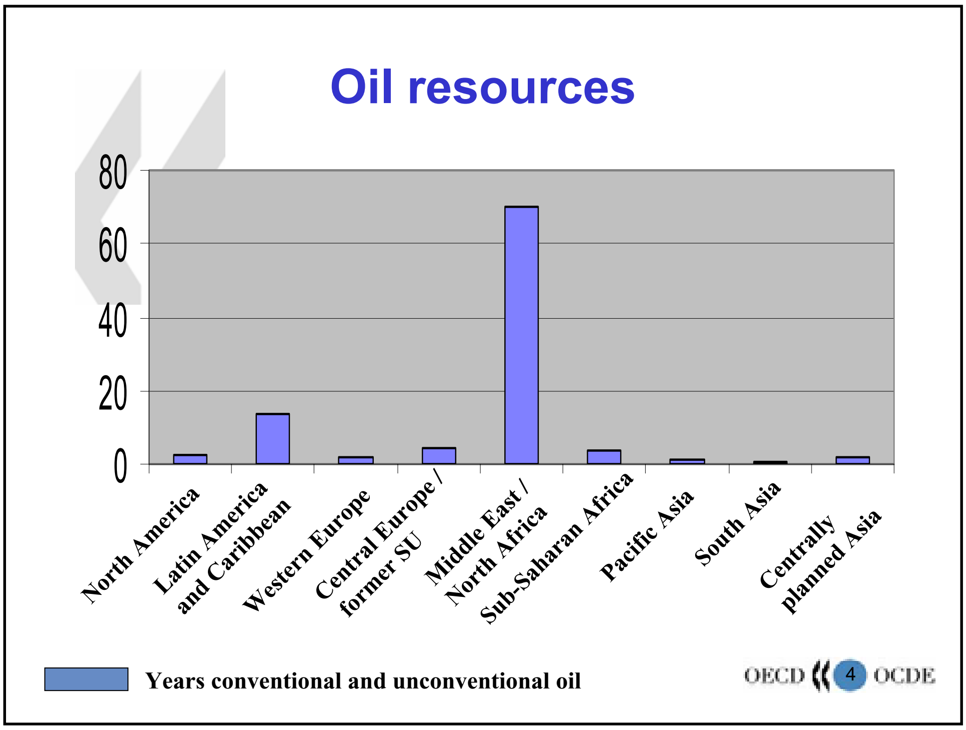
OECD 1 OCDE

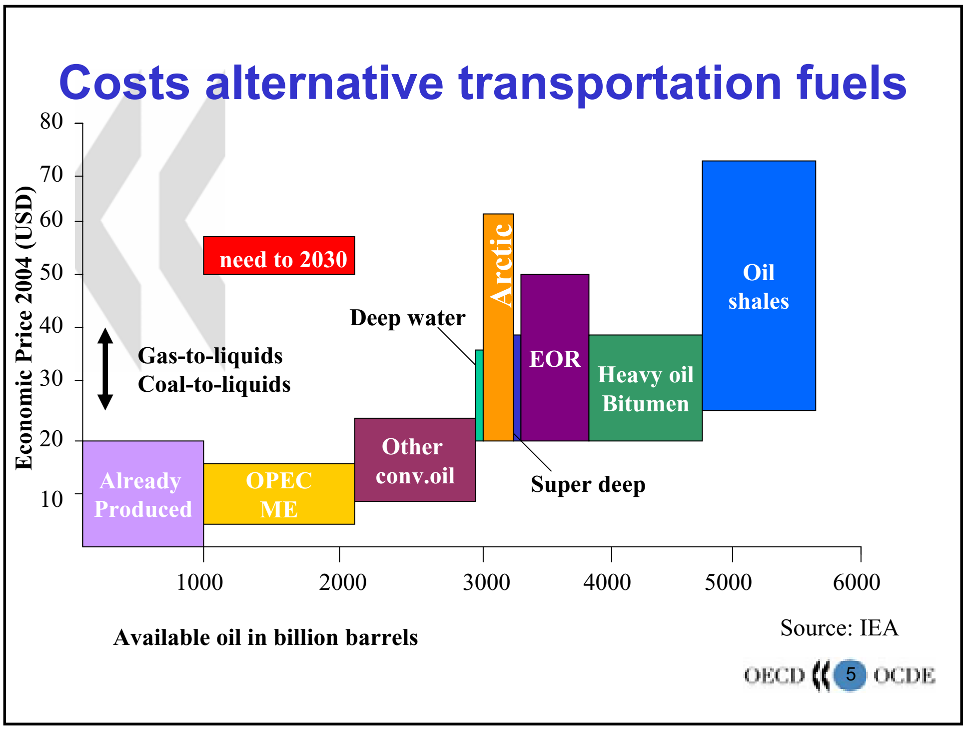
Energy 2050: two myths

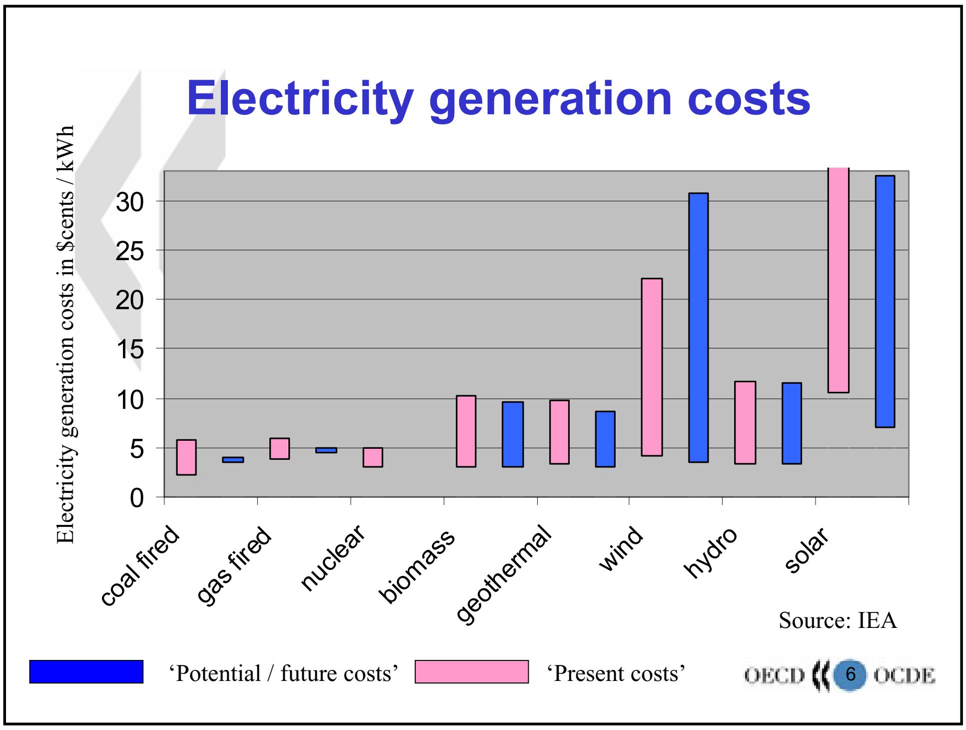
- The world depends on oil from the Middle East
- Technology will come to the rescue to save the planet

OECD 2 OCDE


Fossil fuel resources
150
100
50
0
North America
Latin America and Caribbean
Western Europe
Central Europe / former SU
Middle East / North Africa
Sub-Saharan Africa
Pacific Asia
South Asia
Centrally planned Asia
Years conventional fossil fuels
Years uranium
Years unconventional fossil fuels
OECD 3 OCDE


Oil resources
80
60
40
20
0
North America
Latin America and Caribbean
Western Europe
Central Europe / former SU
Middle East / North Africa
Sub-Saharan Africa
Pacific Asia
South Asia
Centrally planned Asia
Years conventional and unconventional oil
OECD 4 OCDE


Costs alternative transportation fuels
Economic Price 2004 (USD)
80
70
60
50
40
30
20
10
need to 2030
Gas-to-liquids
Coal-to-liquids
Deep water
Arctic
EOR
Heavy oil
Bitumen
Oil
shales
Already
Produced
OPEC
ME
Other
conv.oil
Super deep
1000
2000
3000
4000
5000
6000
Available oil in billion barrels
Source: IEA
OECD OCDE
5


Electricity generation costs
Electricity generation costs in $cents / kWh
30
25
20
15
10
5
0
coal fired
gas fired
nuclear
biomass
geothermal
wind
hydro
solar
Source: IEA
'Potential / future costs'
'Present costs'
OECD OCDE
6

Security of Supply

- Cheap oil in OPEC countries
- But ‘alternative’ fossil fuel resources widely distributed and abundant against ‘reasonable’ costs
- Fungibility of fossil fuels likely to bind producers
- Interconnectedness, market power, smoothen cost curves of backstop technologies

OECD 7 OCDE

Carbon free energy

In 2050 the world needs ~ 15 TW additional

In TW	2003	CO2 Concentration levels		2050	2100
Demand	14.2			29	46
Carbon-			750	~ 11	~ 29
Free	2.8	~380	550	~ 15	~ 38
Supply			450	~ 21	~ 42

Source: Hoffert et al (1998) and IEA

OECD 8 OCDE

Global carbon free alternatives

Bio-energy

~ 3 TW (total additional potential)

Wind

~2-7 TW

Nuclear

~ 2 TW is 18 new plants a year until 2050

CCS

~ ?

(15 TW = roughly two Sleipner plants a day until 2050)

Geothermal

~ 1 TW (2003: 0.06 TW and not much room for improvement)

Hydro

~ 1 TW (total potential)

Solar

~ ? TW (2003: 0.006 TW)

2050: Fossil fuels dominate energy mix

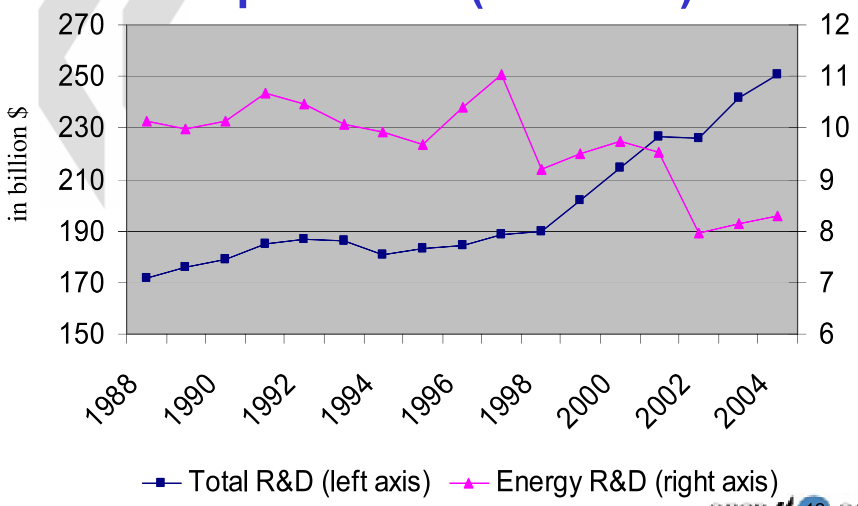
- IEA scenario's: fossil fuels 85% energy mix
- Because (1) path dependency and (2) competitiveness
- Technology fix, if any, should come from solar or fusion
- In both cases → too late for global warming

R&D priorities and programmes - not up to the task -

- Trend is declining, challenge is increasing
  - Public expenditure
  - Private expenditure
- R&D intensity in comparison with other sectors of the economy is low
- Energy R&D portfolio is not well focused (Solar, CCS seem under funded)

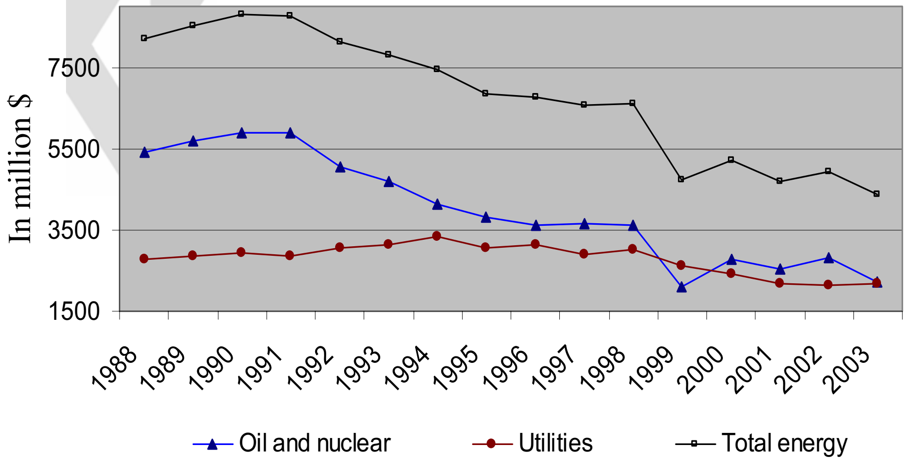
OECD 11 OCDE

Development public R&D expenditure (in OECD)



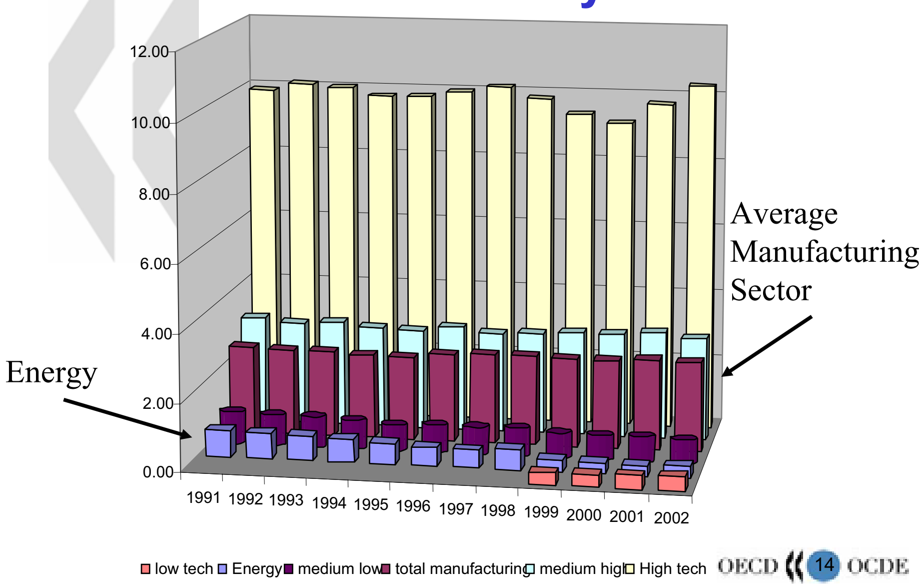
OECD 12 OCDE

Development private R&D expenditure (in OECD)



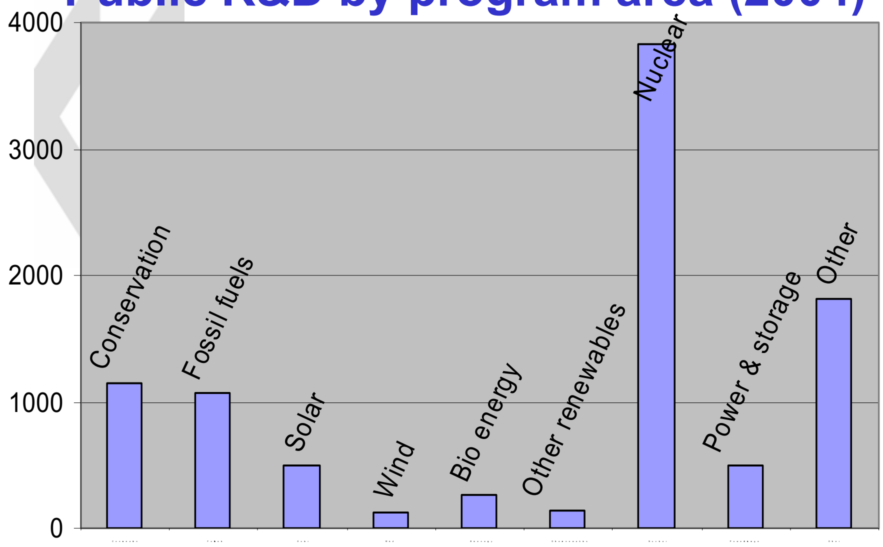
OECD 13 OCDE

R&D intensity



OECD 14 OCDE

Public R&D by program area (2004)



Source: IEA

OECD 15 OCDE

Catch 22?

- Treaty, only if the technology is there at low cost
- Technology becomes available at low cost, only if there is a treaty
- Is the technology there? At what costs?
  - Pacala and Socolow's Stabilisation Wedges (2004)
  - IEA Technology perspectives (2006)
  - Annual increase in real energy price ≤ 1%?

OECD 16 OCDE

Energy 2050: carbon price now!

- Real challenge, not security of supply but 'clean' technology
  - in time
  - on a sufficient scale
- Global R&D
  - insufficient
  - important to reduce cost 'clean' technology
  - not crucial for mitigation
  - window of opportunity next 10-20 years
- Global carbon price only way!

OECD 17 OCDE

References

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- **Hoffert, M.I., et al (1998)**, *Energy Implications of Future Stabilization of Atmospheric CO_2 Content*, Nature, VOL 395, Macmillan Publishers Ltd.
- **IEA (2005)**, *World Energy Outlook*, IEA/OECD, Paris, France
- **IEA (2006)**, *Energy Technology Perspectives, Scenarios & Strategies to 2050*, IEA/OECD, Paris, France
- **OECD (2005)**, STAN Indicators Database
- **OECD (2005),** ANBERD Database
- **OECD (2006)**, R&D Database
- **WEA (2000)**, *World Energy Assessment: Energy and the Challenge of Sustainability*, United Nations Development Program, New York

OECD 18 OCDE

Globale und österreichische Energieperspektiven Forschungs- und Investitionsbedarf

Nebojša Nakićenović
Technische Universität Wien
Internationales Institut für Angewandte Systemanalyse
naki@iiasa.ac.at

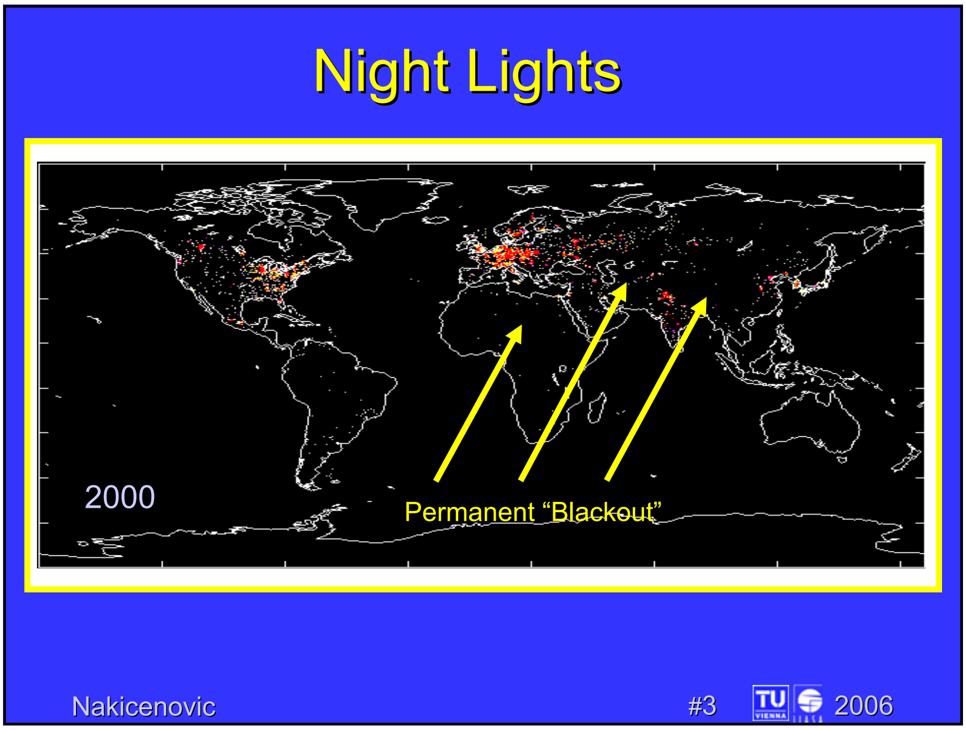
Sichere Energieversorgung, Strategien und Technologien für die Zukunft, Energie 2050, BMVIT und IEA, Millennium Event Center, Wien – 29 November 2006

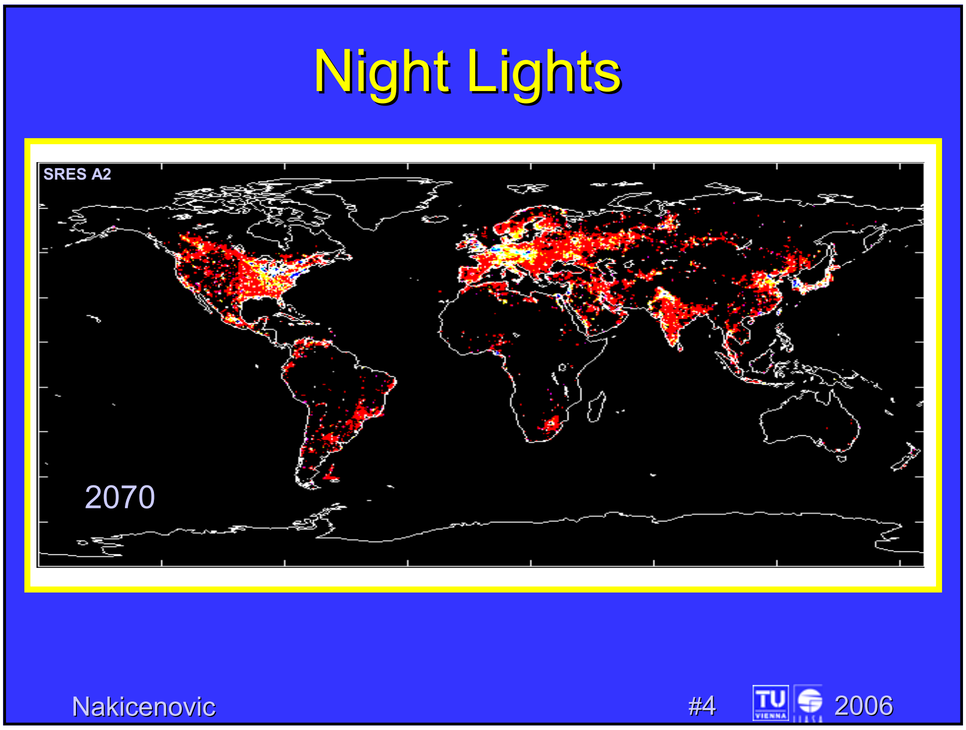
Herausforderungen

Challenges

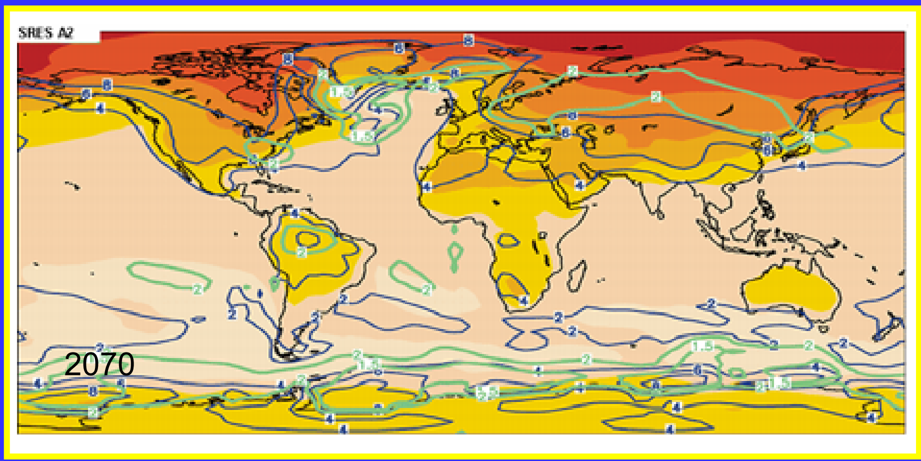
- Bereitstellung von nachhaltigen Energiedienstleistungen
  - Provisioning of energy services
- Technologiediffusionsdauer 20 bis 70 Jahre
  - Technology diffusion takes 20 to 70 years
- Finanzierung des Strukturwandels
  - Financing energy transformations
- Energieeffizienz und Entkarbonisierung
  - Efficiency improvements and decarbonization
- Energiesicherheit und Zuverlässigkeit
  - Safety and security

Nakicenovic #2 2006


Night Lights
2000
Permanent “Blackout”
Nakicenovic
#3
2006


Night Lights
SRES A2
2070
Nakicenovic
#4
2006

Δ Temperature



Nakicenovic IPCC, 2001 #5 2006

Scenario Overview (World by 2100)

	2000	A2r	B2	B1
Population, 10^9	6	12	10	7
GDP, 10^{12}\$	36	190	240	330
PE, EJ	440	1750	1300	1050
PE intensity, %/yr	-0.9	-0.6	-1.2	-1.7
Zero-C, % share	15	36	47	61
GtC energy	7	27	16	6
GtC forests	1	<1	-2	-1
GtC-e all others	3	10	5	4
GtC-e total	11	38	19	9
ppmv (CO_2-equiv)	370	1390	980	790
Stabil. Levels (ppm-equiv)	~480	670-1090	520-670	480-670

Nakicenovic #6 2006

Scenario Overview (World by 2100)

	2000	A2r	B2	B1
Population, 10^9	6	12	10	7
GDP, $10^{12}$$	36	190	240	330
PE, EJ	440	1750	1300	1050
PE intensity, %/yr	-0.9	-0.6	-1.2	-1.7
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Nakicenovic #7 2006

Scenario Overview (World by 2100)

	2000	A2r	B2	B1
Population, 10^9	6	12	10	7
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Stabil. Levels (ppm-equiv)	~480	670-1090	520-670	480-670

Nakicenovic #8 2006

Scenario Overview (World by 2100)

	2000	A2r	B2	B1
Population, 10^9	6	12	10	7
GDP, 10^{12}\$	36	190	240	330
PE, EJ	440	1750	1300	1050
PE intensity, %/yr	-0.9	-0.6	-1.2	-1.7
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GtC-e total	11	38	19	9
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Stabil. Levels (ppm-equiv)	~480	670-1090	520-670	480-670

Nakicenovic #9 2006

Scenario Overview (World by 2100)

	2000	A2r	B2	B1
Population, 10^9	6	12	10	7
GDP, 10^{12}\$	36	190	240	330
PE, EJ	440	1750	1300	1050
PE intensity, %/yr	-0.9	-0.6	-1.2	-1.7
Zero-C, % share	15	36	47	61
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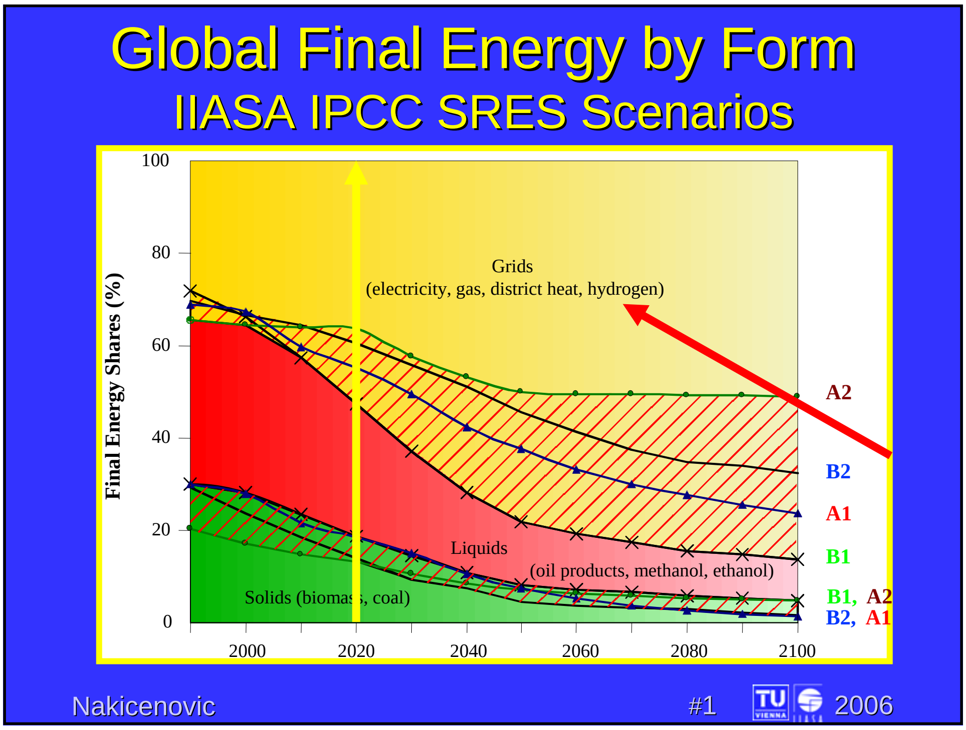
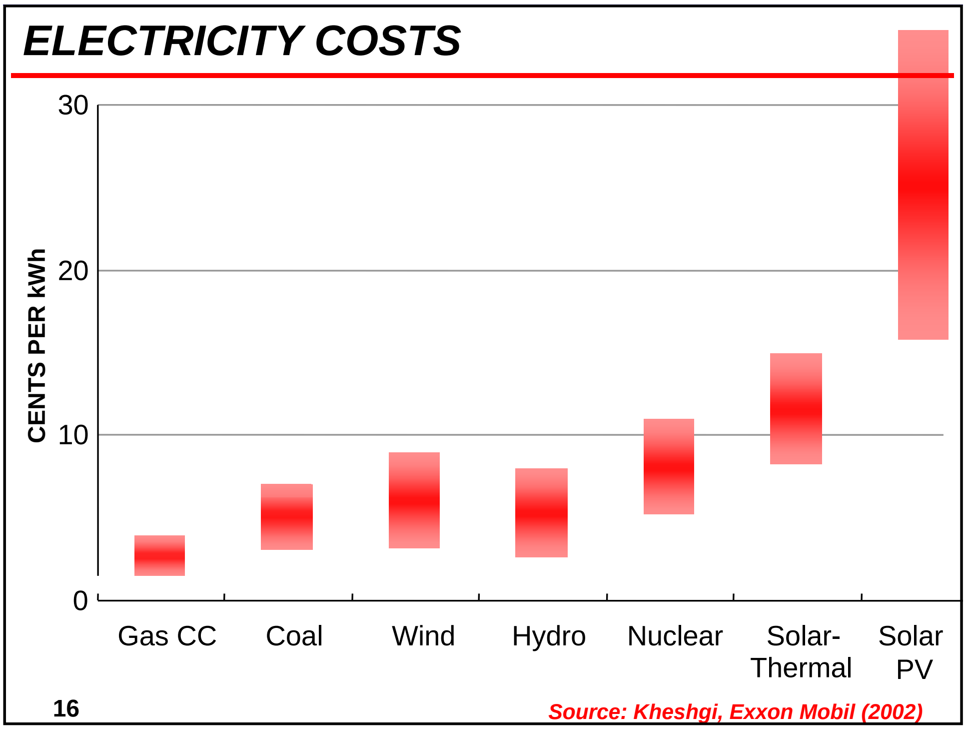
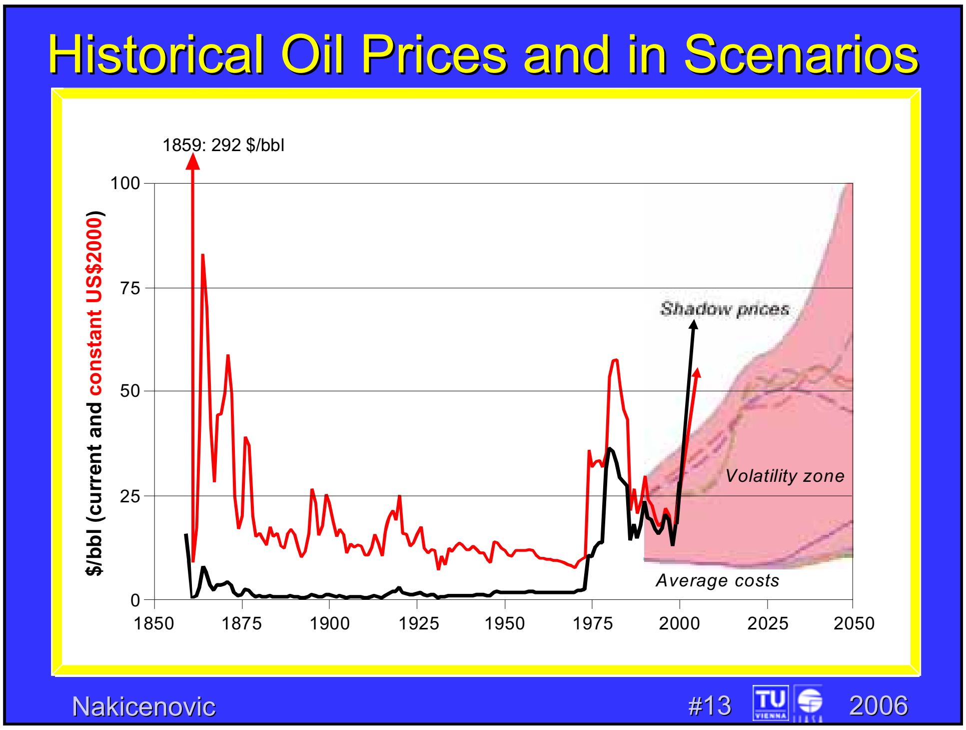
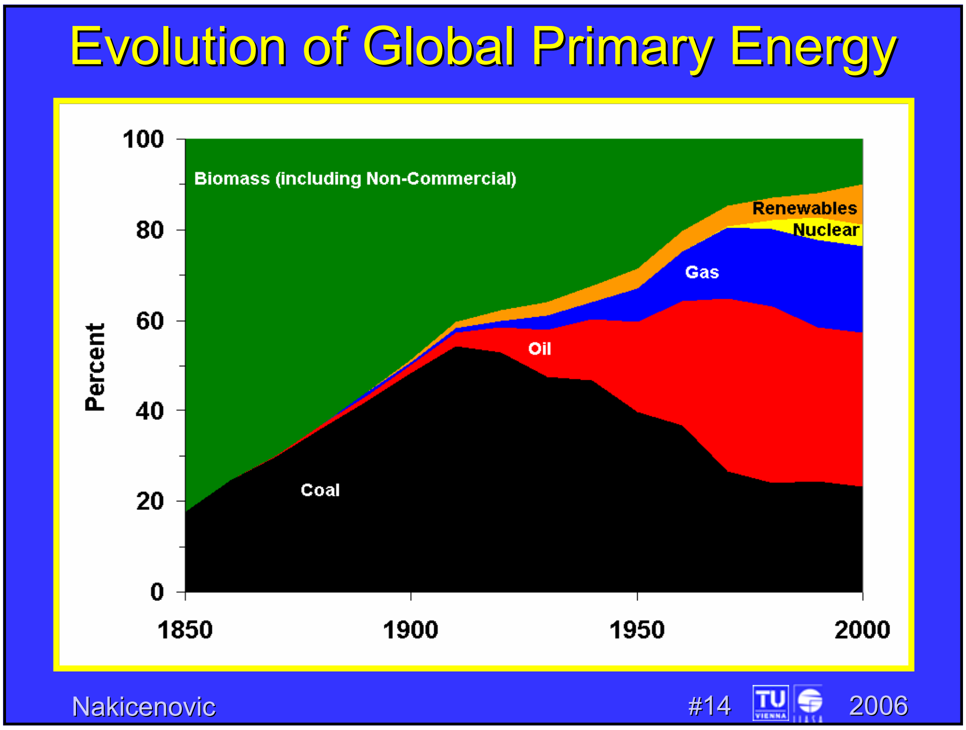
GtC-e total	11	38	19	9
ppmv (CO_2-equiv)	370	1390	980	790
Stabil. Levels (ppm-equiv)	~480	670-1090	520-670	480-670

Nakicenovic #10 2006

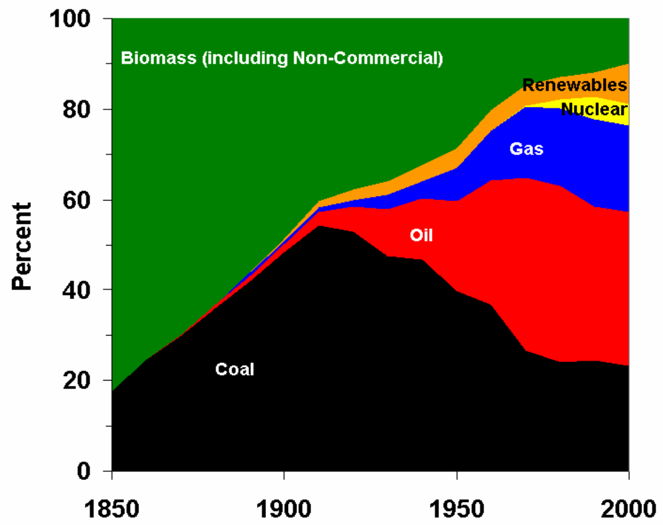

Global Final Energy by Form
IIASA IPCC SRES Scenarios
Final Energy Shares (%)
100
80
60
40
20
0
2000
2020
2040
2060
2080
2100
Grids
(electricity, gas, district heat, hydrogen)
Liquids
(oil products, methanol, ethanol)
Solids (biomass, coal)
A2
B2
A1
B1
B1, A2
B2, A1
Nakicenovic
#1
2006


ELECTRICITY COSTS
CENTS PER kWh
30
20
10
0
Gas CC
Coal
Wind
Hydro
Nuclear
Solar-Thermal
Solar PV
16
Source: Kheshgi, Exxon Mobil (2002)


Historical Oil Prices and in Scenarios
1859: 292 $/bbl
$/bbl (current and constant US$2000)
100
75
50
25
0
1850
1875
1900
1925
1950
1975
2000
2025
2050
Shadow prices
Volatility zone
Average costs
Nakicenovic
#13
2006

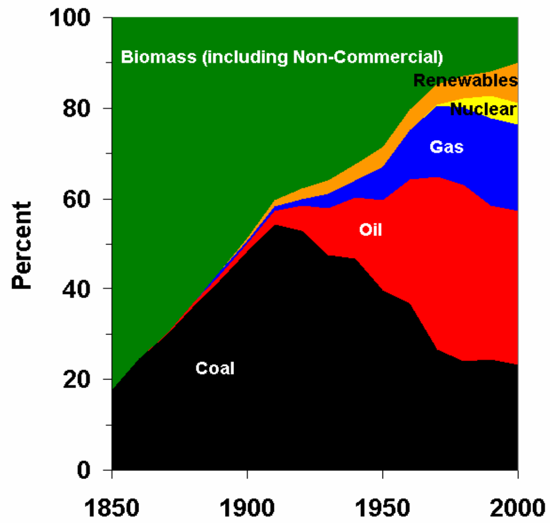

Evolution of Global Primary Energy
Percent
100
80
60
40
20
0
1850
1900
1950
2000
Biomass (including Non-Commercial)
Renewables
Nuclear
Gas
Oil
Coal
Nakicenovic
#14
2006

Evolution of Global Primary Energy

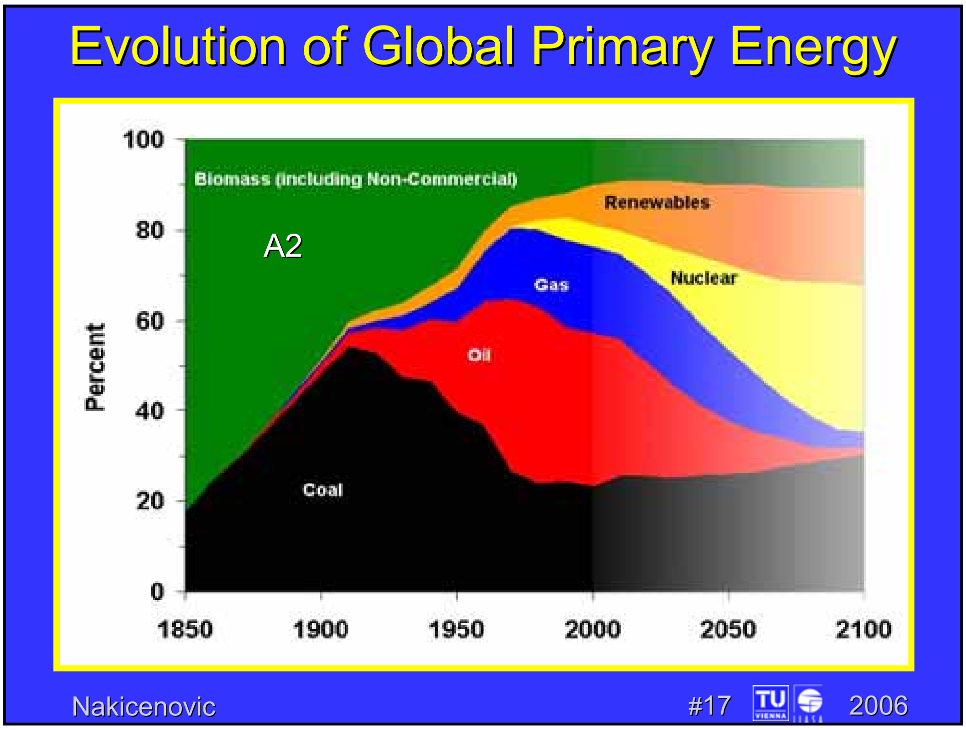


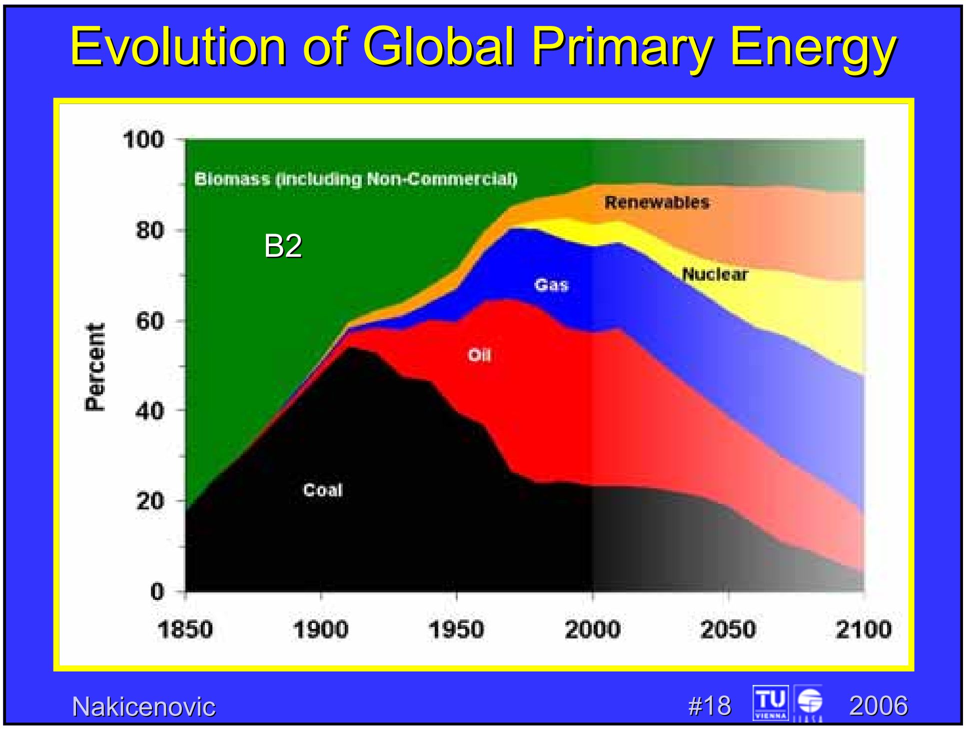
Nakicenovic #15 2006

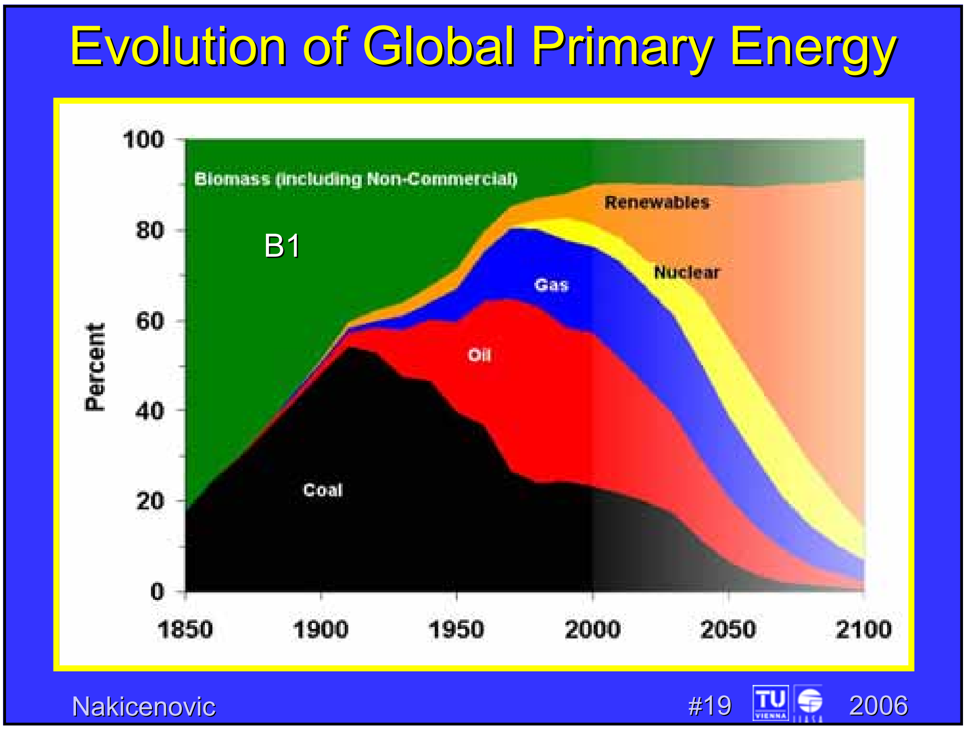
Evolution of Global Primary Energy

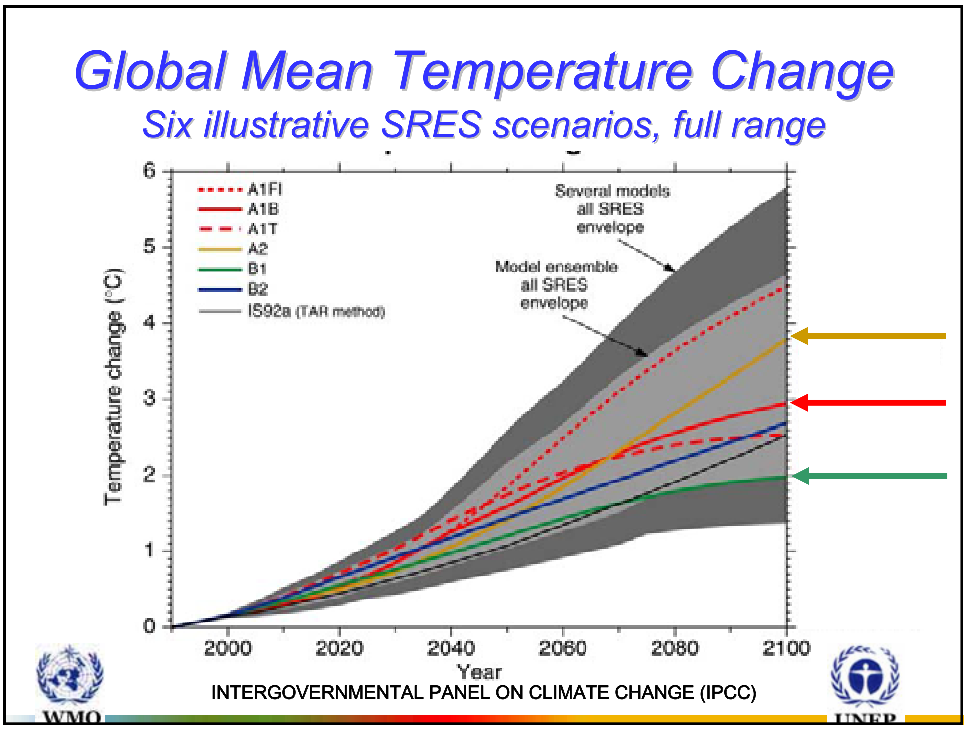


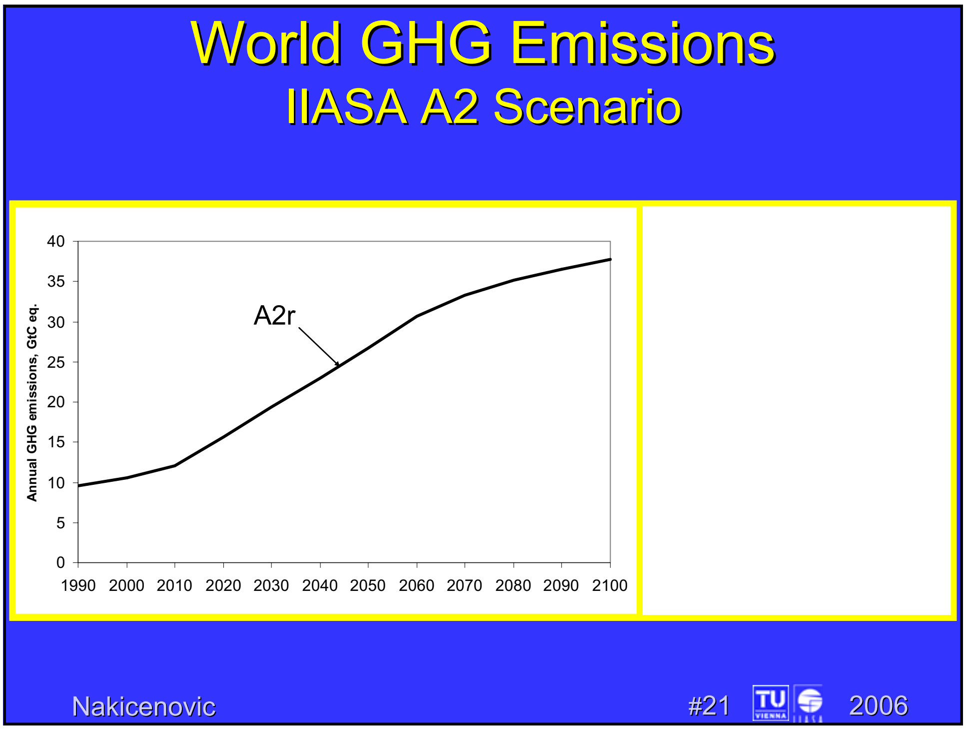
Nakicenovic #16 2006

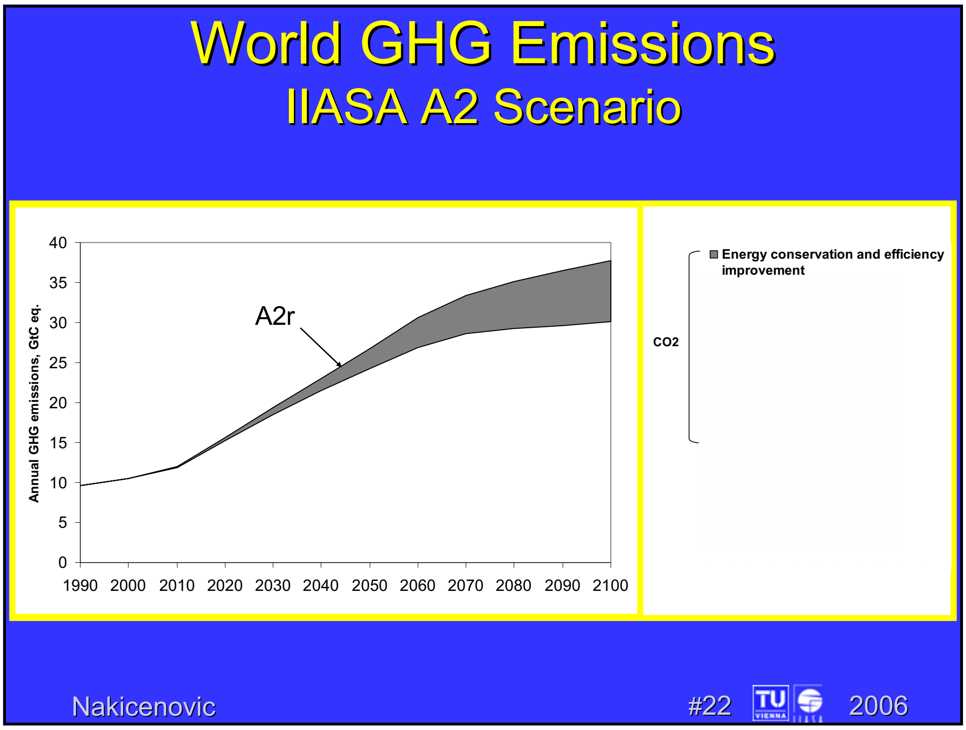

Evolution of Global Primary Energy
100
80
60
40
20
0
Percent
1850
1900
1950
2000
2050
2100
Biomass (including Non-Commercial)
A2
Renewables
Nuclear
Gas
Oil
Coal
Nakicenovic
#17
2006

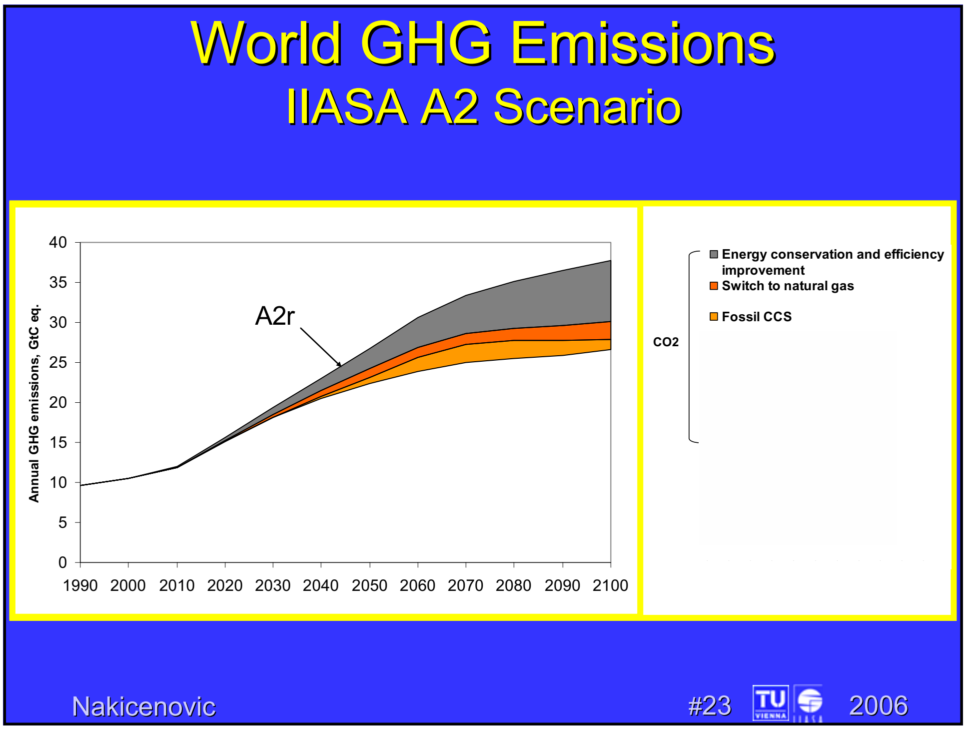

Evolution of Global Primary Energy
100
80
60
40
20
0
Percent
1850
1900
1950
2000
2050
2100
Biomass (including Non-Commercial)
B2
Renewables
Nuclear
Gas
Oil
Coal
Nakicenovic
#18
2006

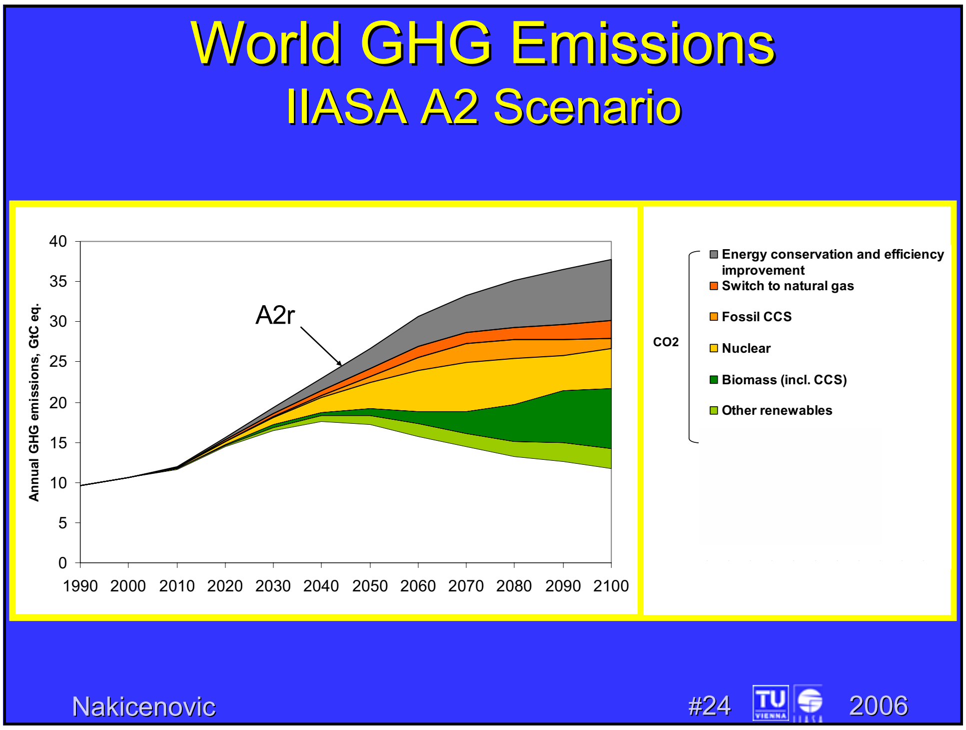

Evolution of Global Primary Energy
100
80
60
40
20
0
Percent
1850
1900
1950
2000
2050
2100
Biomass (including Non-Commercial)
B1
Renewables
Nuclear
Gas
Oil
Coal
Nakicenovic
#19
2006


Global Mean Temperature Change
Six illustrative SRES scenarios, full range
A1FI
A1B
A1T
A2
B1
B2
IS92a (TAR method)
Several models all SRES envelope
Model ensemble all SRES envelope
Temperature change (°C)
0
1
2
3
4
5
6
2000
2020
2040
2060
2080
2100
Year
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)
WMO
UNEP

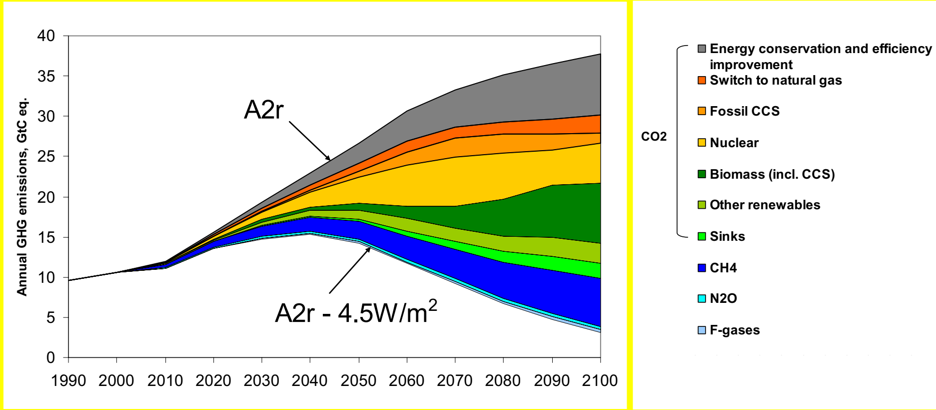

World GHG Emissions
IIASA A2 Scenario
Annual GHG emissions, GtC eq.
40
35
30
25
20
15
10
5
0
1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100
A2r
Nakicenovic
#21
2006


World GHG Emissions
IIASA A2 Scenario
Annual GHG emissions, GtC eq.
40
35
30
25
20
15
10
5
0
1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100
A2r
Energy conservation and efficiency improvement
CO2
Nakicenovic
#22
2006


World GHG Emissions
IIASA A2 Scenario
Annual GHG emissions, GtC eq.
40
35
30
25
20
15
10
5
0
1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100
A2r
CO2
Energy conservation and efficiency improvement
Switch to natural gas
Fossil CCS
Nakicenovic
#23
2006

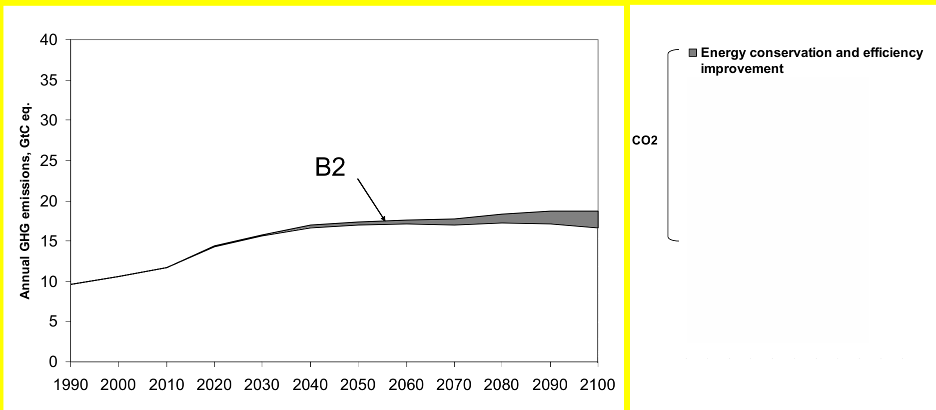

World GHG Emissions
IIASA A2 Scenario
Annual GHG emissions, GtC eq.
40
35
30
25
20
15
10
5
0
1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100
A2r
CO2
Energy conservation and efficiency improvement
Switch to natural gas
Fossil CCS
Nuclear
Biomass (incl. CCS)
Other renewables
Nakicenovic
#24
2006

World GHG Emissions
IIASA A2 Scenario

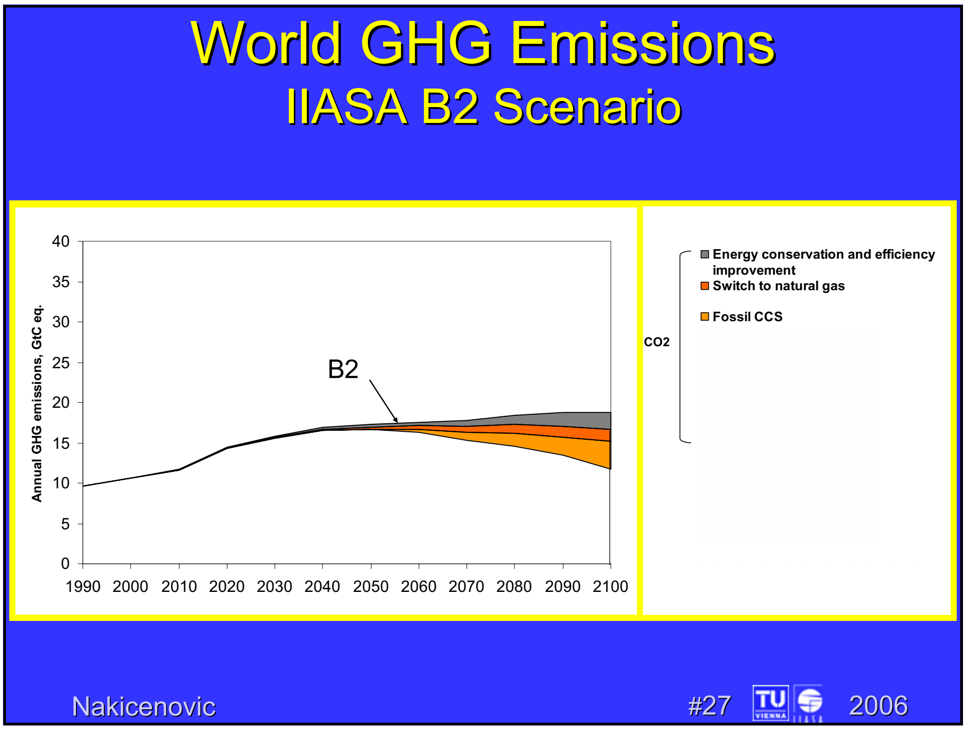


Nakicenovic #25 2006

World GHG Emissions
IIASA B2 Scenario



Nakicenovic #26 2006


World GHG Emissions
IIASA B2 Scenario
Annual GHG emissions, GtC eq.
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35
30
25
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10
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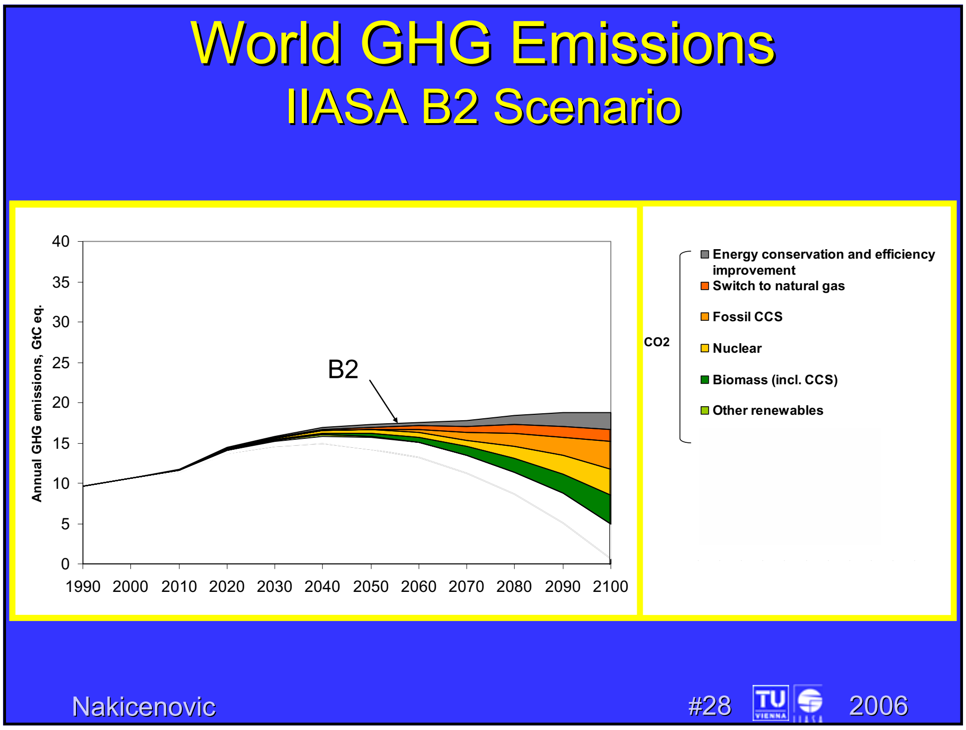
0
1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100
B2
CO2
Energy conservation and efficiency improvement
Switch to natural gas
Fossil CCS
Nakicenovic
#27
2006


World GHG Emissions
IIASA B2 Scenario
Annual GHG emissions, GtC eq.
40
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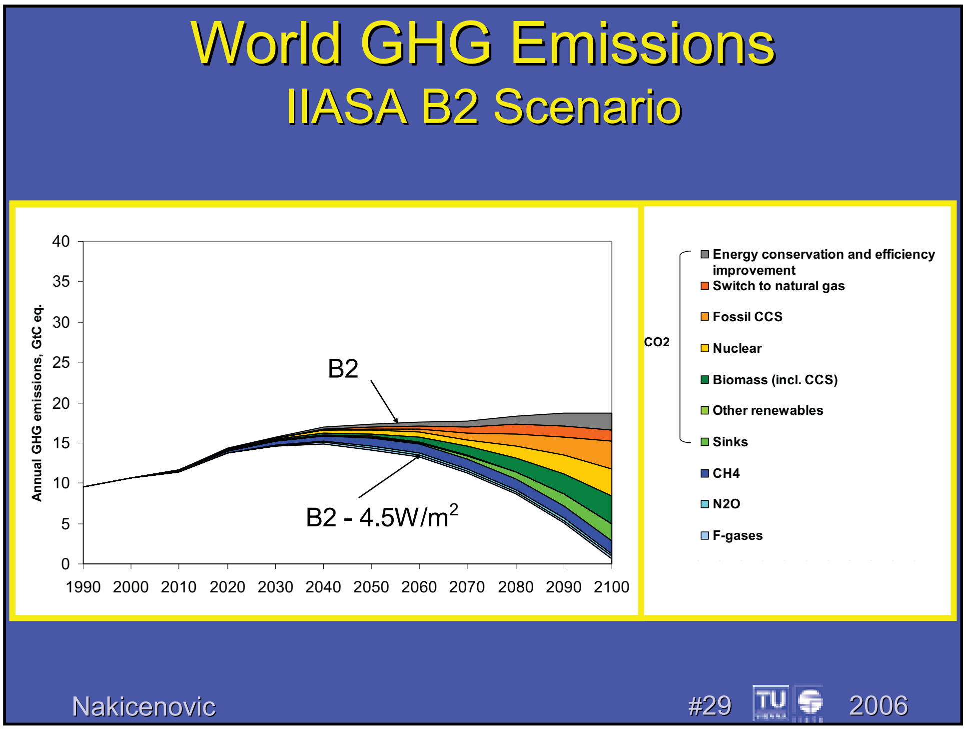
0
1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100
B2
CO2
Energy conservation and efficiency improvement
Switch to natural gas
Fossil CCS
Nuclear
Biomass (incl. CCS)
Other renewables
Nakicenovic
#28
2006



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Research for climate protection – technological options for mitigation

Methode

Baseline Szenario 2050

- ▶ **Top-Down (Makroökonomischer) Ansatz**

IPAT Analyse

(Impact = Population x Affluence x Technology)

Erlich, Holdren (1972)

Basierend auf folgender Literatur

- ▶(1) **Wifo-Szenario (2005)**
- ▶(2) **European Energy and Transport Trends to 2030 (2004, DG TREN, PRIMES-Modell)**
- ▶(3) **IPCC Spezial Report on Emissions (2001)**

$$Emissionen\ in\ CO_2Equiv = B \cdot \frac{BIP(VA)}{B} \cdot \frac{E}{BIP(VA)} \cdot \frac{CO_2Equiv}{E}$$

B ... Bevölkerung

BIP ... Bruttoinlandsprodukt

VA ... Sektorielle Wertschöpfung

E ... Energiebedarf

- ▶ **Baselineszenario 2020-2050**
  - ▶**Intensitäten von (2) und (3) MESSAGE A1-B2 Szenarien**
  - ▶**Übernommen und an (1) angepasst**
- ▶ **Baseline Szenario ist energieintensives Szenario**

Müller, 2006

#30

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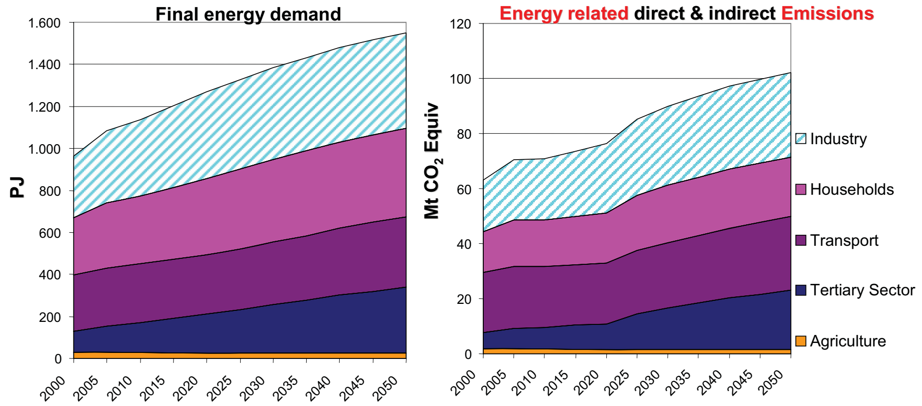
Baseline Szenario 2050

Energiebedarf und Emissionen



► **End-Energiebedarf +60%** **Emissionen +70%**

Müller, 2006 #31

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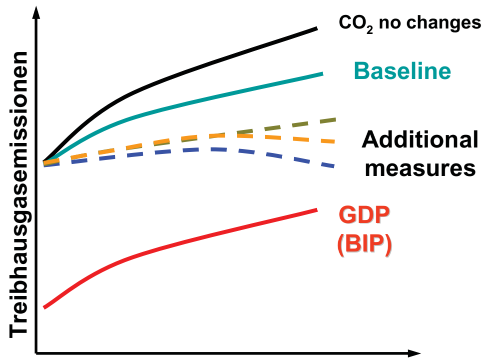
Emissionen:

Vermeidungsmaßnahmen

- **Analysen werden bei konstanter Energiedienstleistungsnachfrage und Nachfragestruktur durchgeführt**
- **Durch effizientere Bereitstellung der Energiedienstleistung**
  - **Technologien mit höherem Jahresnutzungsgrad**
  - **Gebäudedämmung / -struktur**
  - **Reduktion des Flottenverbrauchs**
- **Durch Substitution von emissionsintensiven Technologien**
  - **Änderung der Energieträger**
  - **Verstärkte Nutzung von öffentlichen Verkehrsmittel**
  - **CO2-Abtrennung**



Müller, 2006 #32

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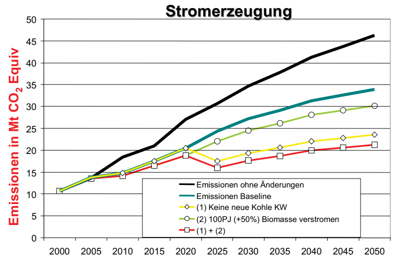
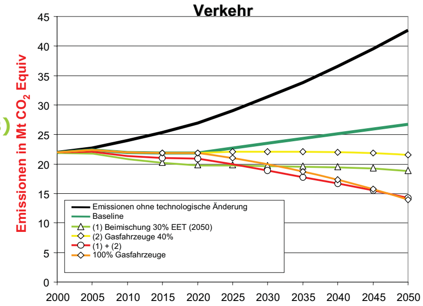
Vermeidungsmaßnahmen:

Brennstoffwechsel

- **Elektrizität:**
  - **Ohne Techn. Änderungen: ~10 -> 46 Mt**
  - **Baseline: ~ -12 Mt integriert**
  - **(1) 100PJ (+50%) Biomasse verstromen: -4 Mt (320 PJ energ. BMnutzung)**
  - **(2) Keine neuen Kohle-KW: -10 Mt**
  - **(1) + (2): -13 Mt**
- **Verkehr:**
  - **Ohne Techn. Änderungen: ~22 -> 43 Mt**
  - **Baseline: ~ -16 Mt integriert**
  - **(1) 30% Biofuels: -8 Mt (200 PJ Biofuels)**
  - **(2) 40% Erdgasfahrzeuge: -5 Mt**
  - **(3) 100% Erdgasfahrzeuge: -12,5 Mt**
  - **(1) + (2): -12,5 Mt**





Müller, 2006 #33

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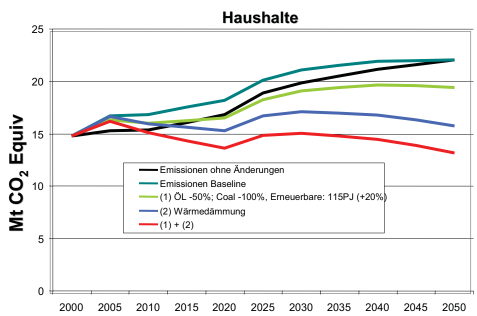
Vermeidungsmaßnahmen:

Haushalte

- **Raumwärme**
  - **Ohne Techn. Änderungen: ~10 -> 22 Mt**
  - **Baseline: ~ -0 Mt integriert**
  - **(1) Öl -50% (42 PJ) Erneuerbare: +20%(115 PJ): -2,5 Mt**
  - **(2) Energieeffizienz: -25% Energiebedarf: 6,3 Mt**
  - **(1) + (2): 8,5 Mt**



Müller, 2006 #34

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Vermeidungsmaßnahmen:

Kosten

- **Maßnahmenkosten sind von weiteren globalen Entwicklungen der betrachteten Maßnahmen abhängig**
- **Da diese nicht betrachtet werden, werden Kosten im wesentlichen exogen aus**
  - **IPCC – SRES**
  - **World Energy Assessment Report**

Übernommen und österreichische Kostenpotential angepasst

- **Technologische Maßnahmen zur Reduktion auf niedriges Emissionsniveau verursachen in energieintensiven Szenarien vergleichsweise hohe Kosten**

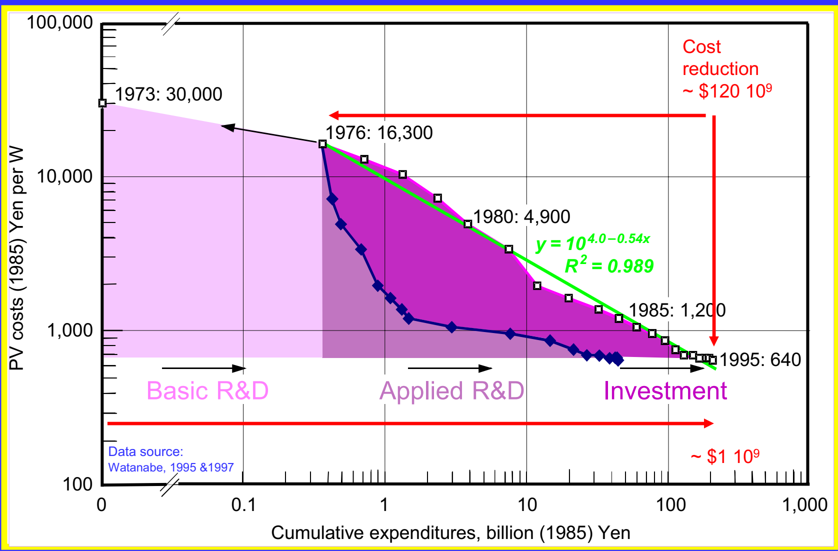
Müller, 2006 #35

TECHNOLOGIE-ENTWICKLUNG
Technology Dynamics

- Technologische Unsicherheit: Beschränktes Wissen über zukünftige Technologien
  - Deep Uncertainty: Limited knowledge on feasibility and costs of future technologies
- Endogene Technologiedynamik: Kostensenkungen von Technologien sind Folgen der gesammelten Erfahrung
  - Technological Learning: Improvements are a function of accumulated experience (learning curve)

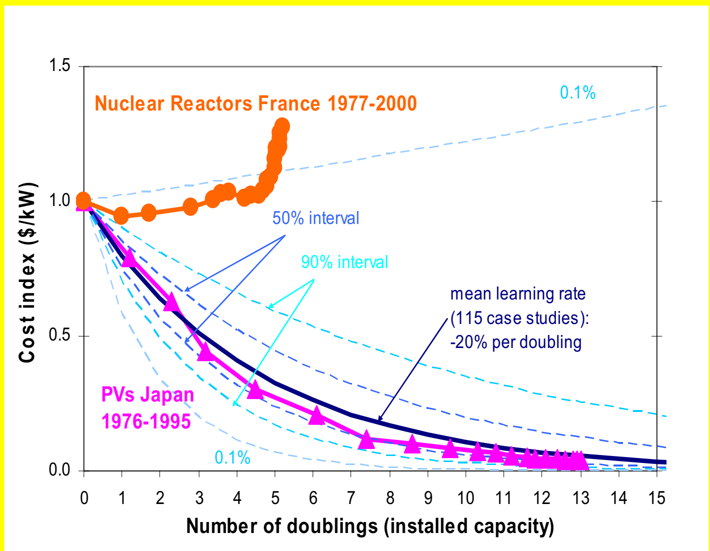
Nakicenovic #36 2006

Japan - PV Costs vs. Expenditures



Nakicenovic Grübler, 2002 #37 2006

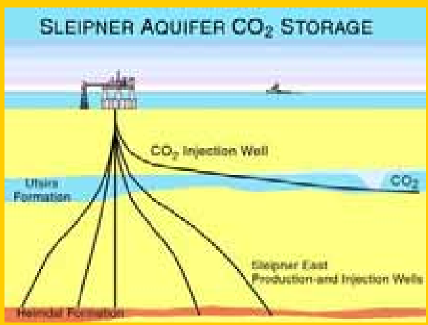
Technological Uncertainties: Learning rates (push) and market growth (pull)



Nakicenovic #38 2006

Existing and Planned Projects

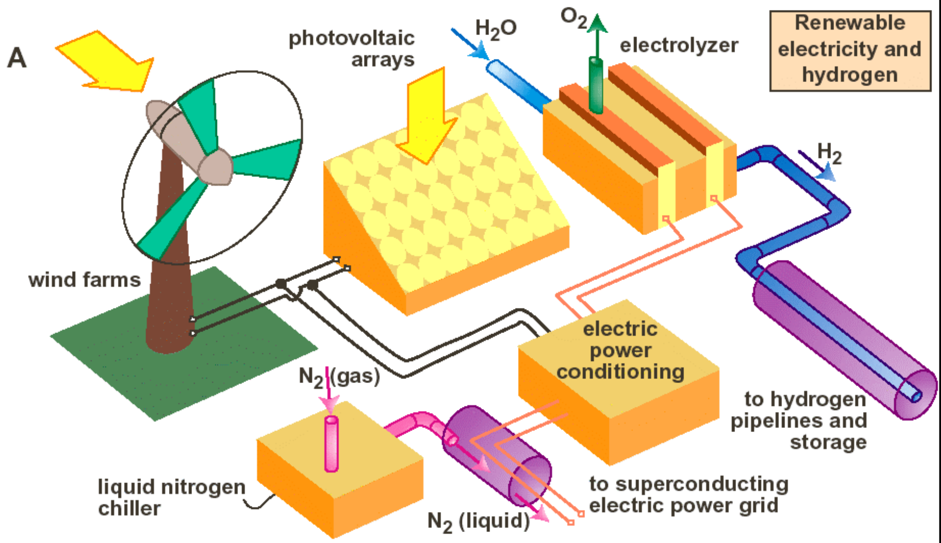
- Sleipner Project, saline formation, North Sea
- Weyburn, EOR, Saskatchewan, Canada
- In Salah, gas reservoir, Algeria (development)
- Snohvit, off-shore saline formation, North Sea
- Gorgon, saline formation, Australia (planning)



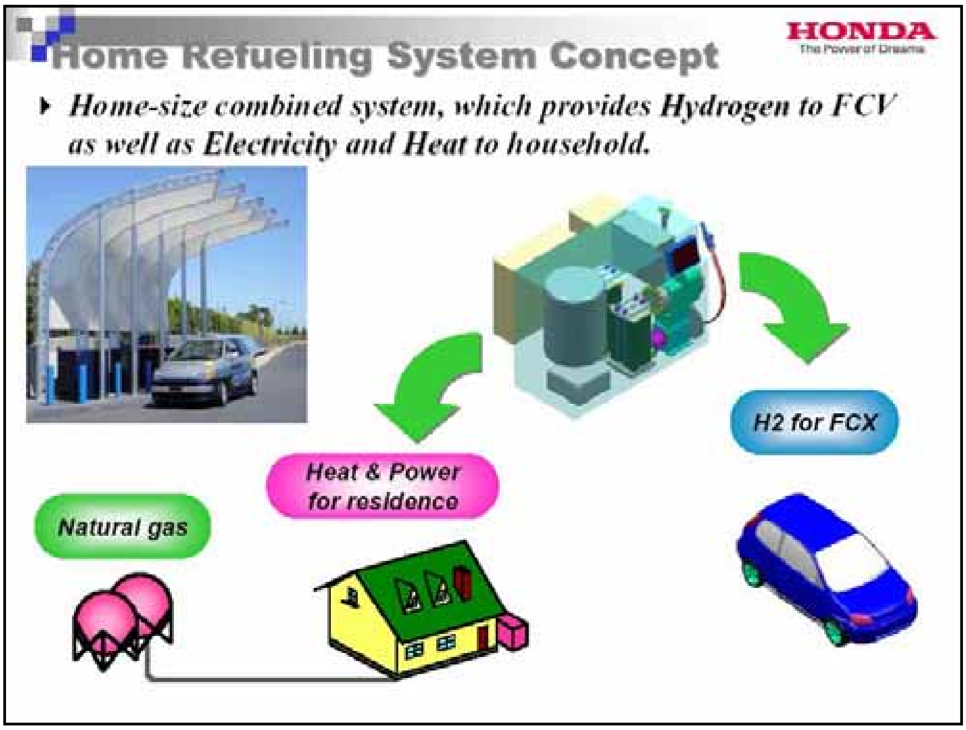
Nakicenovic #39 Source: Sally Benson, 2003

RENEWABLES

Hoffert et al., Science, 2002

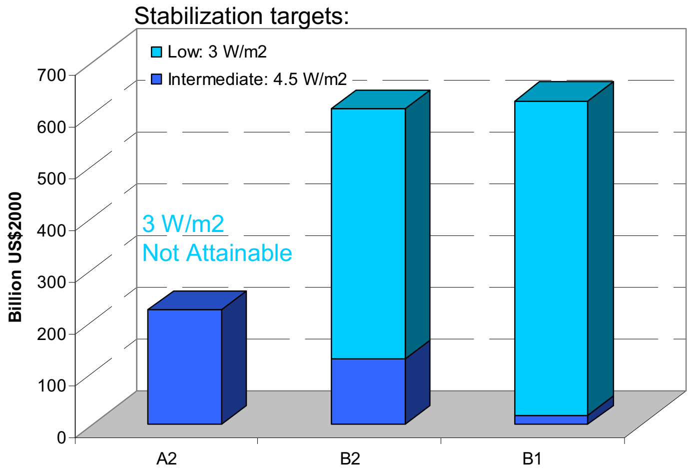


Nakicenovic # 40 IIASA&VUT 2003

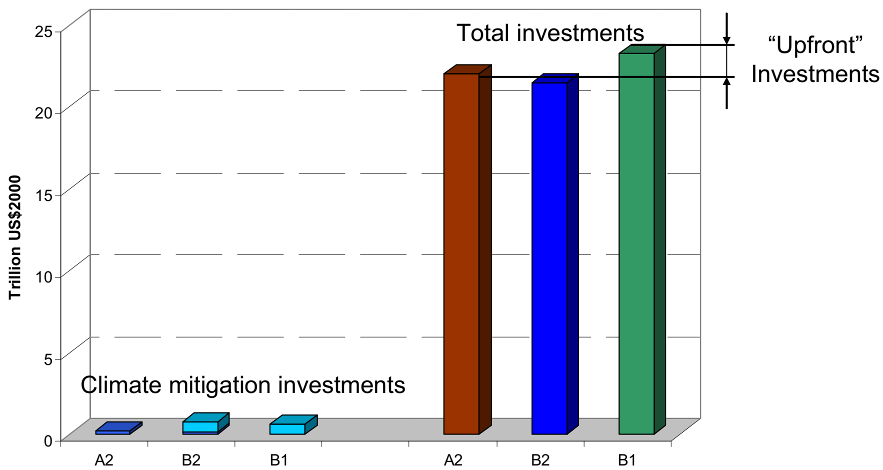

Home Refueling System Concept
HONDA
The Power of Dreams
Home-size combined system, which provides Hydrogen to FCV as well as Electricity and Heat to household.
H2 for FCX
Heat & Power for residence
Natural gas

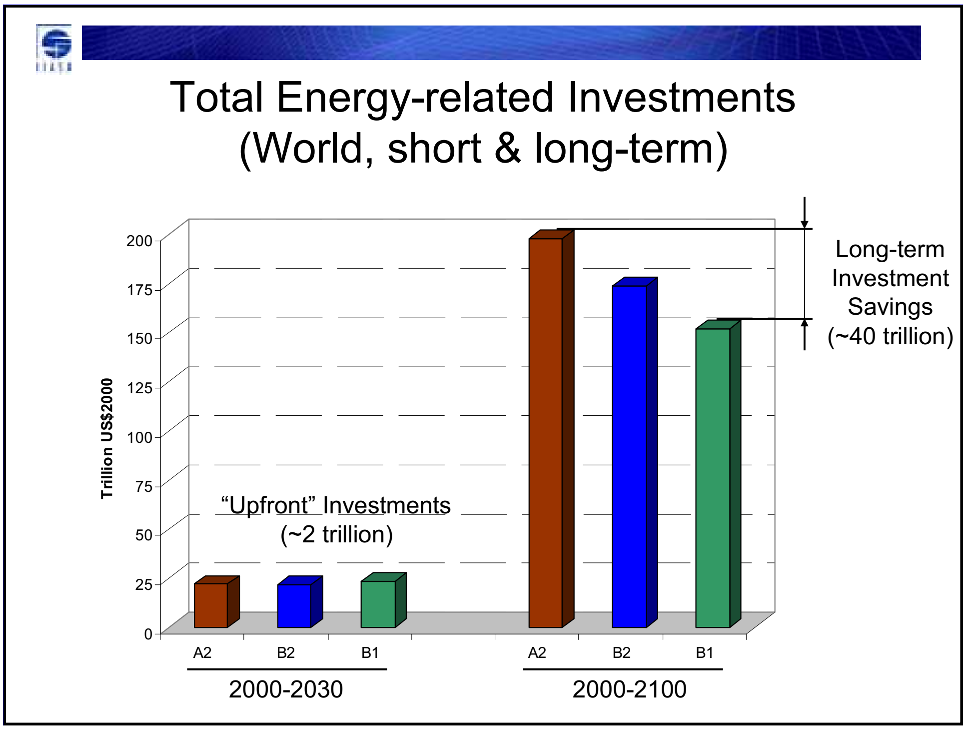

Hydrogen Airplane Design
Source: Airbus
Nakicenovic
#42
2006

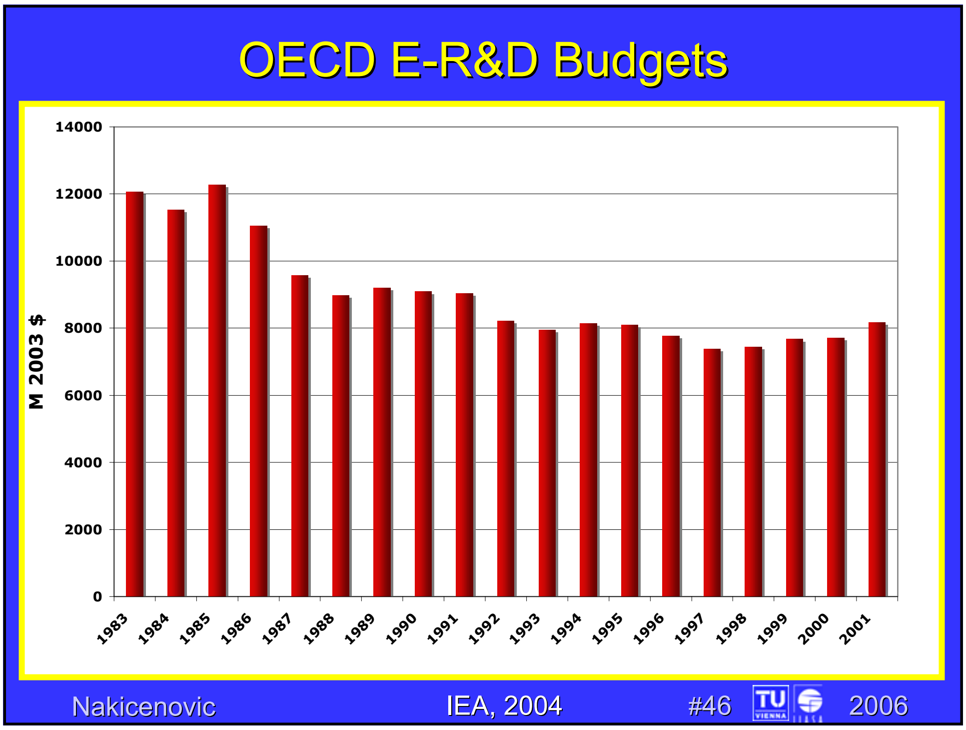
Climate-related Investments (2000-2030) (mitigation in the energy sector)



Climate Mitigation vs Total Energy Investments (World, 2000-2030)




Total Energy-related Investments
(World, short & long-term)
Trillion US$2000
0
25
50
75
100
125
150
175
200
"Upfront" Investments
(~2 trillion)
Long-term
Investment
Savings
(~40 trillion)
A2
B2
B1
A2
B2
B1
2000-2030
2000-2100


OECD E-R&D Budgets
M 2003 $
0
2000
4000
6000
8000
10000
12000
14000
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
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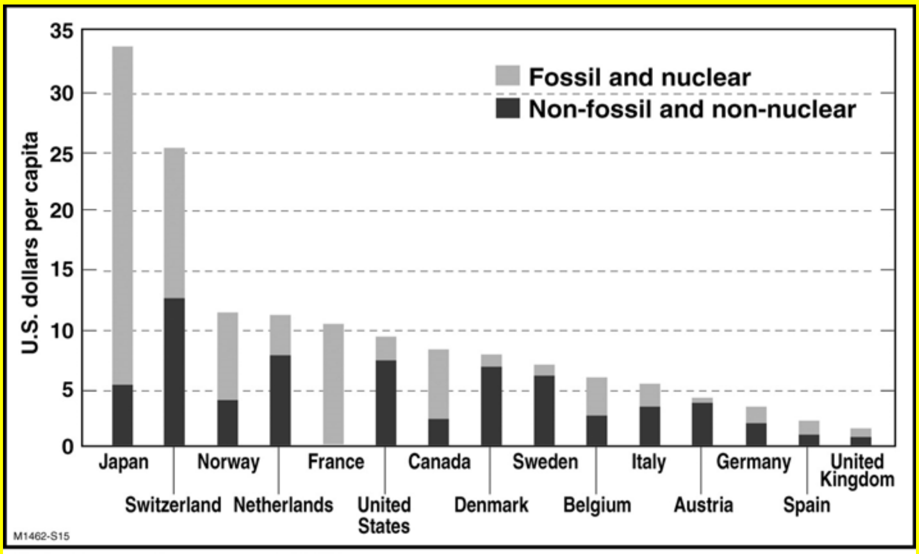
1998
1999
2000
2001
Nakicenovic
IEA, 2004
#46
2006

Public Expenditure on E-R&D



World Energy Assessment, 2000

Nakicenovic #47 2006

Global Energy Assessment:
Towards a more Sustainable Future

- The *magnitude* of the change required is *huge*
- The challenge is to find a way forward that addresses all the issues *simultaneously*
- A paradigm shift is needed: energy end-use efficiency, renewables, and carbon capture and storage.

Nakicenovic #48 2006

IIASA

International Institute for Applied Systems Analysis
presents a proposal for a

Global Energy Assessment

MIZUHO

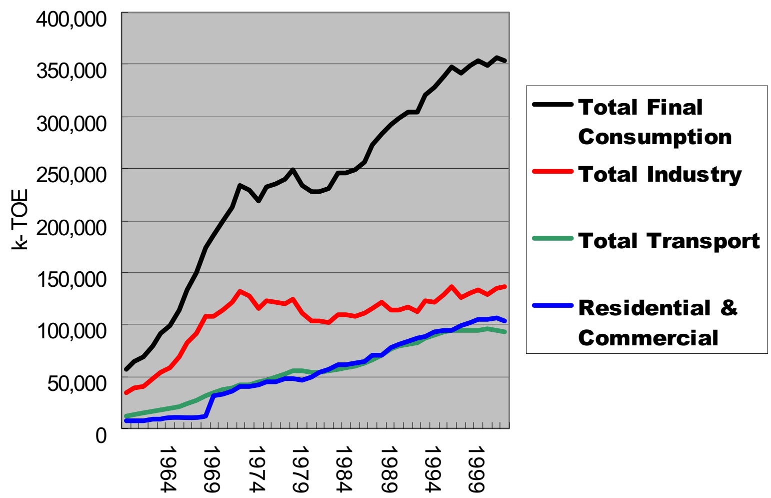
Energy Technology Vision 2100

Strategic Technology Roadmap
in Energy Field

Yasushi SETOGUCHI
MIZUHO Information and Research Institute Inc.

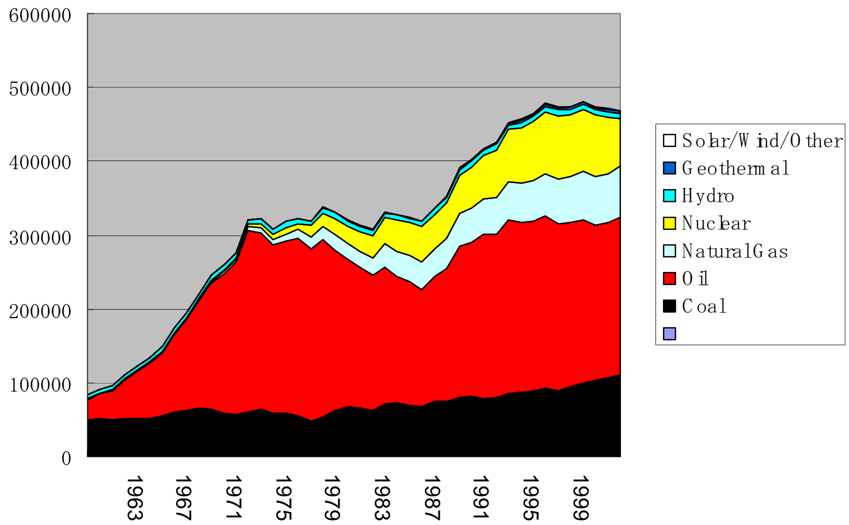
1

Final Energy Consumption in Japan



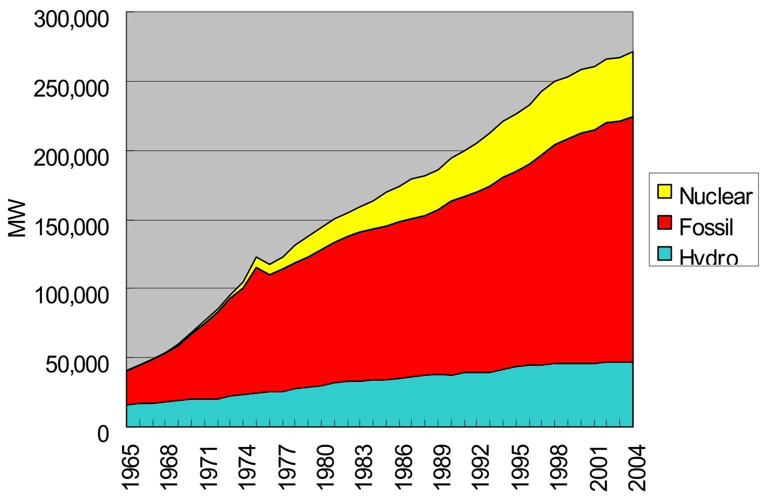
2

Primary Energy Supply in Japan



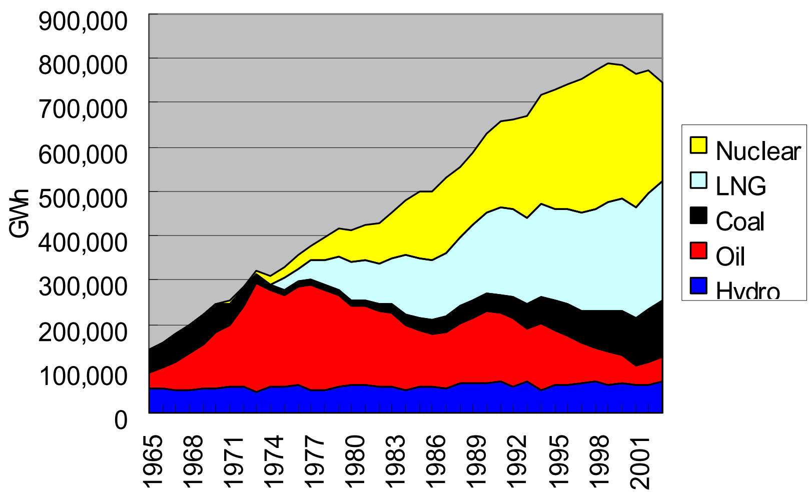
3

Power Plants Structure in Japan



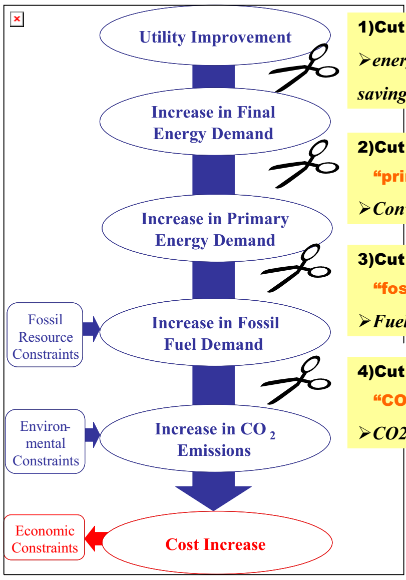
4

Source of Generated Power



5

A fundamental concept of measures



1)Cut off the chain between "utility" and "energy demand“

➢*energy saving, efficiency improvement, self-sustaining, and material saving*

2)Cut off the chain between “final energy demand" and “primary energy demand“

➢*Conversion efficiency improvement*

3)Cut off the chain between “primary energy demand" and “fossil fuel demand“

➢*Fuel switching to non-fossil*

4)Cut off the chain between “fossil fuel demand" and “CO2 emissions“

➢*CO2 capture and sequestration*

6

Energy Technology Vision 2100

- Introduced by Ministry of Economy, Trade and Industry, **METI**
- To prioritize R&D based on the long-term vision
- Developed by "backcasting" method
- Excessive conditions on the 4 sectors
  - residential/commercial
  - transport
  - industry
  - energy transformation

7

Forecasting vs. Backcasting

	Forecasting	Backcasting
Question	what future is likely to happen?	how desirable futures can be attained?
Direction	exploratory (opportunity-oriented) from present to future	normative (goal-setting) from futures to present
Focus	prediction and likelihood	feasibility and choice
Execution	one-time snap-shot	on-going monitoring
Analysis	extrapolation from historical data	interpolation from goal setting (futures)
Quality	accuracy-dependent	implication-oriented
Result	converge on the most likely future	diverge to possible futures with respect to freedom of action
Future(s)	preceded by present assessment	interpreted and envisioned from present assessment

8

Goal Definition

- Based on the constraints of energy and environment
  - Population
  - Economy (GDP)
  - Resources (fossil fuels, nuclear fuels, etc.)
  - Environment (climate change)

⇒ Quantitative Target for 2100

9

Population

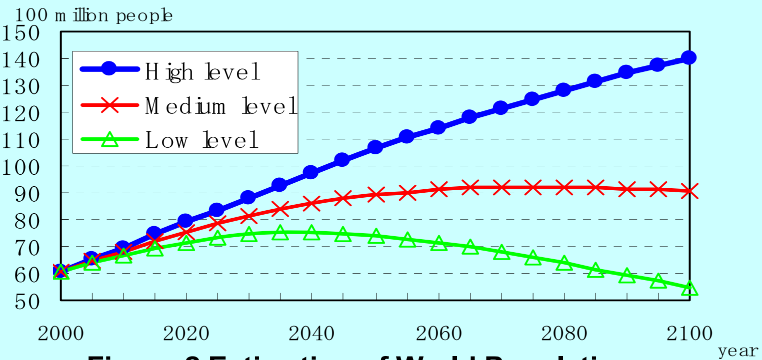
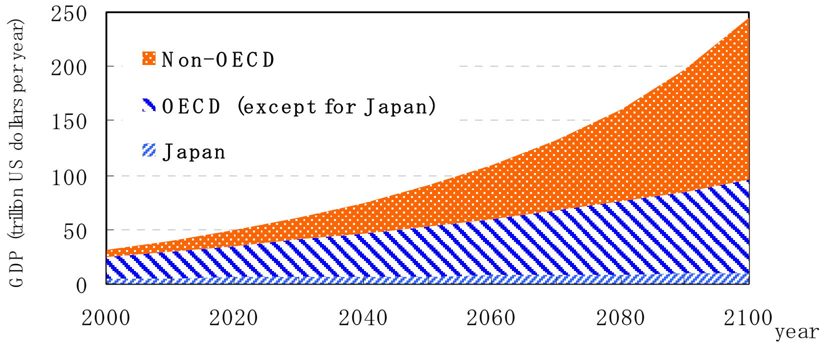


Figure 2.Estimation of World Population (world population to the year 2300)

10

Economy

- Trial calculation of GDP (by an integrated assessment model - GRAPE)



- Also referring to IPCC scenarios

11

Resources - Fossil

	Oil	Natural gas	Coal
R/P ratio	40.6 years	60.7 years	204 years
Proved recoverable reserves	1,048 Bbbl	156 Gm^3	984.5 Bt
Annual production	27 Bbbl	2.5 Gm^3	4.83 Bt

*** Source: oil, natural gas, coal: BP statistics 2003.**

12

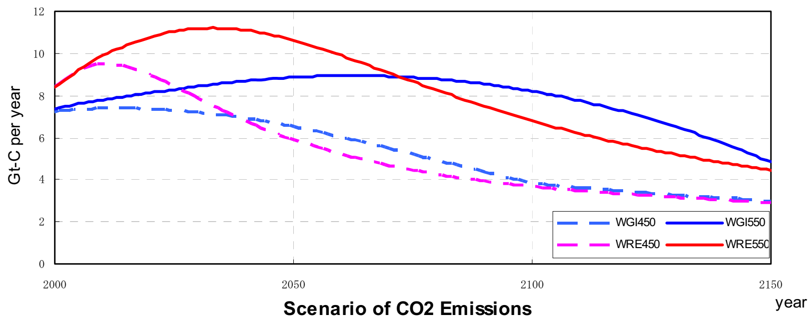
Resources - Nuclear

Reactor/nuclear fuel cycle	Known resources of conventional types	Resources of conventional types (including known resources)
Present nuclear fuel cycle (Light-water reactor, once-through fuel cycle)	85 years	270 years
Nuclear fuel cycle (Pu, single cycle)	100 years	300 years
Light-water reactor And fast reactor (Combined recycle)	130 years	410 years
fuel cycle (Recycle)	2,550 years	8,500 years

*Source: Uranium 2003, OECD/NEA.

13

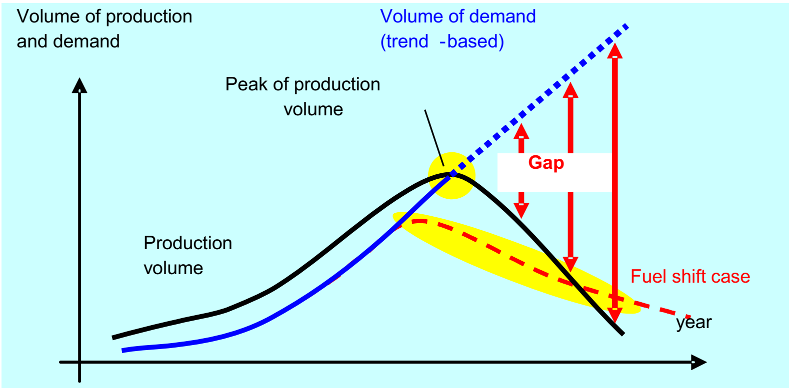
Environment – Climate Change



- Stabilization scenarios by WGI (IPCC WG1) and WRE (Wigley, Richels and Edmonds)

14

Surmounting Resource Constraint



Conceptual Diagram of Fuel Demand and Production

- If the demand continues to trend upward after the peak of production volume, the gap between the demand and production expands, and the balance of demand and supply is lost. Therefore, fuel shift is necessary before the peak.

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(1)Assumption of constraints in the future

Global resource constraint:

>Oil production is assumed to peak in 2050

>Natural gas production is assumed to peak in 2100

Global environmental constraint:

>CO_2 emission intensity per GDP (CO_2/GDP) should be reduced to 1/3 in 2050 and less than 1/10 in 2100

Condition of the future image of technologies in Japan:

- Up to the production peaks, substitution of other energy resource should be realized

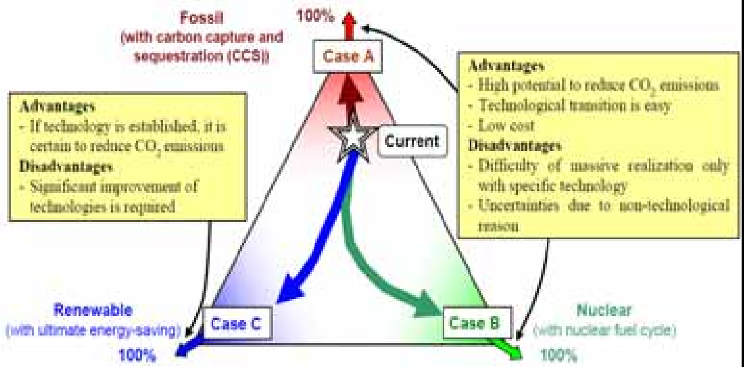
-CO_2 intensity should be reduced at the same ratio as above

➡ Japan leads the world into the foreseeable future

16

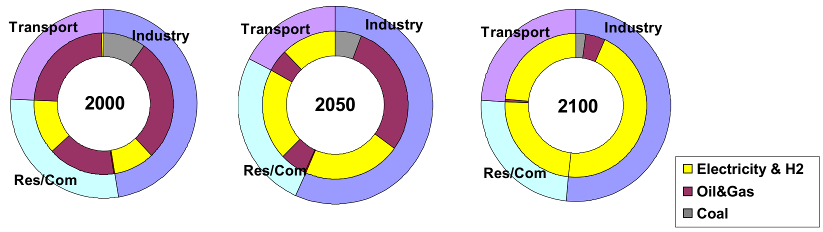
(2)Case studies under excessive conditions of energy structure

Case A: Maximum use of fossil resources such as coal combined with CO_2 capture and sequestration
Case B: Maximum use of nuclear energy
Case C: Maximum use of renewable energy combined with ultimate energy-saving

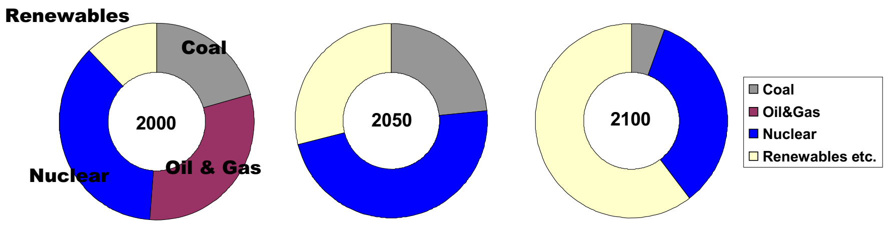


Images of the three cases of primary energy supply structures

Demand composition for each sector



Composition of power generation and hydrogen production



18

(3) Extraction of technology specification which is required in each sector

(4) Expanding major technology menu which is needed to realize the technology specification along the time axis

19

Concept of technology specifications in transport sector

(1) Common constraints of all cases and sectors

- Resource constraints: Up to the production peaks (oil: 2050, natural gas: 2100), substitution of other energy resources should be realized.
- Environmental constraints: CO_2 emissions intensity (CO_2/GDP) to be reduced to less than 1/3 in 2050 and 1/10 in 2100.

(2) Technology specifications of each case

-It is assumed that the utility (person·km and ton·km) increases in proportion to GDP and the share of each transport mode such as automobiles, aircraft, ships, and trains do not change.
-In Case C , it aims at the energy saving for each utility of 70% in the transport sector.
-the automobile sets the energy saving of 80% as a technological specification in consideration of the energy saving possibility according to each transport mode in 2100.
- The share of electricity and/or hydrogen of 100% is necessary to achieve the technology specifications.

20

Concept of technology specifications in transport sector

(3) Technology specifications in 2050 of case C

- The energy saving technology specifications for the entire transport sector and for each transport mode are set with consideration of backcasting from technology specifications in 2100 as well as the balance of the common constraints and the energy saving possibility in the end use sectors. The share of electricity and/or hydrogen required for achieving the energy saving technology specifications on automobiles are set.

(4) Milestones in 2030 are set with back casting based on the requirements in 2050 and 2100

- For example, hydrogen/electric vehicles are required to be commercialized to compete in the market in 2030 if 40% of electricity and/or hydrogen use is to be achieved in 2050.

(5) A roadmap of technology specifications expected to meet requirements at each time

		2000	2030	2050	2100
Utility (person-km, ton-km)		1 time		1.5 times	2.1 times
Energy supplied from transformation sector* (overall)			20% reduction	50% reduction	70% reduction
Automobiles	Energy demand		30% reduction	60% reduction	80% reduction
	Share of electricity and/or H2	0%	1% or more	40%	100%
	CO_2 intensity	160 g-CO_2/km (1 time)	100 g-CO_2/km (2/3 times)	50 g-CO_2/km (1/3 times)	0 g-CO_2/km
Aircraft, ships, and trains	Energy demand		10-20% reduction	20-35% reduction	30-50% reduction

21

*The percentage of reduction of energy per unit should be supplied from the transformation sector, compared with utility increases in proportion to GDP.

Concept of technology specifications in transport sector

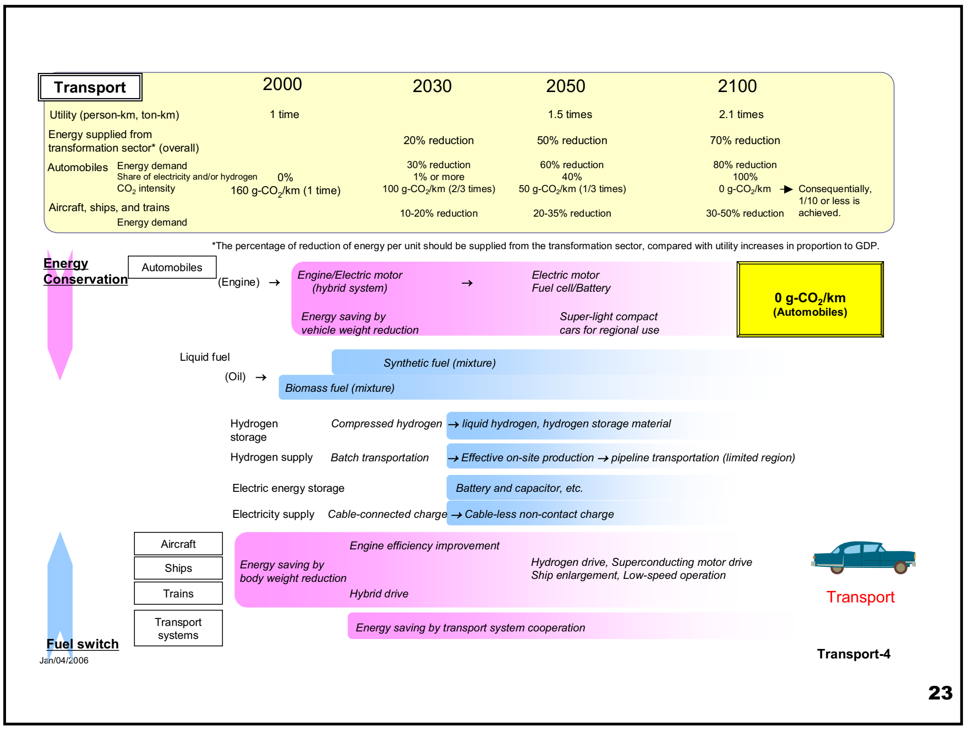
All Transport Sector

	2000	2030	2050	2100
Utility Person-km, ton-km	**Unit**		**X 1.5**	**X 2.1**
Energy supplied from transformation sector	**Unit**	**- 20%**	**- 50%**	**- 70%**

Automobiles

Energy demand		**- 30%**	**- 60%**	**- 80%**
Share of Electricity and/or H2	**0%**	**1% ～**	**40%**	**100%**
CO2 intensity (CO2 / km)	**160g**	**100g**	**50g**	**ZERO**

22


Transport
2000
2030
2050
2100
Utility (person-km, ton-km)
1 time
1.5 times
2.1 times
Energy supplied from transformation sector* (overall)
20% reduction
50% reduction
70% reduction
Automobiles
Energy demand
30% reduction
60% reduction
80% reduction
Share of electricity and/or hydrogen
0%
1% or more
40%
100%
CO2 intensity
160 g-CO2/km (1 time)
100 g-CO2/km (2/3 times)
50 g-CO2/km (1/3 times)
0 g-CO2/km
Consequentially, 1/10 or less is achieved.
Aircraft, ships, and trains
Energy demand
10-20% reduction
20-35% reduction
30-50% reduction
*The percentage of reduction of energy per unit should be supplied from the transformation sector, compared with utility increases in proportion to GDP.
Energy Conservation
Automobiles
(Engine)
Engine/Electric motor (hybrid system)
Electric motor Fuel cell/Battery
Energy saving by vehicle weight reduction
Super-light compact cars for regional use
0 g-CO2/km (Automobiles)
Liquid fuel
(Oil)
Synthetic fuel (mixture)
Biomass fuel (mixture)
Hydrogen storage
Compressed hydrogen
liquid hydrogen, hydrogen storage material
Hydrogen supply
Batch transportation
Effective on-site production
pipeline transportation (limited region)
Electric energy storage
Battery and capacitor, etc.
Electricity supply
Cable-connected charge
Cable-less non-contact charge
Aircraft
Ships
Trains
Transport systems
Engine efficiency improvement
Energy saving by body weight reduction
Hydrogen drive, Superconducting motor drive
Ship enlargement, Low-speed operation
Hybrid drive
Energy saving by transport system cooperation
Transport
Fuel switch
Jan/04/2006
Transport-4
23

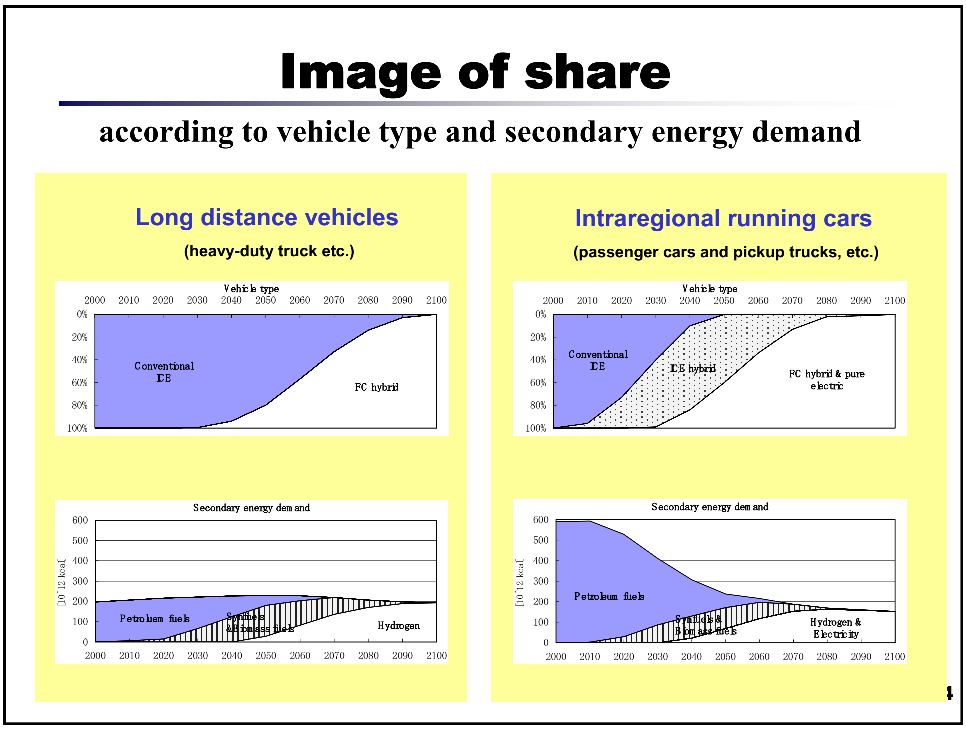


Image of share
according to vehicle type and secondary energy demand
Long distance vehicles
(heavy-duty truck etc.)
Intraregional running cars
(passenger cars and pickup trucks, etc.)
Vehicle type
Conventional ICE
FC hybrid
ICE hybrid
FC hybrid & pure electric
Secondary energy demand
[10^12 kcal]
Petroleum fuels
Synthetic & Biomass fuels
Hydrogen
Hydrogen & Electricity
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100

Industry

	2000	2030	2050	2100
(Production) X (Value of product)	1 time		1.5 times	2.1 times
Energy supplied from transformation sector*		25% reduction	40% reduction	70% reduction
1) Production energy intensity		20% reduction	30% reduction	50% reduction
2) Material/energy regeneration ratio		50%	60%	80%
3) Improvement of functionality such high-strength etc. (functionality / amount of material)	1 time	2 times	3 times	4 times

*The percentage of reduction of energy per utility (production x value of product) should be supplied from transformation sector, compared with the case where total energy demand increases in proportion to GDP.

High level of energy use at production process ***"create skillfully"***

(Energy saving in process) — *Development of innovative production process* / *Use of bio/nano catalyst etc* — *Zero-emission process*

Cogeneration & cascade use of heat

Integration and cooperation of material and energy

Co-production (simultaneous production of material and energy)

(Fossil resource use) → *Biomass/hydrogen use*

Regeneration of material/energy ***"use skillfully"***

Efficiency improvement of material regeneration process

Regeneration and utilization of material/energy in products

Regeneration & utilization of material/energy beyond sectors

Cross-boundary measures beyond sectors

Design technique for easy separation & sorting

Durability improvement

Improvement of functionality of material and parts

Material saving of products

Industry

Energy reduction for production with few resources ***"create good things"***

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Transformation

	2000	2030	2050	2100
Total energy demand on the demand side (maximum case)	1 time		1.5 times	2.1 times
Share of electricity and/or hydrogen in final energy	1 time		2 times (Case A and C) 3 times (Case B)	4 times (Case A and B) 3 times (Case C)
CO_2 Intensity	370 g-CO_2/kWh (1 time)	270 g-CO_2/kWh (2/3 times)	120 g-CO_2/kWh (1/3 times)	0 g-CO_2/kWh *110 g-CO_2/kWh (1/3 times) In the case of fossil fuel use with CCS*

Reduction in fossil use

Efficiency improvement of fossil fuel use

Fuel switching and efficiency improvement

(oil) → *Natural gas*

(coal) → *Coal (clean coal technology + CO_2 capture and sequestration (CCS))*

0 t-CO_2/kWh

Nuclear energy use — *Nuclear fuel cycle*

Load following operation

Efficiency improvement

Renewable energy use

Solar — *Technology that can be set up in all places such as roads and dams*

Geothermal

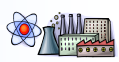
Wind power — *Onshore* → *Offshore*

Biomass — *Wood and biomass (waste and unused biomass)* → *Fuel crops production*

Efficiency improvement

Installation simplification

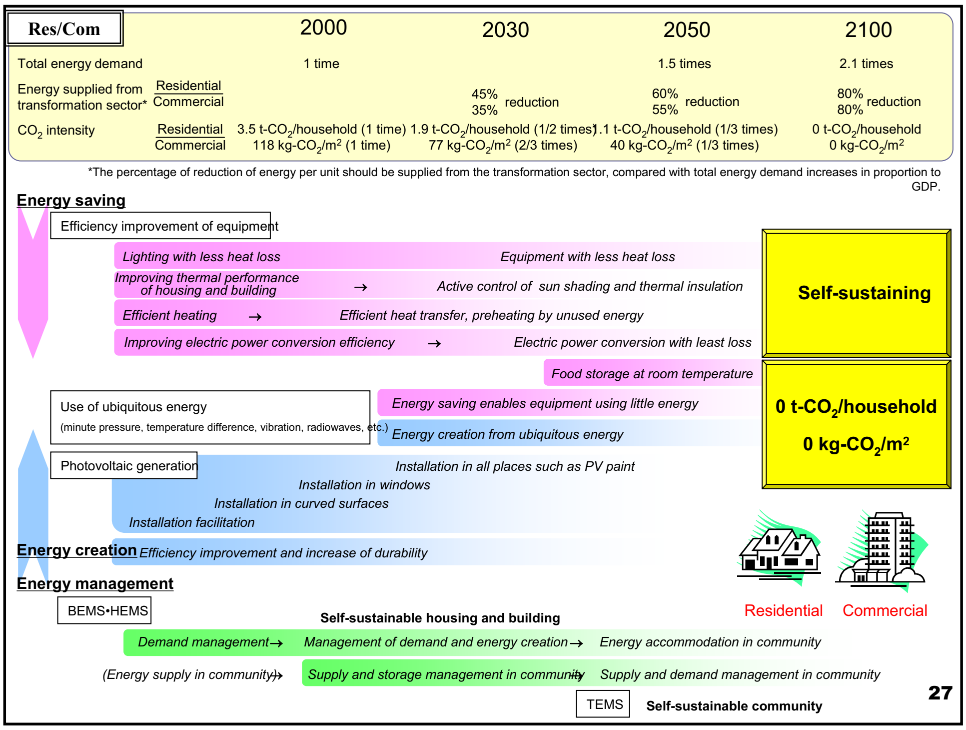
Energy storage



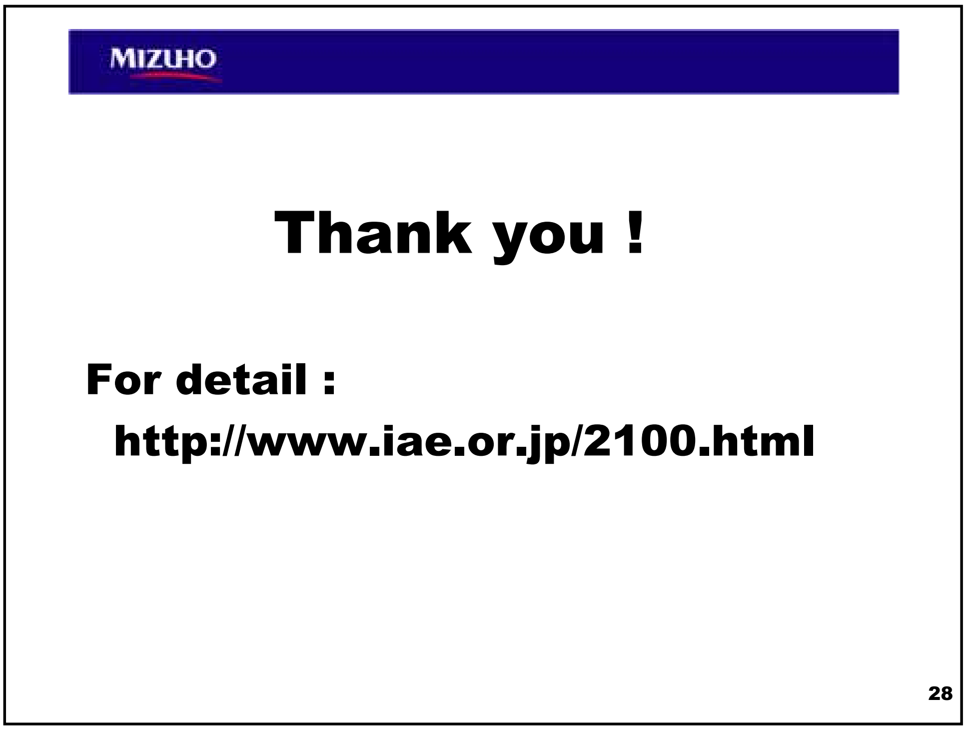
Transformation

Introduction of non-fossil energy

26



Res/Com
2000
2030
2050
2100
Total energy demand
1 time
1.5 times
2.1 times
Energy supplied from transformation sector*
Residential
Commercial
45% 35% reduction
60% 55% reduction
80% 80% reduction
CO$_2$ intensity
Residential
Commercial
3.5 t-CO$_2$/household (1 time)
118 kg-CO$_2$/m^2 (1 time)
1.9 t-CO$_2$/household (1/2 times)
77 kg-CO$_2$/m^2 (2/3 times)
1.1 t-CO$_2$/household (1/3 times)
40 kg-CO$_2$/m^2 (1/3 times)
0 t-CO$_2$/household
0 kg-CO$_2$/m^2
*The percentage of reduction of energy per unit should be supplied from the transformation sector, compared with total energy demand increases in proportion to GDP.
Energy saving
Efficiency improvement of equipment
Lighting with less heat loss
Equipment with less heat loss
Improving thermal performance of housing and building
Active control of sun shading and thermal insulation
Efficient heating
Efficient heat transfer, preheating by unused energy
Improving electric power conversion efficiency
Electric power conversion with least loss
Food storage at room temperature
Self-sustaining
Use of ubiquitous energy
(minute pressure, temperature difference, vibration, radiowaves, etc.)
Energy saving enables equipment using little energy
Energy creation from ubiquitous energy
0 t-CO$_2$/household
0 kg-CO$_2$/m^2
Photovoltaic generation
Installation in all places such as PV paint
Installation in windows
Installation in curved surfaces
Installation facilitation
Energy creation
Efficiency improvement and increase of durability
Energy management
Residential
Commercial
BEMS•HEMS
Self-sustainable housing and building
Demand management
Management of demand and energy creation
Energy accommodation in community
(Energy supply in community)
Supply and storage management in community
Supply and demand management in community
TEMS
Self-sustainable community
27



MIZUHO
Thank you !
For detail :
http://www.iae.or.jp/2100.html
28

MIZUHO

Energy Technology Vision 2100

Appendix

Yasushi SETOGUCHI
MIZUHO Information and Research Institute Inc.

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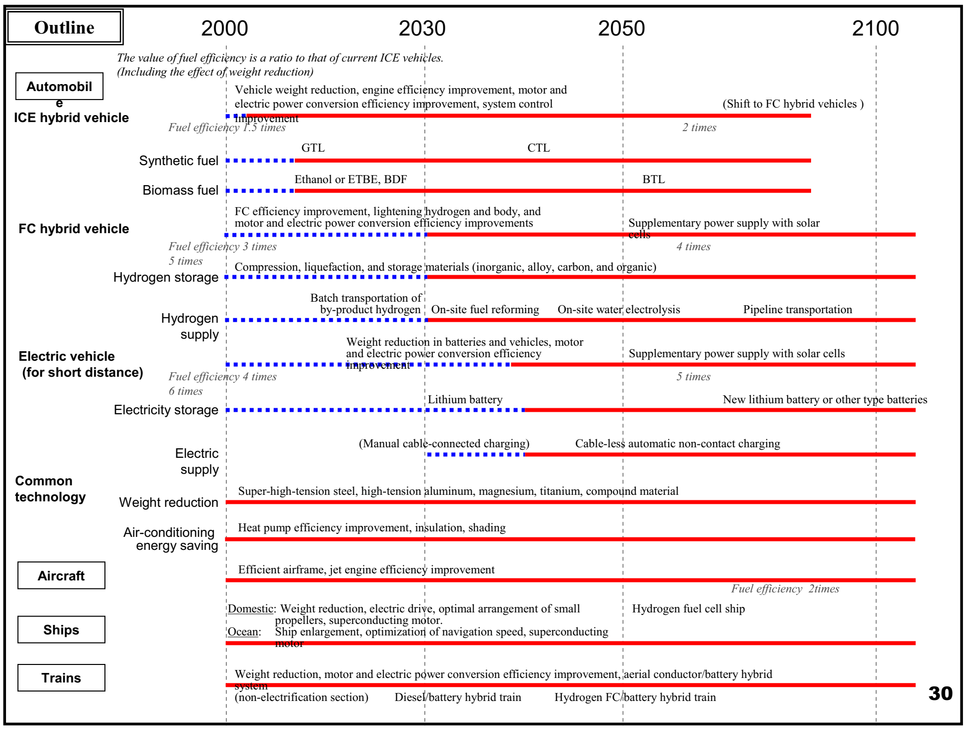
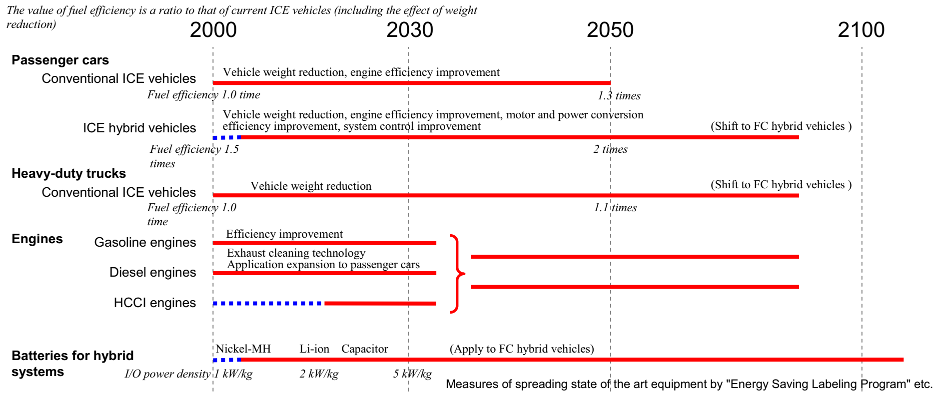


Efficiency improvement of automobiles

- The amount of utility (≈ vehicle number × running distance) supplied by automobiles increases in proportion to GDP.
- The efficiency improvement in power trains and energy saving by weight reduction is necessary to improve energy intensity.
- In order to decrease energy intensity and CO_2 intensity drastically in the future, hydrogen fuel cell vehicles or electric vehicles that have high efficiency and don't emit CO_2 should become mainstream.

Internal combustion engine (ICE) hybrid vehicles

- As for vehicles mainly used for intraregional driving such as pickup trucks and passenger cars, the shift to a hybrid system will progress, and non-hybrid vehicles will not be used by about 2050.
- The use of ICE hybrid vehicles for long-distance vehicles such as heavy-duty trucks will not advance because the advantage of hybridization is small (shift directly from conventional ICE vehicles to FC vehicle).
- Fuel efficiency improvement by weight reduction is expected for both conventional vehicles and hybrid vehicles.
- All ICE vehicles will disappear by 2100.
- When the HCCI engine is put to practical use, three kinds of engines will be integrated into two kinds (or even one).



Non-technical factors

- Measures for the improvement of fuel efficiency by the "Top Runner Standards" of "Energy Saving Labeling Program" etc.
- Taxation discount and subsidies to gas-sipper (fuel efficient cars)

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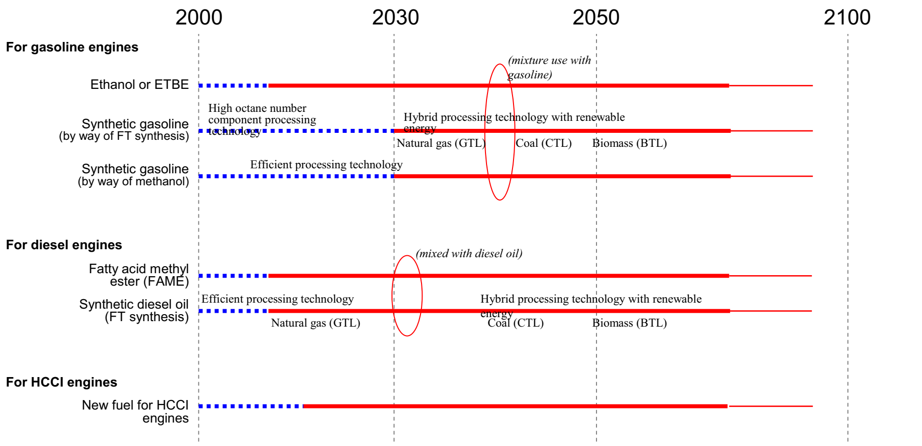
Fuels for internal combustion engine vehicles

- Fuels for ICE will shift from petroleum fuels to synthetic fuels by 2050. During the shift process, mixed petroleum fuels and synthetic fuels are assumed.
- Ethanol (or ETBE) and FAME have the possibility to be introduced in the early stage, but neither of them become a main component of the fuels due to their restricted supply.
- FT synthesis oil will be introduced as a blend component to diesel oil at first. In order to use FT synthesis oil for gasoline engines, processing technology development for high octane number fuel is necessary. The application will be later than that for the diesel engine. Also, synthetic gasoline by way of methanol produced from natural gas or coal may be used.
- The specifications of the fuel for HCCI engines are uncertain at the present time. There is the possibility that the fuels will be integrated into two kinds (or even one) in association with the integration of engines.
- Additionally, the use of DME, CNG, and LPG contributes to oil substitution and CO_2 emissions reduction.



Non-technical factors

- Taxation discounts on new fuel
- Revision of fuel standards and adjustment with exhaust emissions regulations

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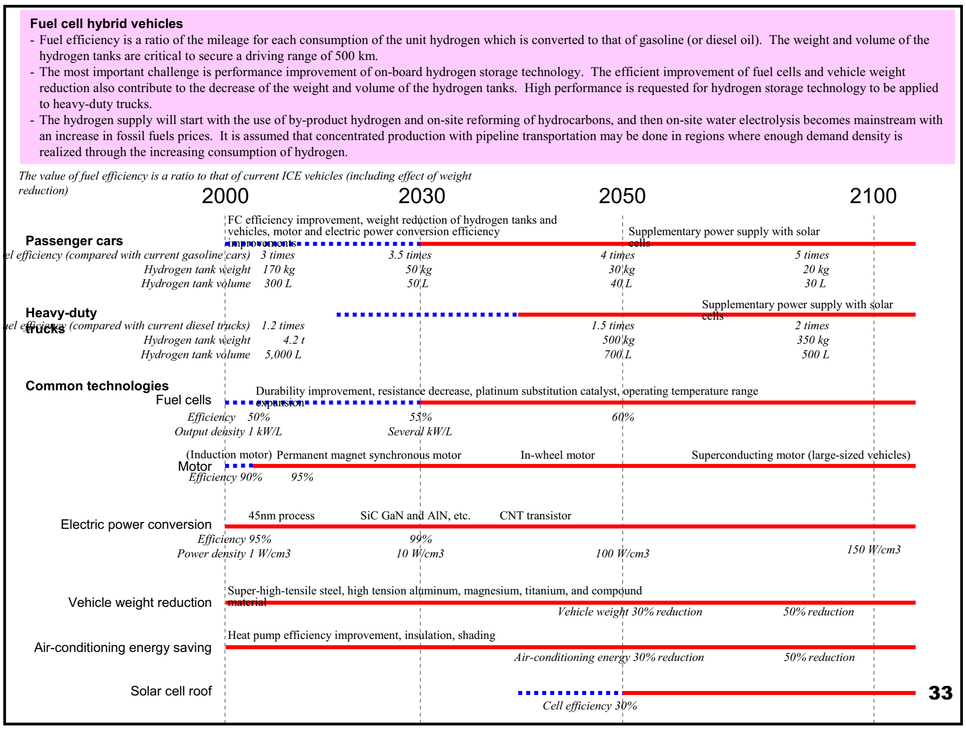
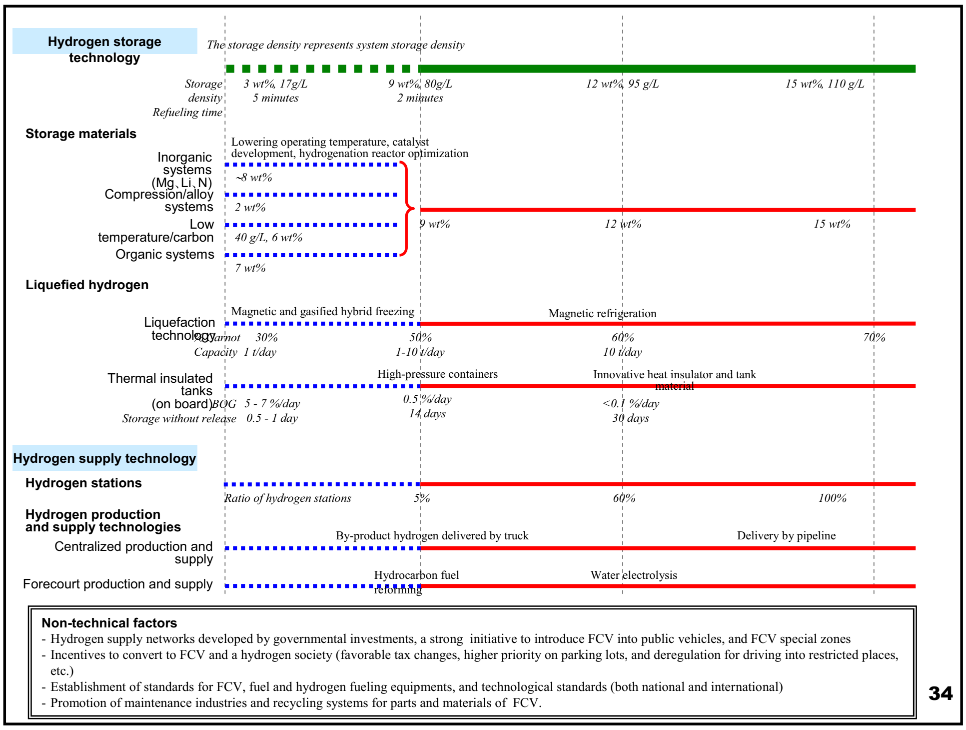

Fuel cell hybrid vehicles
- Fuel efficiency is a ratio of the mileage for each consumption of the unit hydrogen which is converted to that of gasoline (or diesel oil). The weight and volume of the hydrogen tanks are critical to secure a driving range of 500 km.
- The most important challenge is performance improvement of on-board hydrogen storage technology. The efficient improvement of fuel cells and vehicle weight reduction also contribute to the decrease of the weight and volume of the hydrogen tanks. High performance is requested for hydrogen storage technology to be applied to heavy-duty trucks.
- The hydrogen supply will start with the use of by-product hydrogen and on-site reforming of hydrocarbons, and then on-site water electrolysis becomes mainstream with an increase in fossil fuels prices. It is assumed that concentrated production with pipeline transportation may be done in regions where enough demand density is realized through the increasing consumption of hydrogen.
The value of fuel efficiency is a ratio to that of current ICE vehicles (including effect of weight reduction)
2000
2030
2050
2100
Passenger cars
FC efficiency improvement, weight reduction of hydrogen tanks and vehicles, motor and electric power conversion efficiency improvements
Supplementary power supply with solar cells
Fuel efficiency (compared with current gasoline cars) 3 times 3.5 times 4 times 5 times
Hydrogen tank weight 170 kg 50 kg 30 kg 20 kg
Hydrogen tank volume 300 L 50 L 40 L 30 L
Heavy-duty trucks
Supplementary power supply with solar cells
Fuel efficiency (compared with current diesel trucks) 1.2 times 1.5 times 2 times
Hydrogen tank weight 4.2 t 500 kg 350 kg
Hydrogen tank volume 5,000 L 700 L 500 L
Common technologies
Fuel cells
Durability improvement, resistance decrease, platinum substitution catalyst, operating temperature range expansion
Efficiency 50% 55% 60%
Output density 1 kW/L Several kW/L
Motor
(Induction motor) Permanent magnet synchronous motor
In-wheel motor
Superconducting motor (large-sized vehicles)
Efficiency 90% 95%
Electric power conversion
45nm process
SiC GaN and AlN, etc.
CNT transistor
Efficiency 95% 99%
Power density 1 W/cm3 10 W/cm3 100 W/cm3 150 W/cm3
Vehicle weight reduction
Super-high-tensile steel, high tension aluminum, magnesium, titanium, and compound material
Vehicle weight 30% reduction
50% reduction
Air-conditioning energy saving
Heat pump efficiency improvement, insulation, shading
Air-conditioning energy 30% reduction
50% reduction
Solar cell roof
Cell efficiency 30%
33


Hydrogen storage technology
The storage density represents system storage density
Storage density 3 wt%, 17g/L 9 wt%, 80g/L 12 wt%, 95 g/L 15 wt%, 110 g/L
Refueling time 5 minutes 2 minutes
Storage materials
Lowering operating temperature, catalyst development, hydrogenation reactor optimization
Inorganic systems (Mg, Li, N) ~8 wt%
Compression/alloy systems 2 wt%
Low temperature/carbon 40 g/L, 6 wt%
Organic systems 7 wt%
9 wt% 12 wt% 15 wt%
Liquefied hydrogen
Liquefaction technology
Magnetic and gasified hybrid freezing
Magnetic refrigeration
Carnot 30% 50% 60% 70%
Capacity 1 t/day 1-10 t/day 10 t/day
Thermal insulated tanks (on board)
High-pressure containers
Innovative heat insulator and tank material
BOG 5 - 7 %/day 0.5 %/day <0.1 %/day
Storage without release 0.5 - 1 day 14 days 30 days
Hydrogen supply technology
Hydrogen stations
Ratio of hydrogen stations 5% 60% 100%
Hydrogen production and supply technologies
Centralized production and supply
By-product hydrogen delivered by truck
Delivery by pipeline
Forecourt production and supply
Hydrocarbon fuel reforming
Water electrolysis
Non-technical factors
- Hydrogen supply networks developed by governmental investments, a strong initiative to introduce FCV into public vehicles, and FCV special zones
- Incentives to convert to FCV and a hydrogen society (favorable tax changes, higher priority on parking lots, and deregulation for driving into restricted places, etc.)
- Establishment of standards for FCV, fuel and hydrogen fueling equipments, and technological standards (both national and international)
- Promotion of maintenance industries and recycling systems for parts and materials of FCV.
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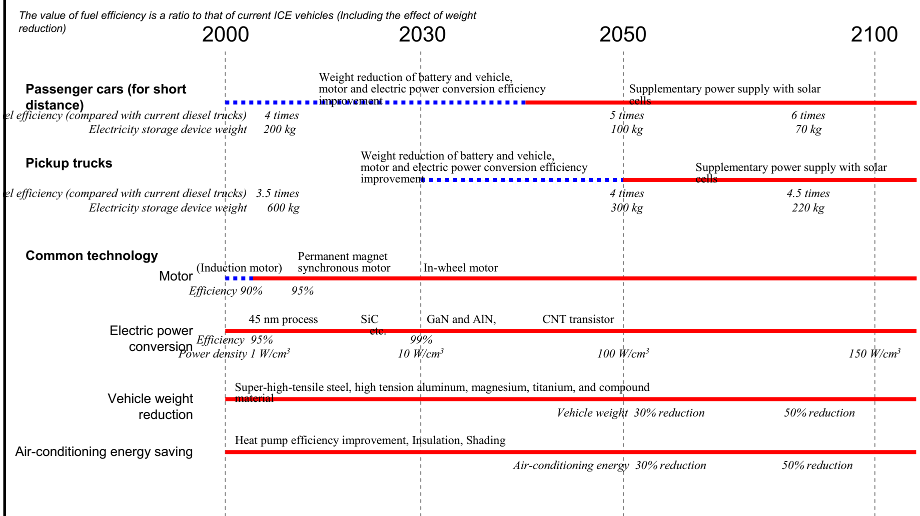
Electric vehicle

- Fuel efficiency is a ratio of the mileage for each amount of the unit charged electric power which is converted gasoline (diesel oil) equivalent. The weight of electricity storage devices is critical to secure a driving range of 200 km.
- The energy density improvement and life extension of electricity storage devices are the most important challenges. Fuel efficiency improvement by body weight reduction also contributes to the weight decrease of the electricity storage devices. Small and light vehicles are easily converted to electric vehicles.
- The practical technologies with a moderate performance have been established for motors and electric power converters. After the prospect of electricity storage technology is established, the development of vehicles, new technologies for charging equipment, and extra power units, are started.
- For distance requirement of 200km or more, a satisfactory result may be achieved by the addition of a small extra power unit (several kW) only when necessary.
- There is a possibility that plug-in hybrid vehicles, which are both fueled and charged (refer to appendix 3), are put to practical use before pure 100% electric vehicles.



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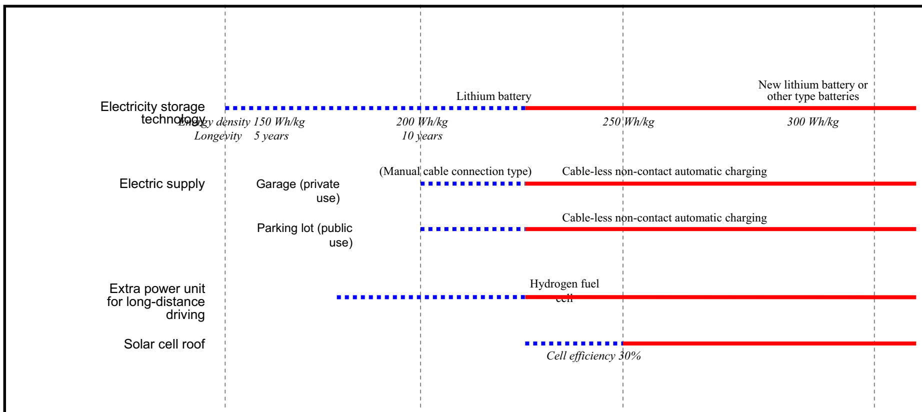

Non-technical factors

- Charging facility network development by government investment, a strong initiative to introduce electric vehicles in the public sector, electric vehicle special zones
- Incentives to convert to electric vehicle (favorable tax changes, higher priority in parking lots, and deregulation for driving into restricted places, etc.)
- Establishment of standards for electric vehicles and charging systems, and technological standards (both national and international)
- Promotion of maintenance industries and a recycling system for parts and materials of FCV.

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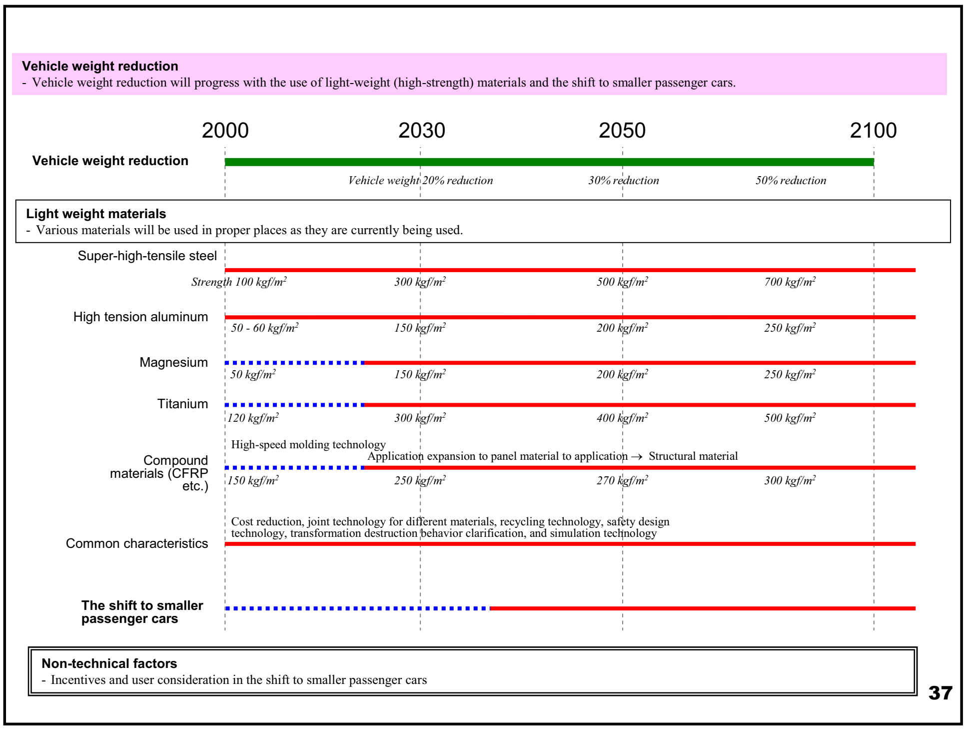

Fast Charge ?

A conventional gasoline vehicle consume 295Mcal (10km/Litter).

		Hydrogen		Electricity		Gasoline
Heating Value		2,580kcal/Nm3		860kcal/kWh		7,820kcal/L
Energy reauired for 500km driving	Mcal	-	-	-	-	391
Fule economy factor		3	5	4	6	1
Energy required for 500km drivingwith consideration of fuel economy factor	Mcal	130	78	98	65	391
	Nm3	51	30	-	-	-
	kWh	-	-	114	76	-
	Litter	-	-	-	-	50
Replenishment time	Min	5	2	5	2	2
Flow rate	L/sec	168	253	-	-	0.42
Charging power (Energy flow rate)	kW	1,819	2,718	1,705	2,842	13,640

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Comparison of energy storage densities of hydrogen, electric power, and liquid fuel

(1) Weight base comparison

	Hydrogen			Electricity		Gasoline
Heating value[1]	28,900 kcal/kg			860 kcal/kWh		10,150 kcal/kg
Storage density[2),3)]	3wt%	15wt%	15wt%	150Wh/kg	300Wh/kg	90wt%
Stored energy per unit tank weight (kcal/kg-tank)	867	4,335	4,335	129	258	9,135
Ratio to gasoline tank	0.09	0.47	0.47	0.01	0.03	1
Vehicle fuel economy factor[6)]	3	5	2	4	6	1
Ratio to gasoline tank (with consideration of fuel economy factor)	0.28	2.37	0.95	0.06	0.17	1

(2) Volume base comparison

	Hydrogen			Electricity		Gasoline
Heating value[1)]	28,900 kcal/kg			860 kcal/kWh		10,150 kcal/kg
Storage density[2),3)]	17g/L	110g/L	110g/L	240Wh/L	480Wh/L	700g/L
Stored energy per unit tank volume (kcal/L-tank)	491	3,179	3,179	206	413	7,105
Ratio to gasoline tank	0.05	0.35	0.35	0.02	0.05	1
Vehicle fuel economy factor[6)]	3	5	2	4	6	1
Ratio to gasoline tank (with consideration of fuel economy factor)	0.16	1.74	0.70	0.09	0.27	1

(Notes)

1) Lower heating value (LHV).
2) The values of storage density of hydrogen and electricity are referred to in the current performance and maximum values described in the road map.
3) The storage density of gasoline is a presumption value.
4) The volume based storage density of electricity is calculated with a specific gravity of batteries of 1.6.
5) Total weight of tank and fuel
6) The value of vehicle fuel efficiency factor is a ratio of the mileage for each LHV of stored energy compared to gasoline vehicles (Fuel cell vehicles are assumed for hydrogen and electric vehicles are assumed for electricity).

< Comments >

(1) Weight base comparison

The hydrogen storage density of 3 wt% is equivalent to energy storage density of 867 kcal/kg-tank, which is about 1/10 of that of gasoline, while it will be improved to about 1/2 with the hydrogen storage performance of 15 wt%. Taking good fuel economy of hydrogen fuel cell vehicles into consideration, 3 wt% for hydrogen storage corresponds to about 30% of energy storage performance of gasoline tanks. With the fuel efficiency factor of 2 times (assumed value for heavy-duty trucks), the hydrogen storage density of 15wt% is almost equivalent to gasoline tanks.

The technology specifications for the fuel economy factor of hydrogen aircraft, hydrogen fuel cell ships, and hydrogen fuel cell trains at 2100 in this road map are about 2 times, 1.7 times, and 2 times, respectively. (They are compared to the current fossil and engine technologies.) The energy storing density of batteries is smaller than that of hydrogen by one order of magnitude. Even if it is improved to 300Wh/kg, and the fuel efficiency of electric vehicles increased by a factor of 6, it would reach only 17% of gasoline.

(2) Volume base comparison

In the volume base comparison, the values for hydrogen are lower than those in the weight based comparison, while a little higher for electricity. The relative relation among gasoline, hydrogen, and electricity doesn't change.

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Energi Rådgivarna

FÖRENINGEN SVERIGES ENERGIRÅDGIVARE

The Association of Swedish Energy Advisers

- Non-profit and non-governmental organisation
- Founded in 1982
- Purpose: information and promotion on energy efficiency and renewables
- 500 personal members
- 20 companies


Det är vi som driver utvecklingen framåt!
REC INDOVENT
SIEMENS
Dalkia
E.S.S.
Energi Spar System HB
somfy.
Retermia
Värmeåtervinning
emotron
DEDICATED DRIVE
Regelab
ECiS
ENERGIKOMPETENS
BEKAERT
Brunata
IUC Sveriges energi & kyl centrum
Energi Effektiviserings Företagen


Energy Efficiency Watch!

Commission on Oil Independence

Chairman:
Prime minister **Göran Persson**

Delegates:
Professor **Christian Azar**, Chalmers University of Technology
Lars Andersson, government investigator on bioenergy
Lotta Bångens, Chairman of Sweden's Energy Advisers
Birgitta Johansson-Hedberg, CEO, Lantmännen
Leif Johansson, CEO, AB Volvo
Göran Johnsson, former chairman of the Swedish Metalworkers Union
Christer Segersteen, Chairman of the Federation of Swedish Forest Owners
Lisa Sennerby-Forsse, Secretary-General, Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning

Staff:
Stefan Edman, biologist, writer
Anders Nylander, architect, expert on energy

The commission was requested to .....

” find the best strategies for reducing dependence on oil and actual use of oil in Sweden by the year 2020”

Five national objectives for reduced oil dependence

1. We will reduce Sweden’s climate impact

2. We will secure Sweden’s supply of energy in the long term

3. We can become a leading nation in the development of new technology for sustainable use of energy

4. We will strengthen our international economic competitiveness

5. We will use and develop the energy resources from forests and fields, “Sweden’s green gold”

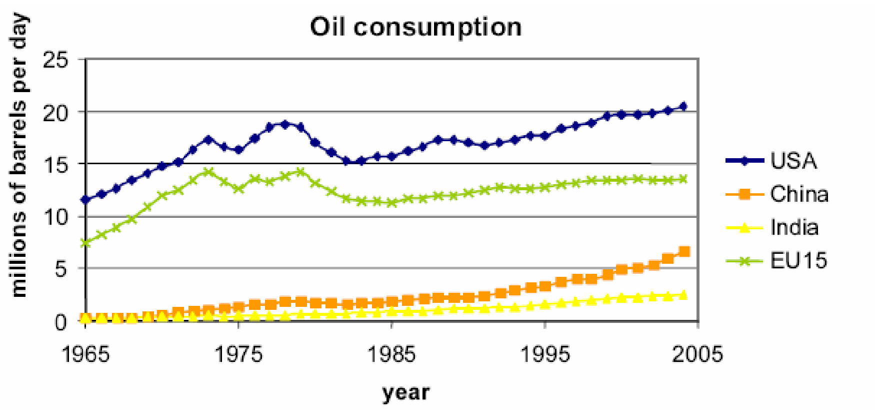
Goals

- Swedish society as a whole should be able to make 20 per cent more efficient use of energy by 2020

- By 2020 in principle no oil should be used for heating in residential and commercial buildings

- Road transport should reduce use of petrol and diesel by 40-50 per cent by 2020

- Industry should reduce its use of oil by 25-40 per cent by 2020



Oil consumption in some major countries. Source: BP World Energy Statistics

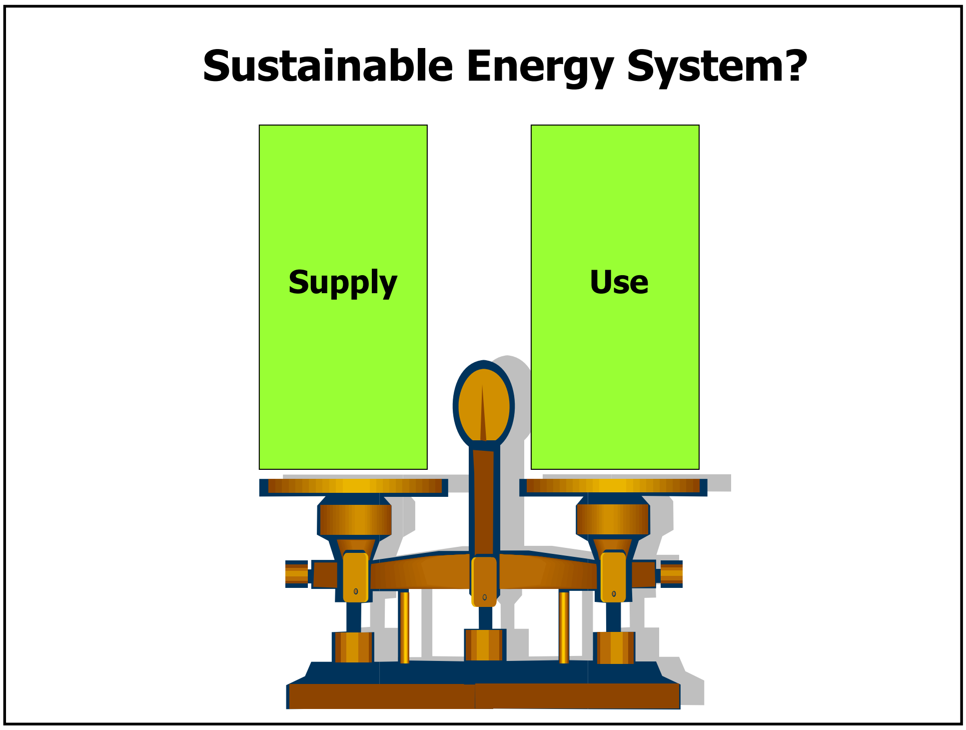
Use of Oil , 2004, by sector

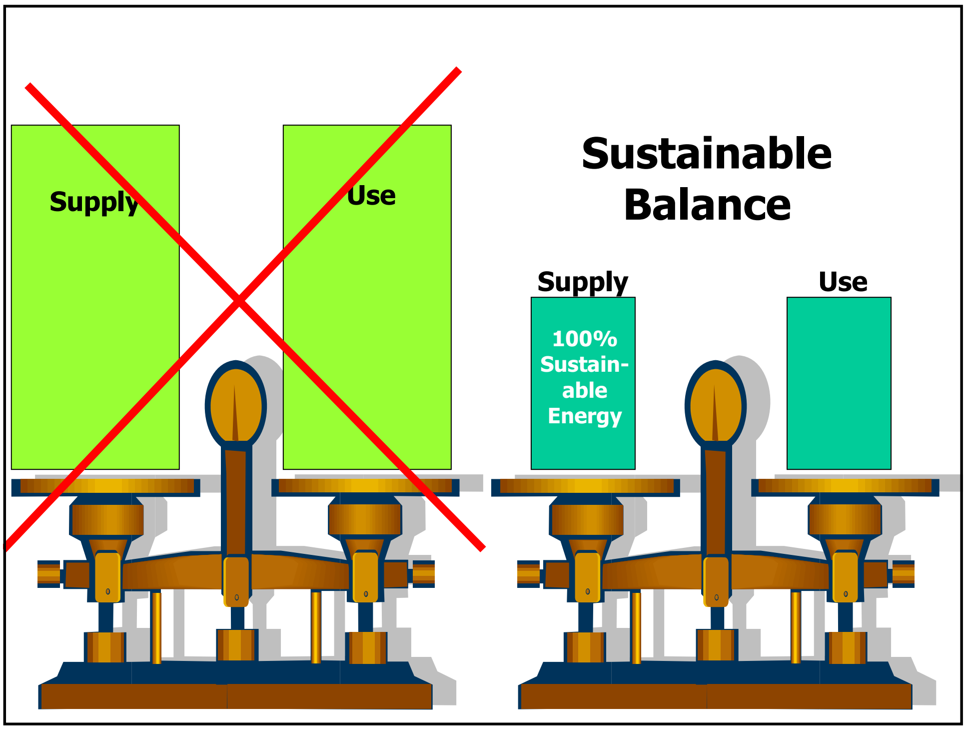
Sector	Oil use	
Transport	97 %	95 TWh
Agriculture, forestry, fisheries	70 %	7 TWh
Building sector	67 %	[illegible]
Residential and commercial buildings	11 %	10 TWh
Industry	11 [illegible]	[illegible]
Production of District heating	8 [illegible]	[illegible]
Service sector	6 %	3 TWh
Production of Electricity	1 %	3 TWh

Bio energy potential (increase)

År	2020	2050
TWh	46	120

TOTAL 142 TWh


Sustainable Energy System?
Supply
Use


Supply
Use
Sustainable Balance
Supply
Use
100% Sustain-able Energy

The Five Strategies:

- Radically more effective use of energy by the whole of society
- Historic investment in forest fuels and energy crops
- Electricity for a sustainable supply of energy
- The role of energy gases
- Control instruments at EU level

Effective use of Energy

- **”Energy Efficiency Center”**
- **Swedish society as a whole should improve energy efficiency by 20 per cent by 2020**
  This implies an average annual 1.5 per cent increase in energy efficiency

Energy Efficiency is invisible!

- … but shows in your wallet …..

30 €

70 €

Increased production of electricity by 25 TWh

Residential and Commercial Buildings

- New Buildings
  - 75 % low energy houses by 2020
  - Tightened building regulations
  - Energy-related deductions on real estate tax
- Reconstruction
  - Requirements for improvement of energy efficiency

Residential and commercial buildings

- Electricity for heating
- Voluntary agreement for building owners
  - Reduction in taxes when implementing measures (directive on energy performance of buildings)
- Public sector as shining examples
  - Procurement & purchasing
  - Measures (from the directive on energy performance of buildings) mandatory

Historic investment in forest fuels and energy crops

- Forest growth be increased in the long term by 15-20 per cent
- Energy crops and energy broad-leaf trees to be cultivated on arable land and disused, nonafforested farmland on a scale of 300 000 – 500 000 hectares
- The Government invest funds to stimulate procurement of technology as well as production facilities for the manufacture of fuels

Electricity for a sustainable supply of energy

- Energy efficiency in industry
- Increased production of domestic renewable electricity
  - Wind power
  - CHP
- Reduced consumption of electricity for heating buildings

Energy gases

- The Commission proposes that the Government does not actively commit itself to increased use of natural gas in Sweden in the future
- The Government should support local and regional infrastructures for bio gas

Control instruments at EU level

- The Commission proposes that Sweden contributes to a gradual tightening of the EU emission trading system.
- Objective - total emissions in the trading sector will be 25 per cent lower in 2020 compared with 1990

Transport

- Encourage a more energy efficient fleet of private cars!
- More efficient legislation
  - CO_2-based tax
  - taxation of company cars shoul promote effeicient cars
  - Energy- and CO_2-tas on fuel
- A higher proportion of modern diesel vehicles
- More hybrid vehicles
- Fuel efficiency should be included as an essential requirement in connection with environmental classification of cars
- Improve the efficiency of goods traffic
- Make public transport cheaper and more attractive!
- Strengthen the role of the train!


What happens
now?
Energi
Rådgivarna


Tack så mycket!
Energi
Rådgivarna

Regionale Aspekte einer (alternativen) Energieversorgung

o.Univ.-Prof. Dr. Friedrich Schneider
Mag. Robert Tichler
Mag. Andrea Kollmann

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ENERGIE 2050

Regionale Aspekte einer (alternativen) Energieversorgung

Inhalt

1. Status Quo in OÖ
2. Nachhaltigkeit und Energieversorgung
3. Beispiel für eine nachhaltige Energiepolitik in OÖ und Ö
   3.1 Investitionen in erneuerbare Energieträger
   3.2 Förderung von nachhaltigen Verkehrsprojekten
4. Fazit

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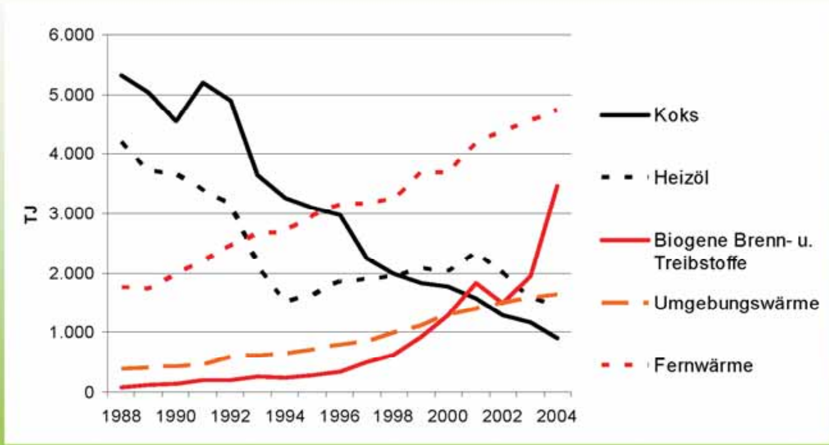
1. Status Quo in OÖ — Regionale Aspekte einer (alternativen) Energieversorgung

Figur 1: **Endenergiekonsum der privaten Haushalte in OÖ in Terajoule, ausgewählte Energieträger**



Quelle: Statistik Austria, eigene Darstellung

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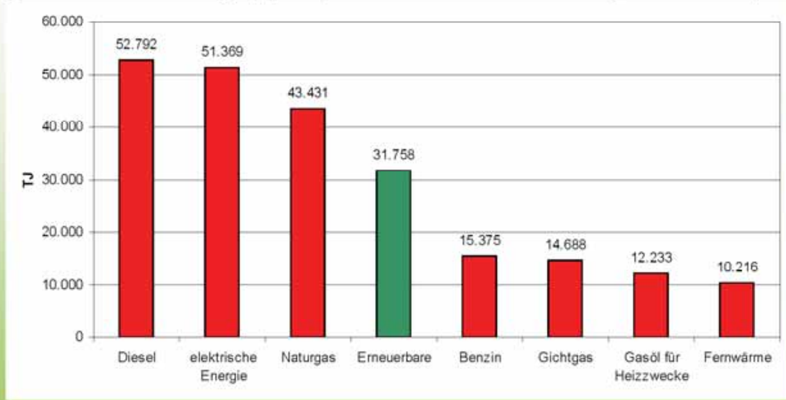
1. Status Quo in OÖ — Regionale Aspekte einer (alternativen) Energieversorgung

Figur 2: **Gesamter energetischer Endverbrauch 2004 in OÖ in Terajoule, größte Verbrauchsgruppen (inkl. Verbrauch der Energiewirtschaft)**



** Brennholz, Biogene Brenn- und Treibstoffe, Brennbare Abfälle, Umgebungswärme*
Quelle: Statistik Austria, eigene Darstellung

Gesamter energetischer Endverbrauch in OÖ 2004: 256.618 TJ

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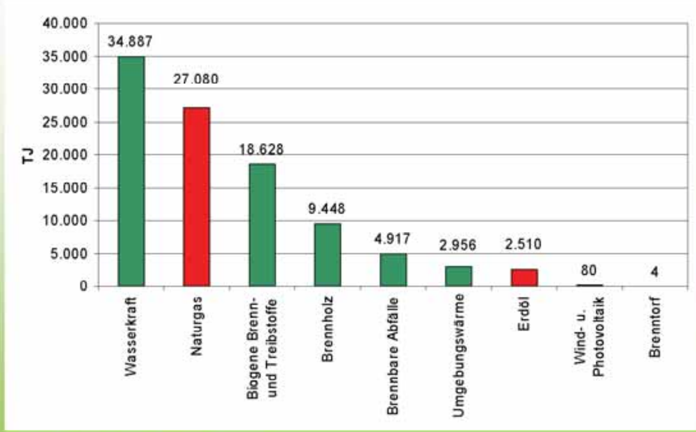
1. Status Quo in OÖ

Regionale Aspekte einer (alternativen) Energieversorgung

Figur 3: **oö. Erzeugung von Rohenergie 2004, in Terajoule**



Quelle: Statistik Austria, eigene Darstellung

Gesamte oö. Erzeugung von Rohenergie 2004: 100.511 TJ

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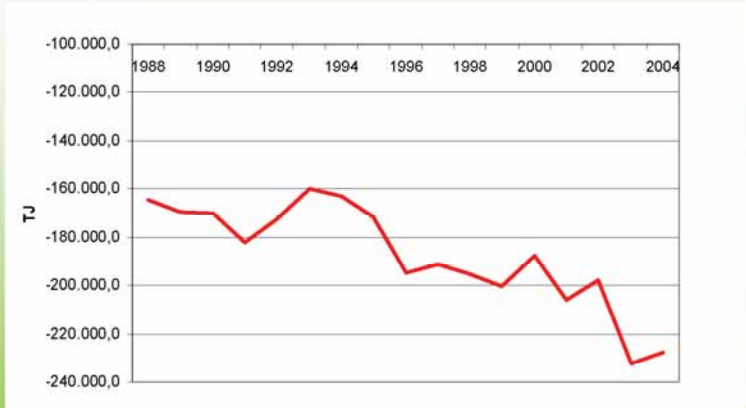
1. Status Quo in OÖ

Regionale Aspekte einer (alternativen) Energieversorgung

Figur 4: **Entwicklung der oö. Energie-Nettoexporte (Exporte minus Importe), in Terajoule**



Quelle: eigene Berechnung auf Basis von Daten der Statistik Austria

→ Negative Nettoexporte: mehr Importe als Exporte

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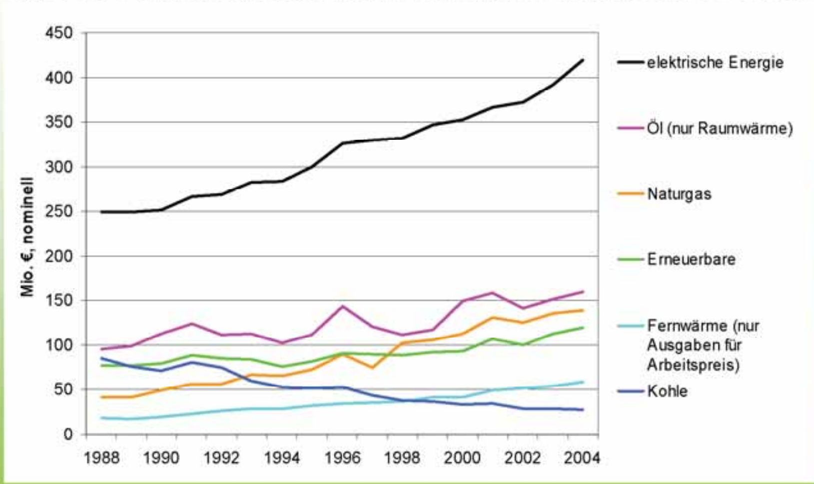
1. Status Quo in OÖ

Regionale Aspekte einer (alternativen) Energieversorgung

Figur 5: **Nominelle Konsumausgaben der privaten Haushalte in OÖ, in Mio. €**



Quelle: eigene Berechnung auf Basis von Daten der Statistik Austria und der Energieagentur

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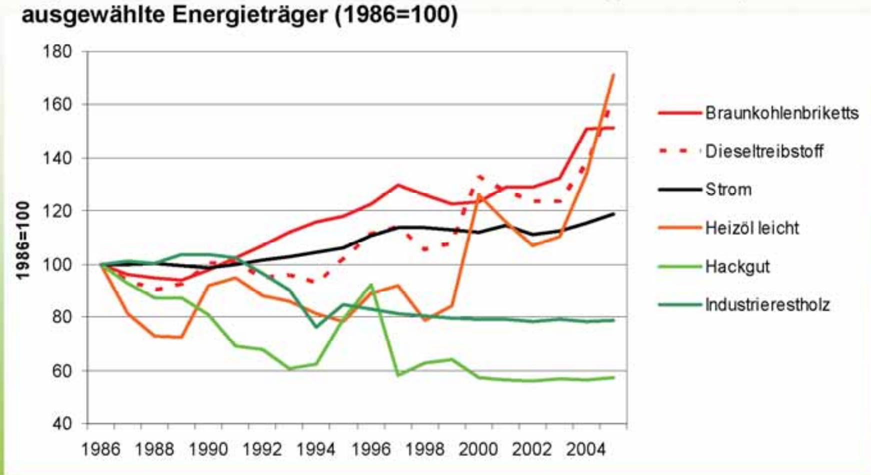
1. Status Quo

Regionale Aspekte einer (alternativen) Energieversorgung

Figur 6: **Österreichische nominelle Preisentwicklung 1986-2005, ausgewählte Energieträger (1986=100)**



Quelle: eigene Berechnung auf Basis von Daten der Statistik Austria und der Energieagentur

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1. Status Quo in OÖ

Regionale Aspekte einer (alternativen) Energieversorgung

→ **Erkenntnisse aus den Graphen:**

- Wachsende Importabhängigkeit der OÖ. Wirtschaft
- Hoher Anteil an Produktion von erneuerbaren Energieträgern
- In Relation niedriger Endverbrauch von erneuerbaren Energieträgern
- Dennoch hohe Zuwachsraten im Verbrauch von Erneuerbaren der privaten Haushalten in den letzten Jahren
- Rapider Preisanstieg von fossilen Energieträgern

→ **Ist es aus wohlfahrtstheoretischen Gesichtspunkten sinnvoll, in Oberösterreich bzw. in Österreich erneuerbare Energien zu fördern?**

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2. Nachhaltigkeit und Energieversorgung

Regionale Aspekte einer (alternativen) Energieversorgung

„Dauerhafte Entwicklung ist Entwicklung, die die Bedürfnisse der Gegenwart befriedigt, ohne zu riskieren, dass künftige Generationen ihre eigenen Bedürfnisse nicht befriedigen können.“ - **Weltkommission für Umwelt und Entwicklung** („Brundtland-Kommission“, 1987)

Ziele & Maßnahmen einer nachhaltigen Entwicklung:

- Begrenzung des Klimawandels und gesteigerte Nutzung sauberer Energien
- Umgang mit Gefahren für die öffentliche Gesundheit (Externalitäten)
- Verantwortungsbewussterer Umgang mit natürlichen Ressourcen
- Verbesserung des Verkehrssystems und der Flächennutzung

→ **Hypothese: eine nachhaltige Energiepolitik führt zu keiner wirtschaftlichen Verschlechterung**

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2. Nachhaltigkeit und Energieversorgung

Regionale Aspekte einer (alternativen) Energieversorgung

Wohlfahrtstheoretische Relevanz eines nachhaltigen Energiewirtschafts-Pfades für Oberösterreich

→ **Externalitäten:**
- Verringerung durch Nachfragerückgang
- Verringerung durch Substitution zu erneuerbaren Energieträgern

→ **Wertschöpfungsabfluss:**
- Verringerung der Importe
- Erhöhte Eigenproduktion von erneuerbaren Energieträgern

→ **Beschäftigungseffekte:**
- Förderung von arbeitsintensiven Energieträgern (= erneuerbare Energieträger)

→ **wirtschaftspolitische Stimulation von technologischem Fortschritt am Energiesektor:**
- Förderung neuer „green technologies“

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2. Nachhaltigkeit und Energieversorgung

Regionale Aspekte einer (alternativen) Energieversorgung

Existiert ein Konflikt zwischen **Wachstum und Nachhaltigkeit**?

→ **Nein, wenn ökologisch orientierte Marktwirtschaft verfolgt wird**

→ Das Erreichen eines nachhaltigen Wachstumspfades hängt vor allem von der ökologisch orientierten Wirtschaftspolitik und vom Grad des **technologischen Fortschrittes** und staatlichen Förderungen ab.

→ Eine **wirtschaftspolitische Stimulation von technologischem Fortschritt** (Z.B. durch Förderungen) in der Form von *environmental research and development* durch politische Strategien lässt das Erreichen von höherem Wirtschaftswachstum, verstärkter Nachhaltigkeit sowie verbesserter Wettbewerbsfähigkeit zu.

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2. Nachhaltigkeit und Energieversorgung

Regionale Aspekte einer (alternativen) Energieversorgung

Existiert ein Konflikt zwischen **Wachstum und Nachhaltigkeit**?

→ Gesellschaft misst der Nachhaltigkeit keine zu große Bedeutung bei!

→ Eine wesentliche Aufgabe des Staates ist daher, eine **Bewusstseinsbildung** für eine nachhaltige Wirtschaft zu schaffen

→ Staatliche Institutionen müssen somit **Rahmenbedingungen für nachhaltiges Wirtschaften** setzen, um umweltschonende Produktion und umweltfreundlichen Konsum zu fördern.

→ **Zentral: Investitionen in F&E; Österreich weist hier einen Nachholbedarf auf!**

Forschungsquoten 2003:

AUT: 2,2%	*SWE: 4,0%*	*Japan: 3,2%*
GER: 2,5%	*FIN: 3,5%*	*USA: 2,6%*

Bei entsprechender ökologisch orientierter Wirtschaftspolitik (und Energiepolitik) ergeben sich langfristig simultan positive ökologische und volkswirtschaftliche Effekte!

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3. Beispiele für eine nachhaltige Energiepolitik in OÖ und Ö

Regionale Aspekte einer (alternativen) Energieversorgung

Ausgewählte (ober-)österreichische Beispiele zur Illustration der Notwendigkeit von Investitionen in eine nachhaltige Energiewirtschaft sowie deren Effekte:

Beispiel 1: Investitionen in Ökostromprojekte im Zuge des ÖKOP-Förderprogramms in OÖ

Beispiel 2: Wertschöpfung aus Investitionen in Kleinwasserkraftwerke

Beispiel 3: Volkswirtschaftliche Wertschöpfungseffekte des (beschleunigten) Ausbaus der Strecke Summerau – Spielfeld/Straß gemäß Generalverkehrsplan-Ö

Beispiel 4: Importreduktion von agrarischen Produkten

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3. Beispiele für eine nachhaltige Energiepolitik in OÖ und Ö

Regionale Aspekte einer (alternativen) Energieversorgung

Investitionen in erneuerbare Energieträger

Beispiel 1: Förderung von Ökostromprojekten in der Periode 2003-2006 durch das Land Oberösterreich *(Figur 7)*

Jahr	Absolute Veränderung gegenüber der Entwicklung ohne Investitionen in Ökostromprojekte im Zuge des ÖKOP-Programms		
	BIP-Zuwachs *(Oberösterreich)*	zusätzliche Beschäftigte *(Oberösterreich)*	zusätzliches Volkseinkommen *(Oberösterreich)*
	[in Mio. €]	[Personen]	[in Mio. €]
2003	39,2	490	24,9
2004	50,9	637	32,4
2005	72,0	901	45,8
2006	30,4	380	19,3
Durchschnitt	*48,1*	*602*	*30,6*

Quelle: eigene Berechnung
a) Wertzuwachs im Vergleich zum Vorjahr; konstante jährliche Aufteilung der gesamten Investitionssumme
b) Jahreszahlen sind nicht kumulativ zu verstehen; der angegebene Wert für ein Jahr gibt die Zahl der in dieser Periode neu entstehenden Arbeitsplätze wieder. Die neu geschaffenen Arbeitsplätze der Vorperioden müssen nicht mehr existieren, sodass bei einer vollständigen Addition der Beschäftigten eine Verzerrung entstehen würde.

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3. Beispiele für eine nachhaltige Energiepolitik in OÖ und Ö

Regionale Aspekte einer (alternativen) Energieversorgung

Investitionen in erneuerbare Energieträger

Zu Beispiel 1: Theoretisch vermeidbare CO_2-Emissionen durch Implementierung des ÖKOP-Programms *(Figur 8)*

Energieträger	CO_2-Emissionen je Einheit Rohstoff	eingesparte CO_2-Emissionen bei Substitution von 409 GWh[a)] fossiler Wärmekraft durch Ökostrom
	in kg	in t
Steinkohle	**2.392**	**97.731**
Braunkohle	**1.543**	**33.178**
Heizöl	**3.140**	**12.801**
Erdgas	**1,88**	**112.915**
Summe	**-**	***256.628***

Quelle: E-Control, Umweltbundesamt, eigene Berechnungen
a) genehmigte Ökostromanlagen von 2003 bis 2006 (Stand 1.1.2005)

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3. Beispiele für eine nachhaltige Energie-politik in OÖ und Ö

Regionale Aspekte einer (alternativen) Energieversorgung

Investitionen in erneuerbare Energieträger

Zu Beispiel 1: Monetäre Bewertung dieser Emissionsreduktionen *(Figur 9)*

	eingesparte CO_2-Emissionen bei Substitution von 409 GWh[a] fossiler Wärmekraft durch Ökostrom
pro Jahr ab Inbetriebnahme aller Anlagen	256.628 t
Schadenskostenreduktion pro Jahr durch Betrieb der Ökostromanlagen in Österreich	5,13 Mio. €

Quelle: eigene Berechnungen
a) genehmigte Ökostromanlagen von 2003 bis 2006 (Stand 1.1.2005)

→ **positive Beschäftigungs- und Wertschöpfungseffekte**

→ **Pro Jahr ergibt sich durch diese Förderungen eine Schadenskosten-reduktion durch geringere CO_2-Emissionen von 5 Mio. €.**

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3. Beispiele für eine nachhaltige Energie-politik in OÖ und Ö

Regionale Aspekte einer (alternativen) Energieversorgung

Investitionen in erneuerbare Energieträger

Beispiel 2: Wertschöpfung aus Investitionen in Kleinwasserkraftwerke (Investitionssumme: 43 Mio. € jährlich, von 2005-2010) *(Figur 10)*

Szenario	Durchschnittliche jährliche Veränderung gegenüber der Entwicklung ohne Investitionen in KWKWs		
	BIP-Zuwachs[a]	zusätzliche Beschäftigte[b]	zusätzliches Volkseinkommen[a]
	Mio. €	Personen	Mio. €
konstanter %-Anteil (auf dem geschätzten Niveau des Jahres 2004) an Strom aus KWKWs am gesamten Stromverbrauch bis 2010.	80	1.006	51

Quelle: eigene Berechnung
a) Wertzuwachs im Vergleich zum Vorjahr; konstante jährliche Aufteilung der gesamten Investitionssumme
b) Jahreszahlen sind nicht kumulativ zu verstehen; der angegebene Wert für ein Jahr gibt die Zahl der in dieser Periode neu entstehenden Arbeitsplätze wieder. Die neu geschaffenen Arbeitsplätze der Vorperioden müssen nicht mehr existieren, sodass bei einer vollständigen Addition der Beschäftigten eine Verzerrung entstehen würde.

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3. Beispiele für eine nachhaltige Energiepolitik in OÖ und Ö

Regionale Aspekte einer (alternativen) Energieversorgung

Förderung von nachhaltigen Verkehrsprojekten

Beispiel 3: Volkswirtschaftliche Wertschöpfungseffekte des (beschleunigten) Ausbaus der Strecke Summerau – Spielfeld/Straß gemäß Generalverkehrsplan-Ö *(Figur 11)*

Realisierungs- (=Wirkungs-) Zeitraum (Bauzeitbeginn – Bauzeitende)	Investitionsvolumen in Mio. €	aggregierte Veränderung gegenüber der Entwicklung ohne Investitionen in den Ausbau der Strecke	
		Regionaler BIP-Zuwachs	Zusätzliches Volkseinkommen
		Mio. €	Mio. €
Summe 2002-2020 gemäß Generalverkehrsplan-Ö	649,4	914,5	695,0
Jährlicher Durchschnitt	34,2	48,1	36,6

Quelle: vgl. Schneider, Dreer, Holzberger (2004)

- Verbesserte Verkehrsanbindung für zahlreiche wichtige Industriebetriebe
- Unterstützung verkehrs- und regionalpolitischer Vorgaben
- **Emissionseinsparungen durch Verkehrsverlagerung auf Schiene**

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3. Beispiele für eine nachhaltige Energiepolitik in OÖ und Ö

Regionale Aspekte einer (alternativen) Energieversorgung

Förderung von nachhaltigen Verkehrsprojekten

Beispiel 4: Importreduktion von agrarischen Produkten

Transportaufkommen land- und forstwirtschaftlicher Produkte (anteilig nach Verkehrsträgern) *(Figur 12)*:

	Straße	Schiene	Donau
Verkehrsträgeraufkommen [a)]	68,1 %	28,8 %	3,1 %
Zunahme ohne Gegenmaßnahmen bis 2010	40 %	21 %	
Externe Kosten in € je 1000 km	72 €	19 €	

[a)] Stand 1995, Rundungsdifferenzen möglich
Quellen: Statistik Austria, Europäische Kommission

- Ziel der Studie: wie wirkt sich die **Reduktion von Importen (= kürzere Wege für den Transport von Gütern)** auf die Umwelt aus
- Reduktion von Importen = vermehrter Konsum heimischer Güter

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3. Beispiele für eine nachhaltige Energiepolitik in OÖ und Ö

Regionale Aspekte einer (alternativen) Energieversorgung

Förderung von nachhaltigen Verkehrsprojekten

<u>Zu Beispiel 4:</u> Summe der durchschnittlichen externen Kosten pro Jahr der Verkehrsträger Straße und Schiene für die Einfuhr aus 27 Referenzländern im Durchschnitt über 1999 – 2002 *(Figur 13)*

	Durchschn. Umwelt- und Klimaveränderungskosten pro Jahr	Differenz
Bei gegebener Einfuhrverteilung (Ausgangsszenario); in Mio. €	358,9 Mio. €	14,9 Mio. €
Einfuhrreduktion aus jedem Land um 10 % und durchschnittl. Transportweglänge innerhalb Österreichs von 150 km; in Mio. €	344,0 Mio. €	

Quelle: vgl. Schneider, Holzberger (2004)

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3. Beispiele für eine nachhaltige Energiepolitik in OÖ und Ö

Regionale Aspekte einer (alternativen) Energieversorgung

Förderung von nachhaltigen Verkehrsprojekten

<u>Zu Beispiel 4:</u> Wertschöpfungs- und Beschäftigungseffekte aufgrund der Reduktion des Einfuhrvolumens landwirtschaftlicher / bäuerlicher Produkte und gleichzeitiger Kompensation durch heimische Produktion für das Jahr 2002 *(Figur 13)*

	Absolute Veränderung gegenüber der Entwicklung OHNE die Reduktion des Einfuhrvolumens landwirtschaftlicher / bäuerlicher Produkte		
	regionales BIP	Regionales Volkseinkommen	Regionale Beschäftigung
Reduktion der Einfuhr von landwirtschaftlichen / bäuerlichen Produkten um 10 %	2.124 Mio. €	1.487 Mio. €	17.053 Personen

Quelle: vgl. Schneider, Holzberger (2004)

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4. Fazit

Regionale Aspekte einer (alternativen) Energieversorgung

- Die aktuelle Energieversorgung in Österreich ist gekennzeichnet durch eine hohe Importabhängigkeit.
- Der aktuelle Energiekonsum wird von fossilen Energieträgern dominiert.
- Erneuerbare Energieträger verzeichnen in den letzten Jahren hohe Wachstumsraten im Verbrauch.
- Die Förderung der erneuerbaren Energieträger stellt einen wichtigen Faktor zur Erreichung eines nachhaltigen Wirtschaftspfades dar.
- Eine nachhaltige Energiepolitik stellt keinen Widerspruch zu ökonomischem Wachstum dar.
- Neue grüne Technologien bieten die Chance, zusätzliches Wachstum zu generieren.
- Eine Substitution zu erneuerbaren Energieträgern reduziert Externalitäten, Wertschöpfungsabflüsse ins Ausland sowie die Importabhängigkeit und schafft neue Arbeitsplätze für die heimische Volkswirtschaft.

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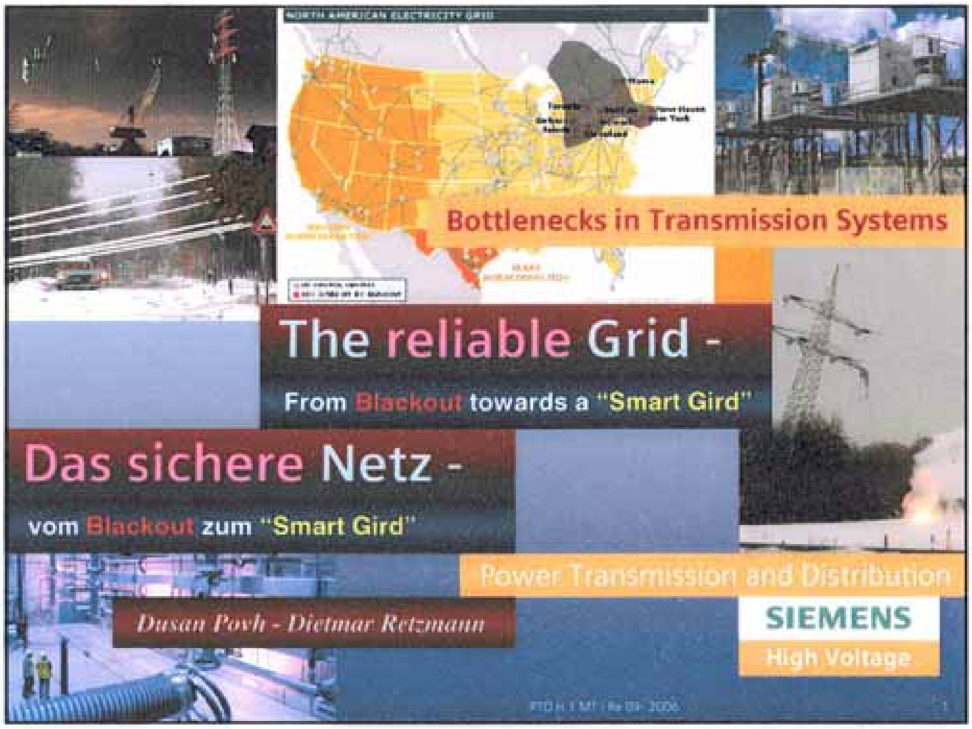
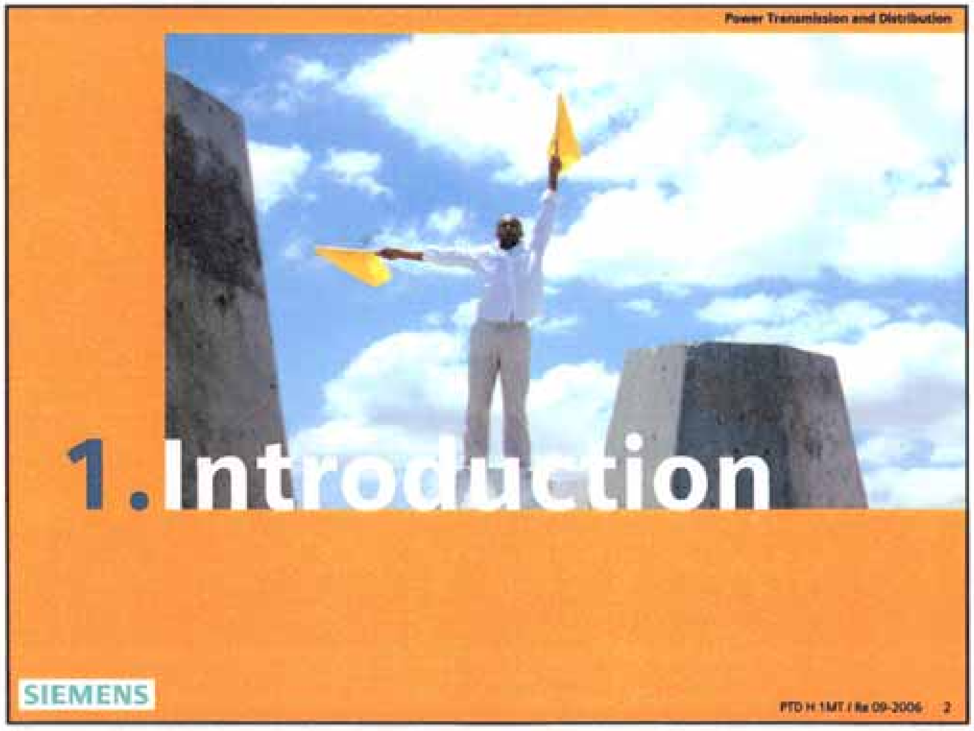

NORTH AMERICAN ELECTRICITY GRID
Bottlenecks in Transmission Systems
The reliable Grid -
From Blackout towards a "Smart Gird"
Das sichere Netz -
vom Blackout zum "Smart Gird"
Power Transmission and Distribution
Dusan Povh - Dietmar Retzmann
SIEMENS
High Voltage
PTD H 1 MT / Re 09- 2006
1


Power Transmission and Distribution
1. Introduction
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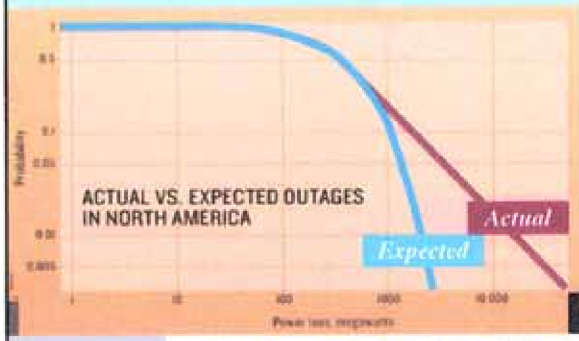
2

High Voltage

Reasons for high Probability of large Blackouts



- Systems too complex to be tested properly (Protection, Controls)
- Insufficient Investments into the System (heavily loaded Network Elements)
- Lack in Maintenance
- Insufficient Training
- Human Errors

Source:

22 IEEE Spectrum | August 2004 | NA

ADVANCED MATHEMATICAL MODELING SUGGESTS THAT BIG BLACKOUTS ARE INEVITABLE BY PETER FAIRLEY

SIEMENS PTD H 1MT / Re 09-2006 3

High Voltage

Classification of Stability Problems in Power Systems

Overview about basic Problems in Terms of Physics, which are related to a high Loading of Transmission Systems by Transport of electrical Energy.

The main Types of Instability Concerns are:

- Cascading Line Tripping by Overload or wrong Protection Settings
- Loss of Synchronism due to Angle Instability
- Oscillatory Instability causing self exciting Inter-Area Oscillations
- Exceeding of the allowed Frequency Range (Over- and Under-Frequency), causing Generator Trips
- Voltage Collapse

SIEMENS Source: UCTE Interim Report 10-27-2003 PTD H 1MT / Re 09-2006 4

High Voltage

The Challenge: Prevention of Instability

As the Consequences of Instability can be dramatic, its Prevention is an important Aspect in Electrical Power Systems.

The Nature of Electrical Power Systems includes the Risk of uncontrollable Chain Reactions leading to a complete Malfunction of the Electricity Supply of Consumers through the Grid.

During such a Blackout, which large Power Systems have experienced world-wide, mostly a Combination of the above mentioned Stability Phenomena occurs.

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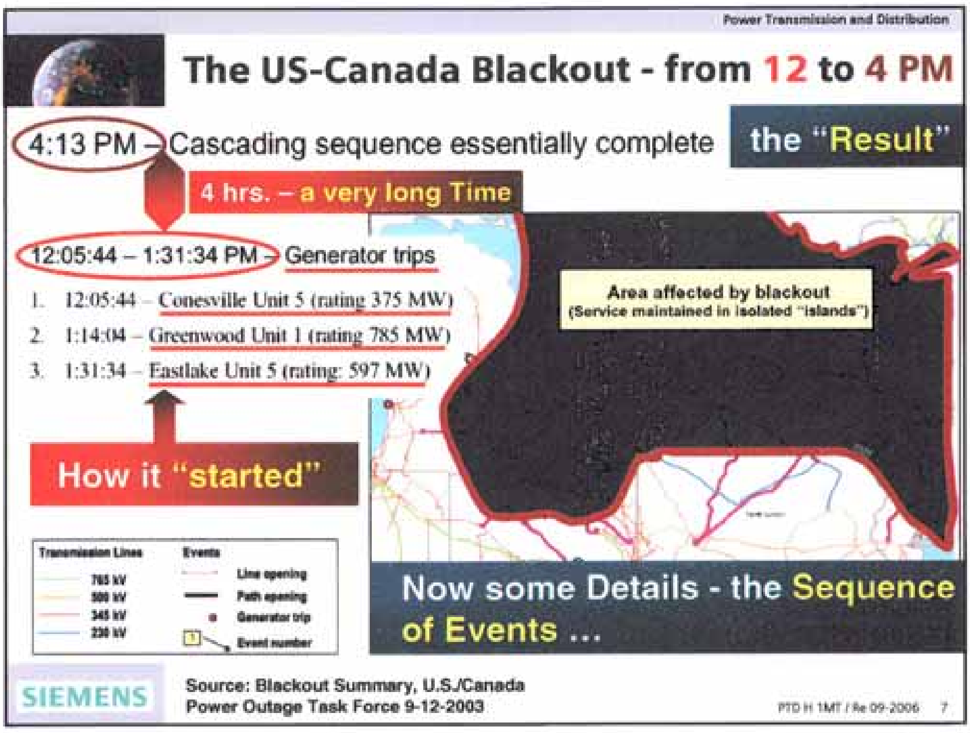
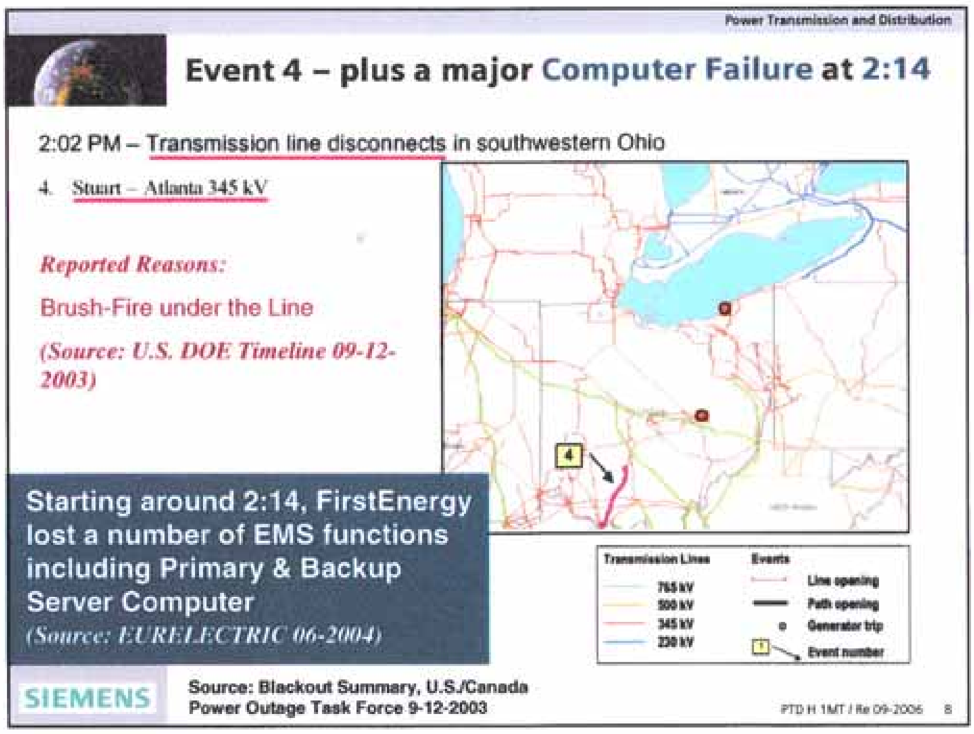
Source: UCTE Interim Report 10-27-2003

2. The US Blackout

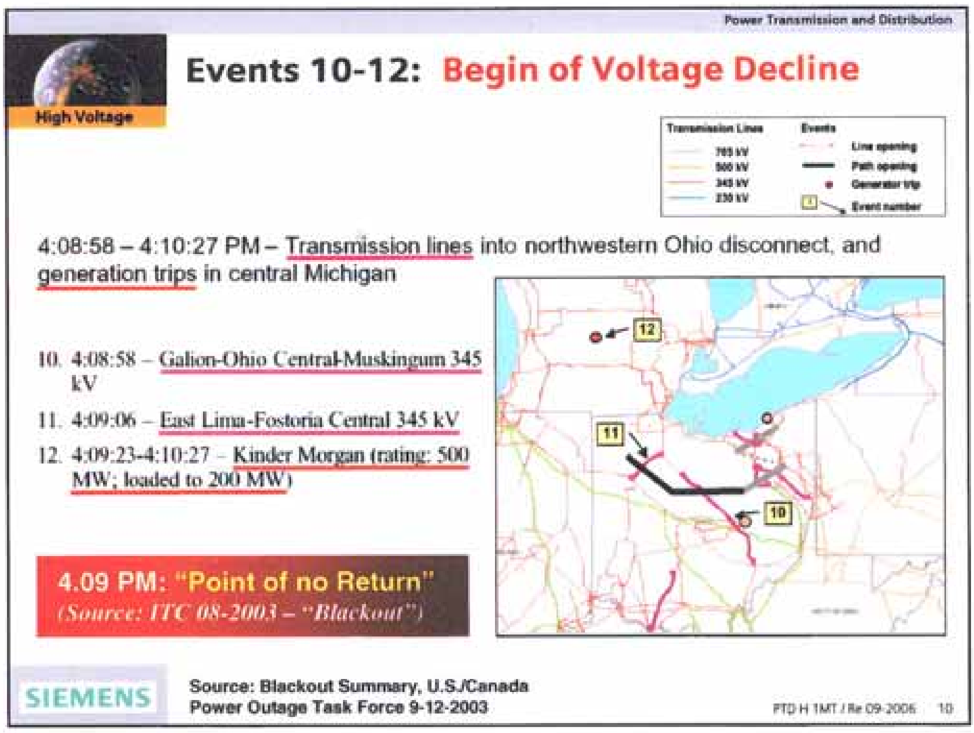
... a brief Review

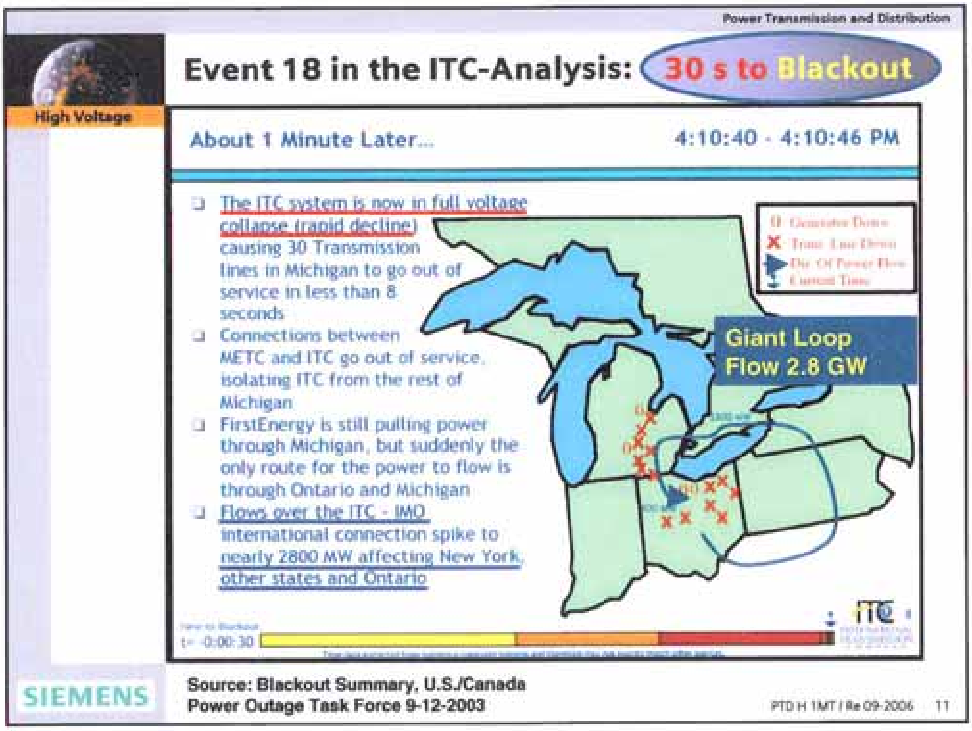
SIEMENS

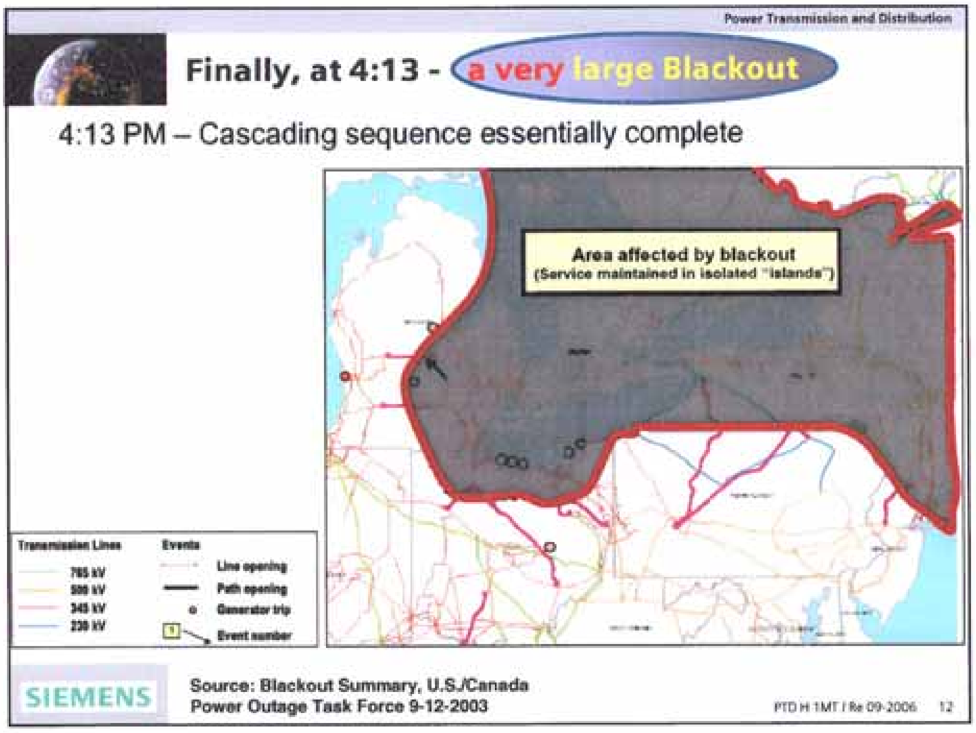

Power Transmission and Distribution
The US-Canada Blackout - from 12 to 4 PM
4:13 PM – Cascading sequence essentially complete
the "Result"
4 hrs. – a very long Time
12:05:44 – 1:31:34 PM – Generator trips
1. 12:05:44 – Conesville Unit 5 (rating 375 MW)
2. 1:14:04 – Greenwood Unit 1 (rating 785 MW)
3. 1:31:34 – Eastlake Unit 5 (rating: 597 MW)
How it "started"
Area affected by blackout
(Service maintained in isolated "islands")
Transmission Lines
765 kV
500 kV
345 kV
230 kV
Events
Line opening
Path opening
Generator trip
Event number
Now some Details - the Sequence of Events ...
SIEMENS
Source: Blackout Summary, U.S./Canada
Power Outage Task Force 9-12-2003
PTD H 1MT / Re 09-2006 7

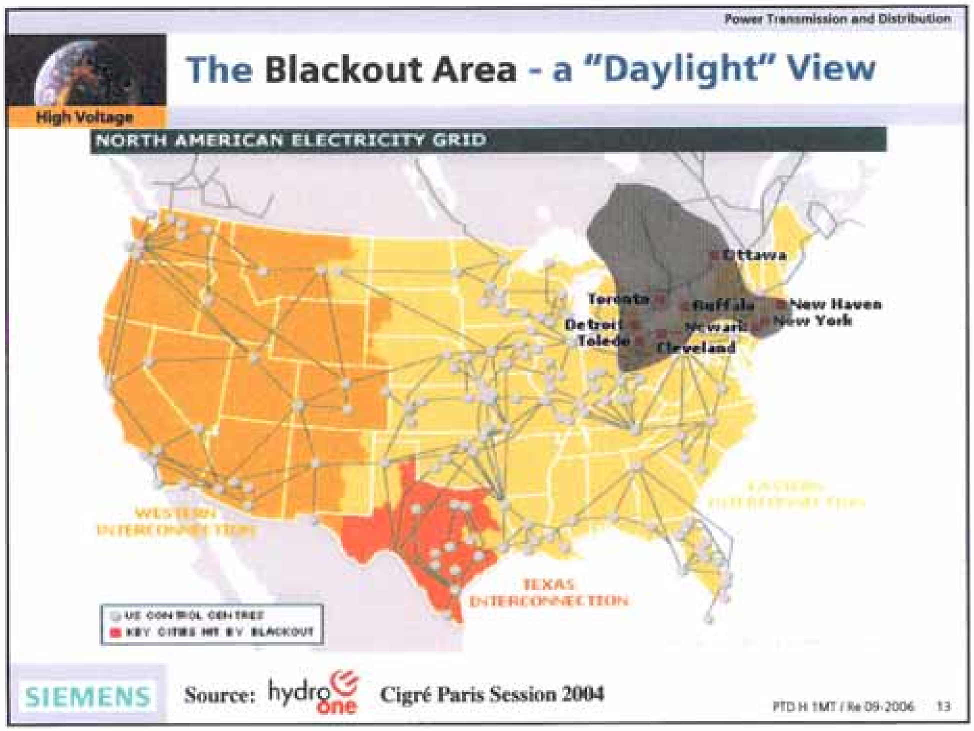

Power Transmission and Distribution
Event 4 – plus a major Computer Failure at 2:14
2:02 PM – Transmission line disconnects in southwestern Ohio
4. Stuart – Atlanta 345 kV
Reported Reasons:
Brush-Fire under the Line
(Source: U.S. DOE Timeline 09-12-2003)
Starting around 2:14, FirstEnergy lost a number of EMS functions including Primary & Backup Server Computer
(Source: EURELECTRIC 06-2004)
Transmission Lines
765 kV
500 kV
345 kV
230 kV
Events
Line opening
Path opening
Generator trip
Event number
SIEMENS
Source: Blackout Summary, U.S./Canada
Power Outage Task Force 9-12-2003
PTD H 1MT / Re 09-2006 8


Power Transmission and Distribution
High Voltage
Event 8 ... and then the decisive Event 9
Transmission Lines
765 kV
500 kV
345 kV
230 kV
Events
Line opening
Path opening
Generator trip
Event number
3:45:33 – 4:08:58 PM – Remaining transmission lines disconnect from eastern into northern Ohio
8. 3:45:33 – Canton Central-Tidd 345 kV
9. 4:06:03 – Sammis-Star 345 kV
Wrong Protection Relay Operation
This was the main "Trigger" of the final Blackout Sequence
(Source: EURELECTRIC 06-2004)
Remaining Paths
9
8
SIEMENS
Source: Blackout Summary, U.S./Canada Power Outage Task Force 9-12-2003
PTD H 1MT / Re 09-2006 9

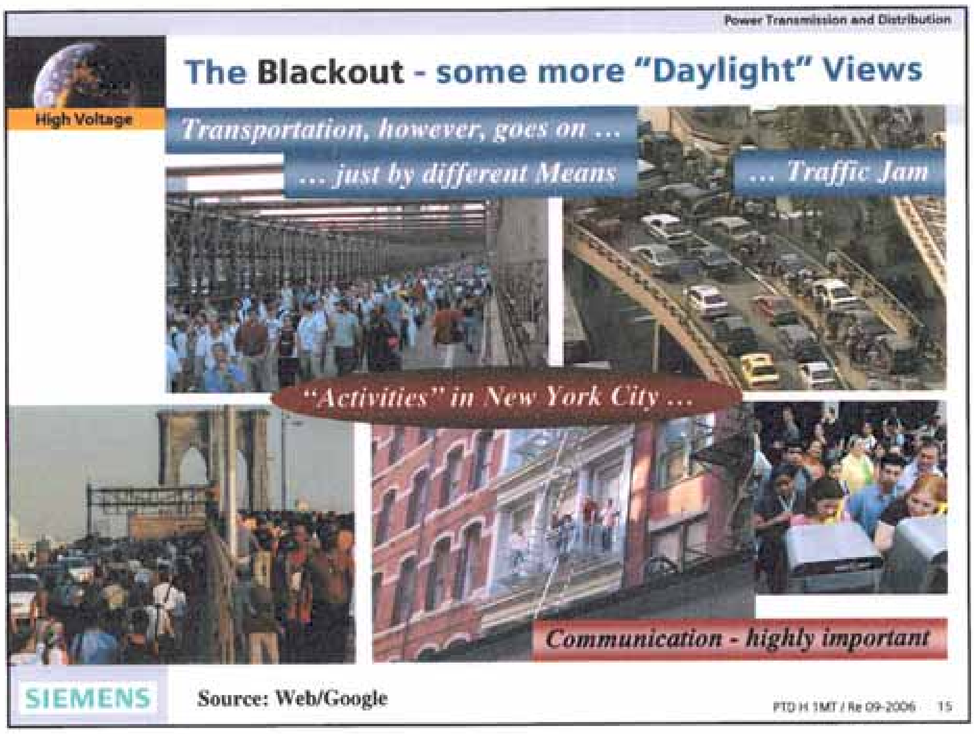

Power Transmission and Distribution
High Voltage
Events 10-12: Begin of Voltage Decline
Transmission Lines
765 kV
500 kV
345 kV
230 kV
Events
Line opening
Path opening
Generator trip
Event number
4:08:58 – 4:10:27 PM – Transmission lines into northwestern Ohio disconnect, and generation trips in central Michigan
10. 4:08:58 – Galion-Ohio Central-Muskingum 345 kV
11. 4:09:06 – East Lima-Fostoria Central 345 kV
12. 4:09:23-4:10:27 – Kinder Morgan (rating: 500 MW; loaded to 200 MW)
4.09 PM: "Point of no Return"
(Source: ITC 08-2003 – "Blackout")
12
11
10
SIEMENS
Source: Blackout Summary, U.S./Canada Power Outage Task Force 9-12-2003
PTD H 1MT / Re 09-2006 10

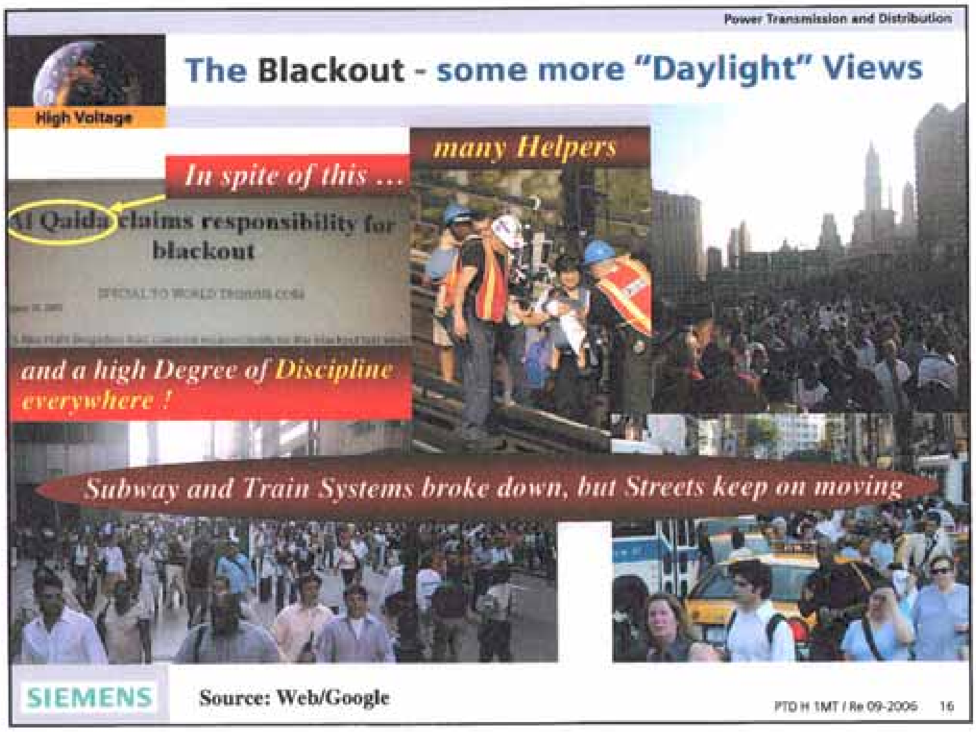

Power Transmission and Distribution
High Voltage
Event 18 in the ITC-Analysis: 30 s to Blackout
About 1 Minute Later...
4:10:40 - 4:10:46 PM
The ITC system is now in full voltage collapse (rapid decline) causing 30 Transmission lines in Michigan to go out of service in less than 8 seconds
Connections between METC and ITC go out of service, isolating ITC from the rest of Michigan
FirstEnergy is still pulling power through Michigan, but suddenly the only route for the power to flow is through Ontario and Michigan
Flows over the ITC - IMO international connection spike to nearly 2800 MW affecting New York, other states and Ontario
Giant Loop Flow 2.8 GW
t= -0:00:30
SIEMENS
Source: Blackout Summary, U.S./Canada Power Outage Task Force 9-12-2003
PTD H 1MT / Re 09-2006 11

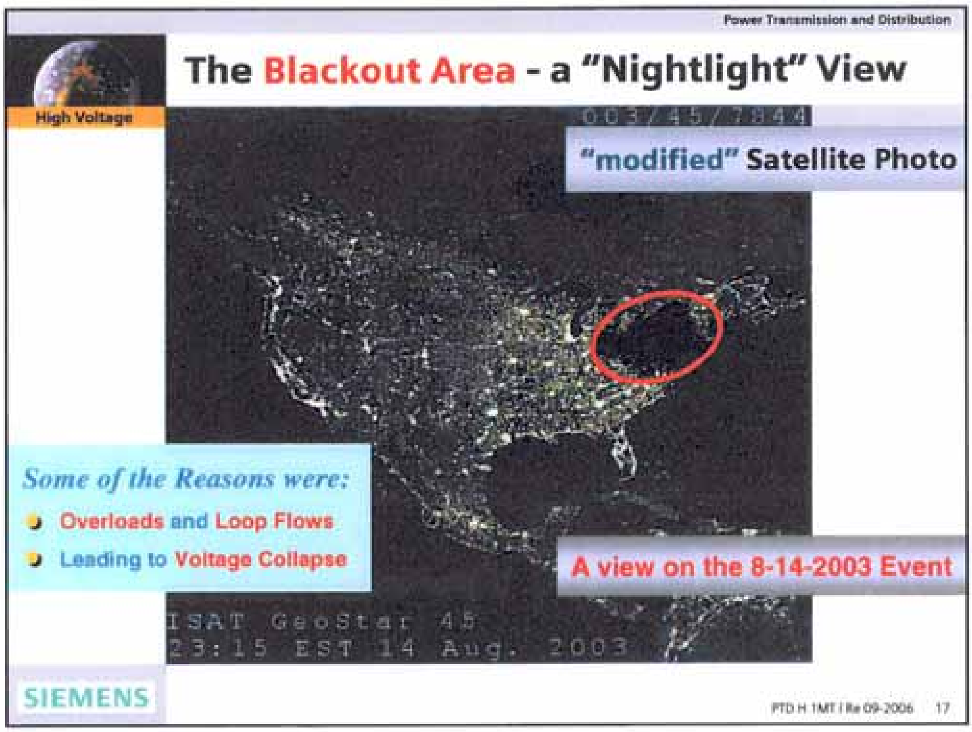

Power Transmission and Distribution
Finally, at 4:13 - a very large Blackout
4:13 PM – Cascading sequence essentially complete
Area affected by blackout
(Service maintained in isolated "islands")
Transmission Lines
765 kV
500 kV
345 kV
230 kV
Events
Line opening
Path opening
Generator trip
Event number
SIEMENS
Source: Blackout Summary, U.S./Canada Power Outage Task Force 9-12-2003
PTD H 1MT / Re 09-2006 12


Power Transmission and Distribution
High Voltage
The Blackout Area - a "Daylight" View
NORTH AMERICAN ELECTRICITY GRID
Ottawa
Toronto
Buffalo
New Haven
Detroit
Newark
New York
Toledo
Cleveland
WESTERN INTERCONNECTION
TEXAS INTERCONNECTION
US CONTROL CENTRES
KEY CITIES HIT BY BLACKOUT
SIEMENS
Source: hydro one Cigré Paris Session 2004
PTD H 1MT / Re 09-2006 13

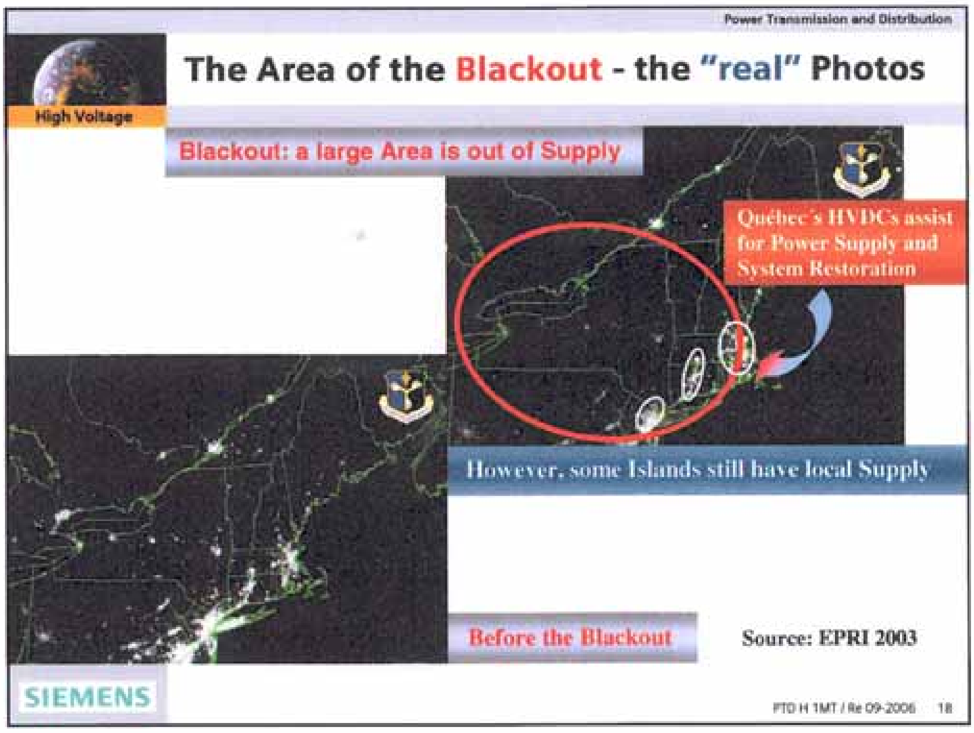

Power Transmission and Distribution
High Voltage
The Blackout – Breaking News ...
POWER OUTAGES
Ottawa
Plattsburgh
Toronto
Syracuse
Utica
Albany
Detroit
Buffalo
Rochester
Hartford
New York
Cleveland
BLACKOUT
BREAKING NEWS
CNN
... the Leaders are concerned
SIEMENS
Source: Web/Google
PTD H 1MT / Re 09-2006 14


Power Transmission and Distribution
High Voltage
The Blackout - some more "Daylight" Views
Transportation, however, goes on ...
... just by different Means
... Traffic Jam
"Activities" in New York City ...
Communication - highly important
SIEMENS
Source: Web/Google
PTD H 1MT / Re 09-2006 15

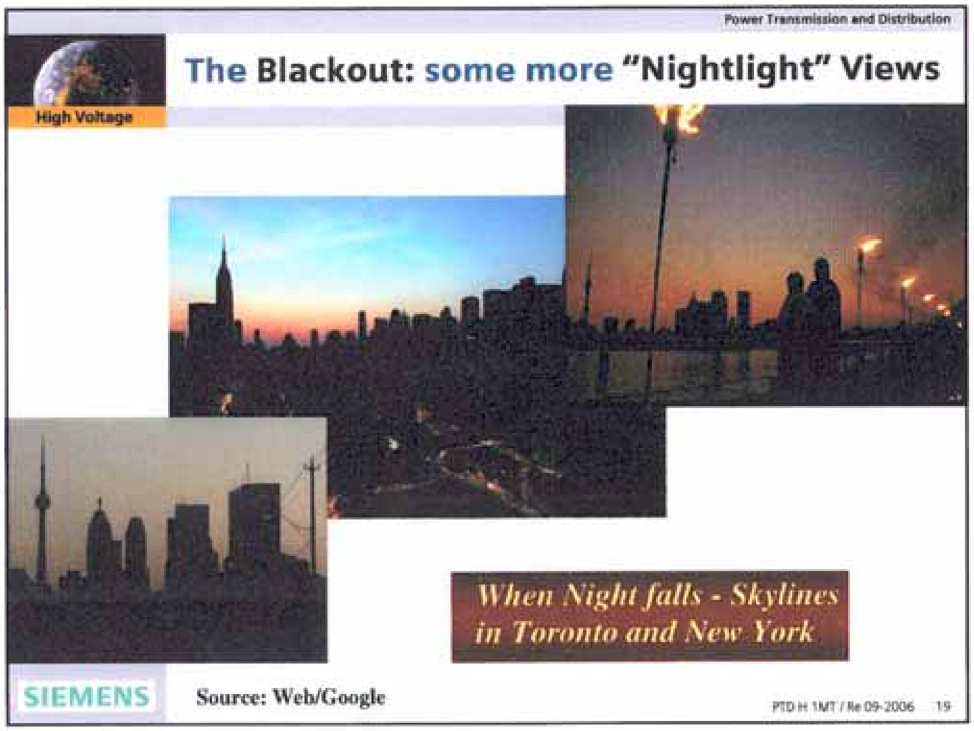

Power Transmission and Distribution
High Voltage
The Blackout - some more "Daylight" Views
many Helpers
In spite of this ...
Al Qaida claims responsibility for blackout
and a high Degree of Discipline everywhere !
Subway and Train Systems broke down, but Streets keep on moving
SIEMENS
Source: Web/Google
PTD H 1MT / Re 09-2006 16

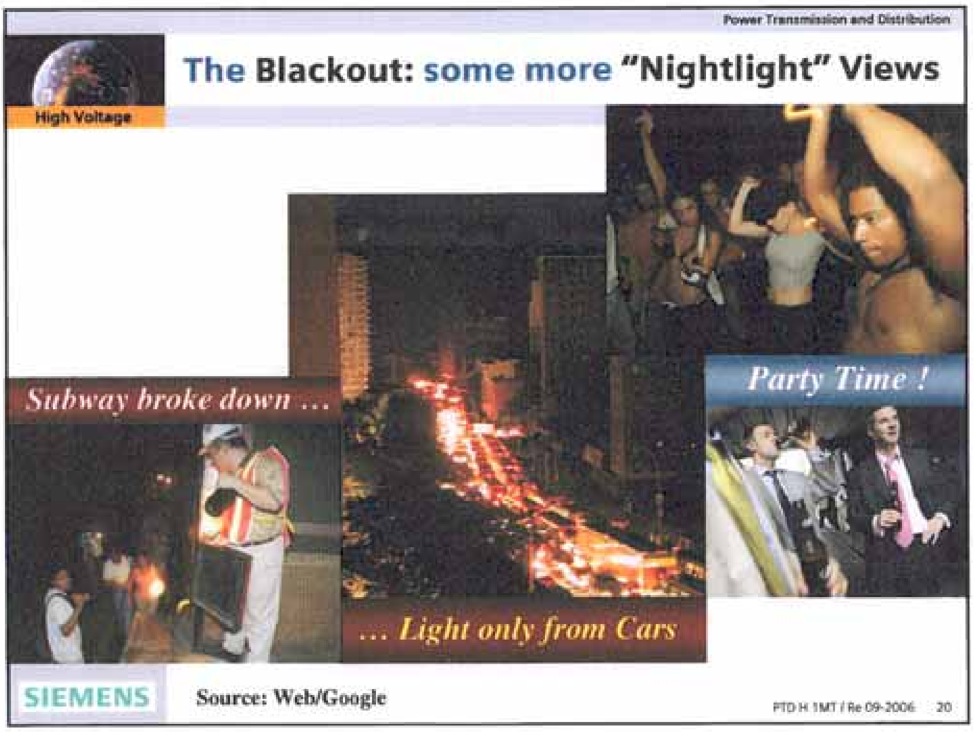


Power Transmission and Distribution
High Voltage
The Blackout Area - a "Nightlight" View
003/45/7844
"modified" Satellite Photo
Some of the Reasons were:
Overloads and Loop Flows
Leading to Voltage Collapse
A view on the 8-14-2003 Event
ISAT GeoStar 45
23:15 EST 14 Aug. 2003
SIEMENS
PTD H 1MT / Re 09-2006 17



Power Transmission and Distribution
High Voltage
The Area of the Blackout - the "real" Photos
Blackout: a large Area is out of Supply
Québec's HVDCs assist for Power Supply and System Restoration
However, some Islands still have local Supply
Before the Blackout
Source: EPRI 2003
SIEMENS
PTD H 1MT / Re 09-2006 18

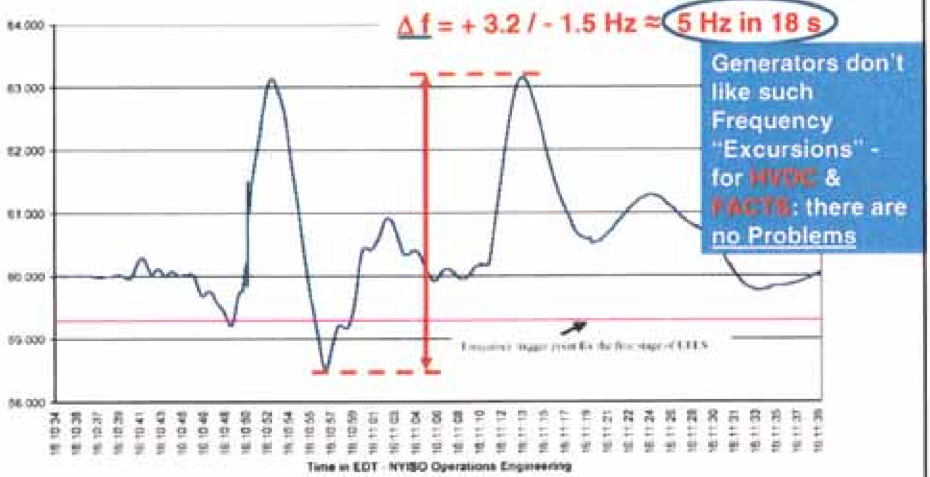

Power Transmission and Distribution
High Voltage
The Blackout: some more "Nightlight" Views
When Night falls - Skylines in Toronto and New York
SIEMENS
Source: Web/Google
PTD H 1MT / Re 09-2006 19


Power Transmission and Distribution
High Voltage
The Blackout: some more "Nightlight" Views
Subway broke down …
… Light only from Cars
Party Time !
SIEMENS
Source: Web/Google
PTD H 1MT / Re 09-2006 20

Power Transmission and Distribution

High Voltage

Frequency Scan at New York – from 16:10:34 to 16:11:39



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PTD H 1MT / Re 09-2006 21

Power Transmission and Distribution

High Voltage

What can actually be done ? Are other large Systems in the World Safe ?

- Improvement of System Protection and Enhancement of Communication and Monitoring with IT (EMS & DSM)
- Review of Generator and Load Trip Strategy (Under-Voltage and Under-Frequency Trip Levels and Times)
- Use of FACTS & HVDC for Reactive-Power Compensation, Power-Flow Control and Prevention of Voltage Collapse
- Active Damping of Power Oscillations with FACTS & HVDC
- Possibly more HVDC in the interconnected US-Canada Areas: HVDC is a Firewall against cascading events (Voltage Collapse and Frequency decline): Québec was not affected !
- Increase of Reserve Capacity (HVDC, new Generations)

Task Forces were "looking into" their own Systems all over the World

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PTD H 1MT / Re 09-2006 22

Power Transmission and Distribution

High Voltage

Québec Canada was not affected – Why ?

The Reasons are very clear:

- Québec´s major Interconnections to the affected Areas are DC-Links
- These DC-Links are like a Firewall against Cascading Events
- They split the System at the right Point on the right Time, whenever required
- Therefore, Québec was "saved"
- Furthermore, the DCs assisted the US-System Restoration by means of "Power Injection"

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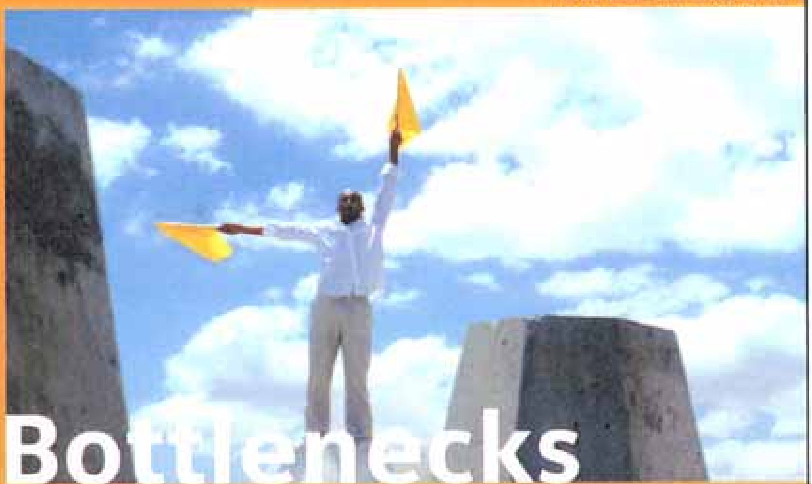
PTD H 1MT / Re 09-2006 23

Power Transmission and Distribution



3. Bottlenecks

... in UCTE ?

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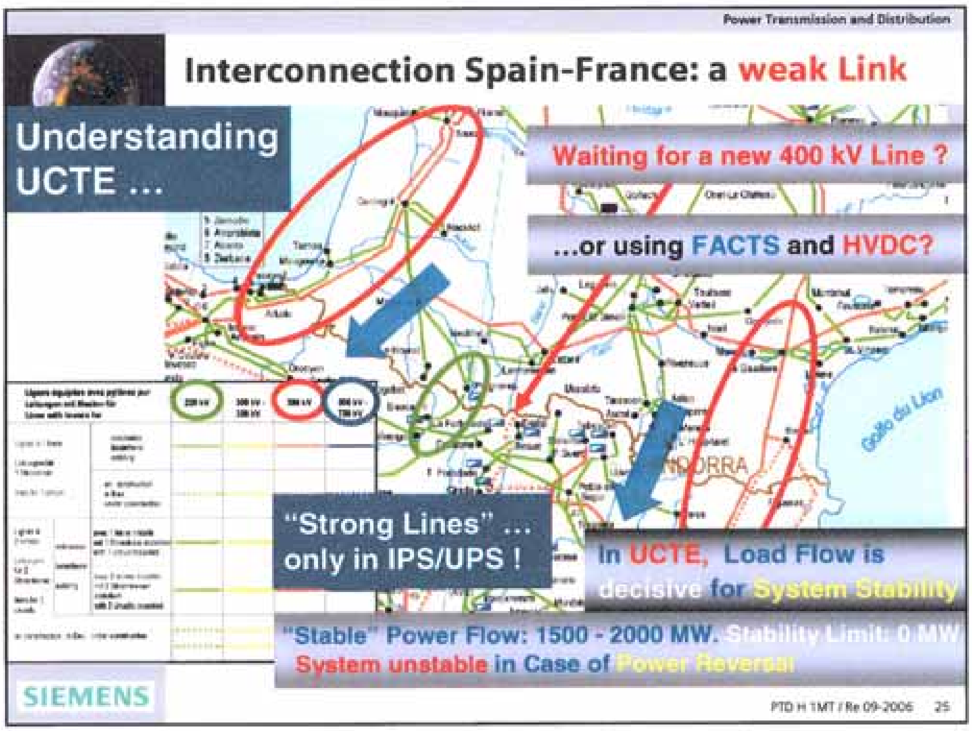
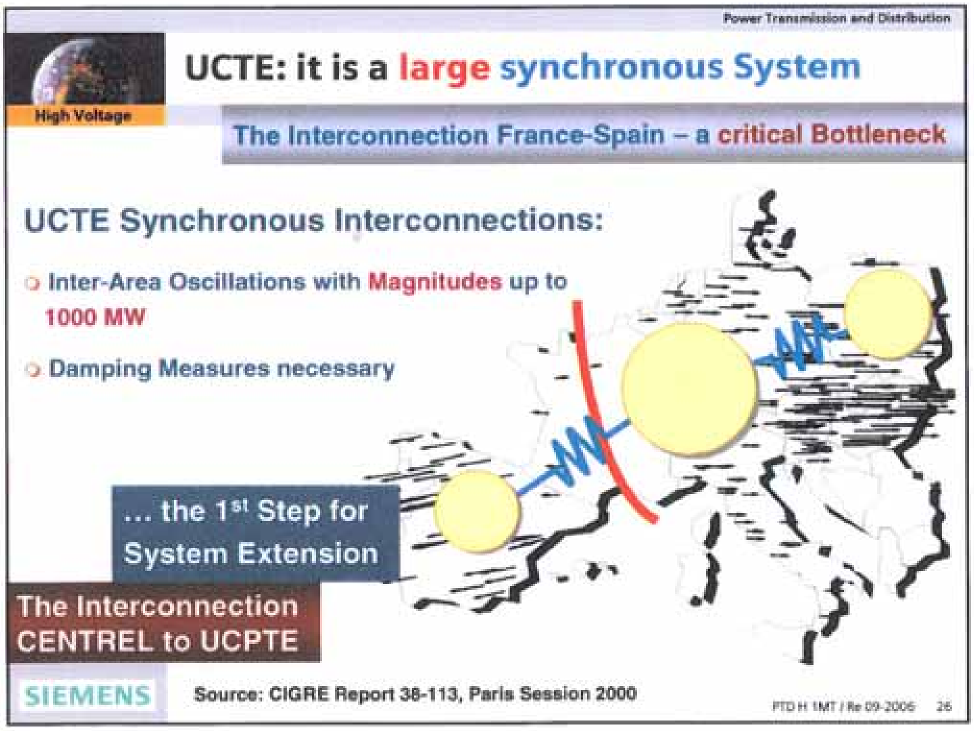
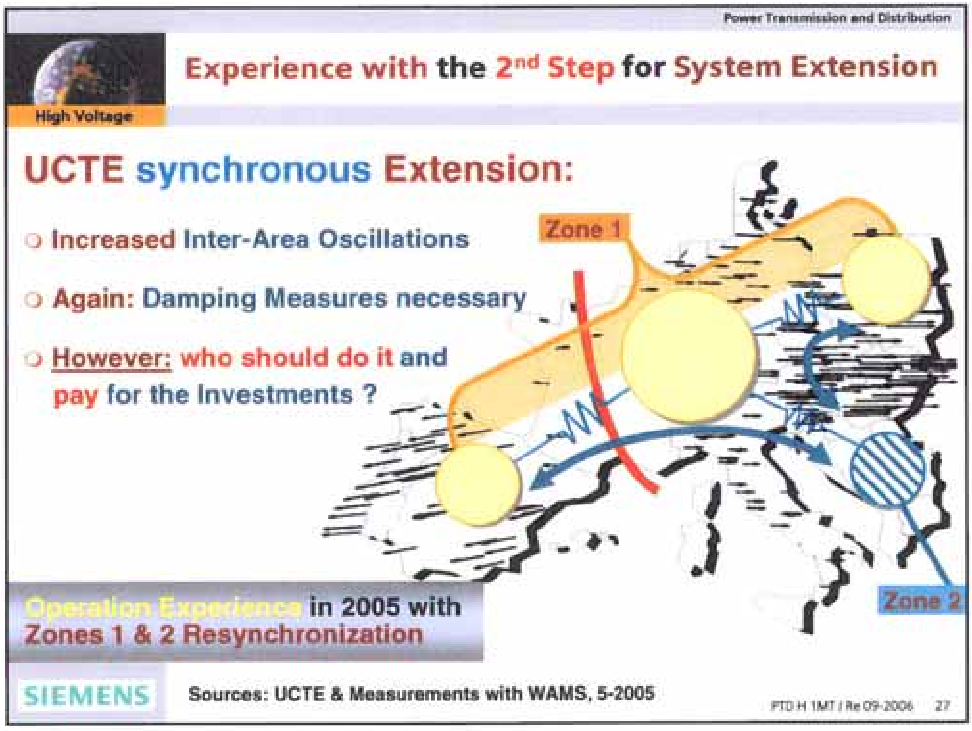
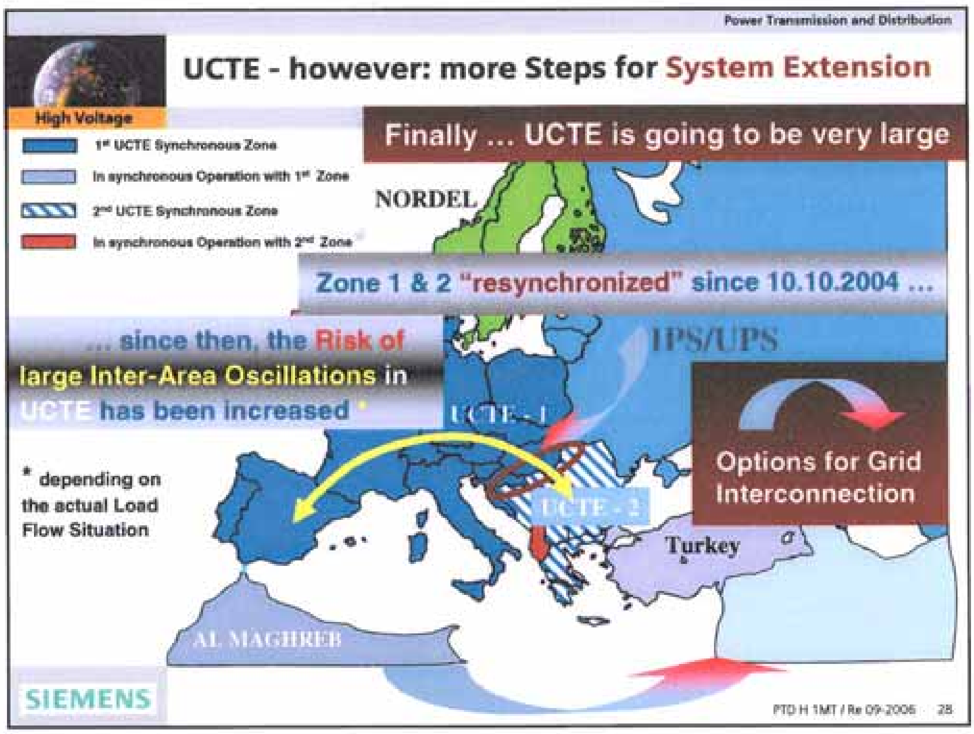
PTD H 1MT / Re 09-2006 24


Power Transmission and Distribution
Interconnection Spain-France: a weak Link
Understanding UCTE ...
Waiting for a new 400 kV Line ?
...or using FACTS and HVDC?
Golfe du Lion
ANDORRA
"Strong Lines" ... only in IPS/UPS !
In UCTE, Load Flow is decisive for System Stability
"Stable" Power Flow: 1500 - 2000 MW. Stability Limit: 0 MW
System unstable in Case of Power Reversal
SIEMENS
PTD H 1MT / Re 09-2006 25

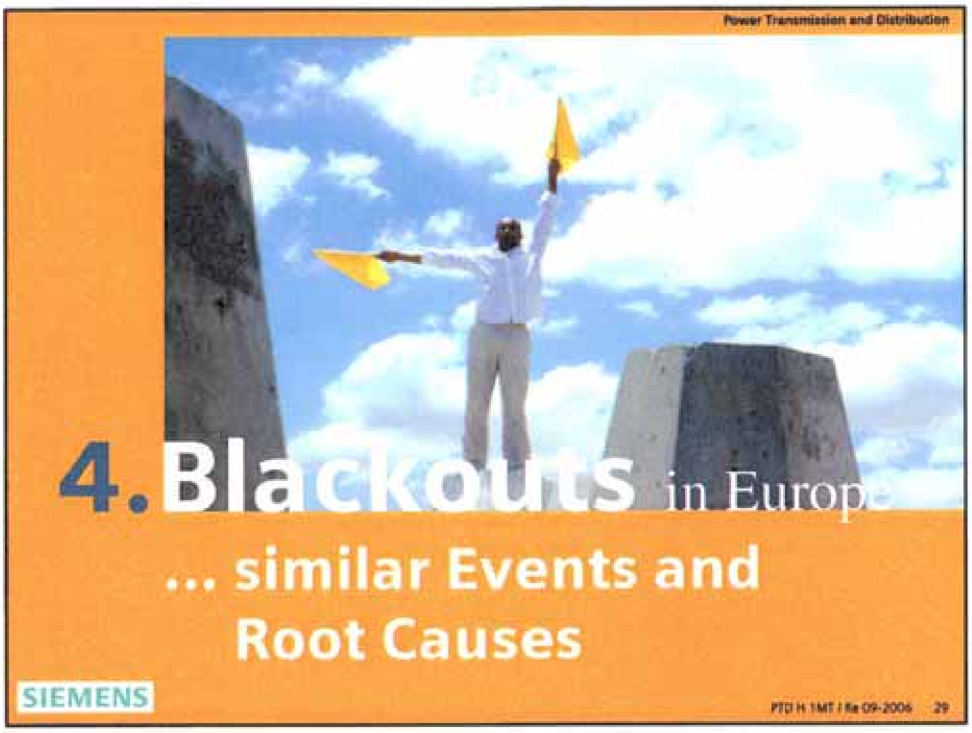

Power Transmission and Distribution
High Voltage
UCTE: it is a large synchronous System
The Interconnection France-Spain – a critical Bottleneck
UCTE Synchronous Interconnections:
Inter-Area Oscillations with Magnitudes up to 1000 MW
Damping Measures necessary
... the 1st Step for System Extension
The Interconnection CENTREL to UCPTE
SIEMENS
Source: CIGRE Report 38-113, Paris Session 2000
PTD H 1MT / Re 09-2006 26

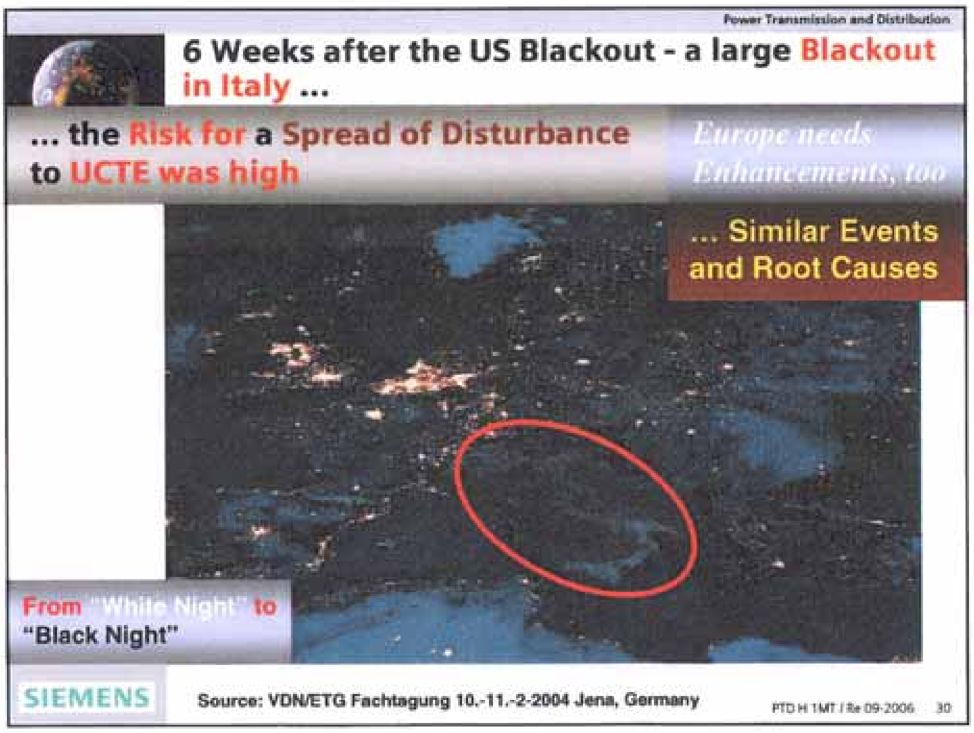


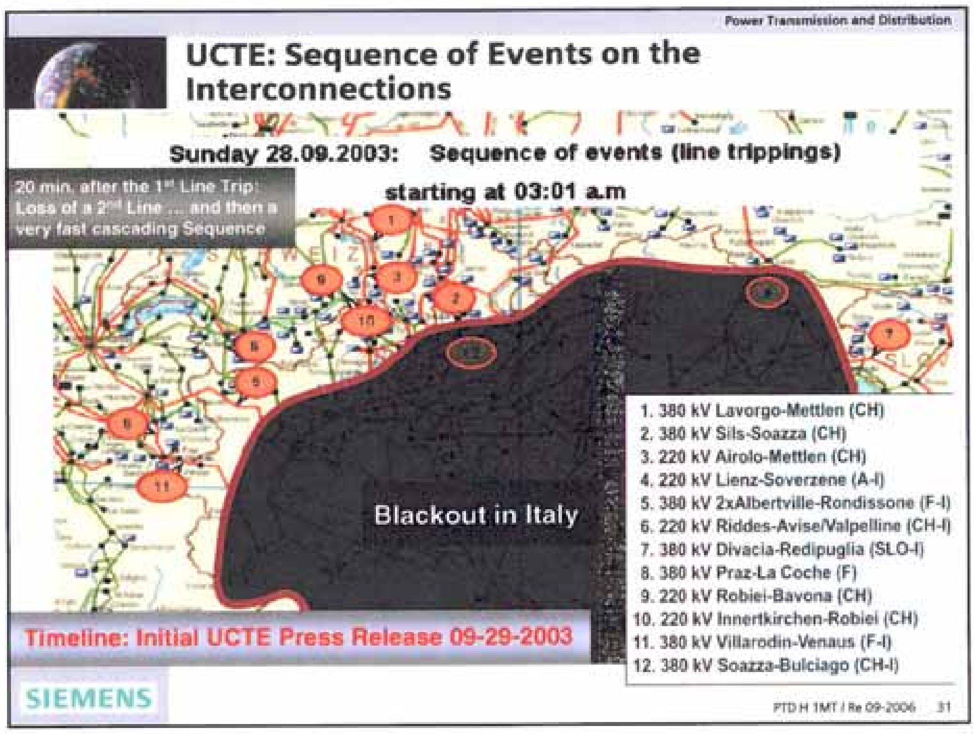
Power Transmission and Distribution
High Voltage
Experience with the 2nd Step for System Extension
UCTE synchronous Extension:
Increased Inter-Area Oscillations
Again: Damping Measures necessary
However: who should do it and pay for the Investments ?
Zone 1
Zone 2
Operation Experience in 2005 with Zones 1 & 2 Resynchronization
SIEMENS
Sources: UCTE & Measurements with WAMS, 5-2005
PTD H 1MT / Re 09-2006 27

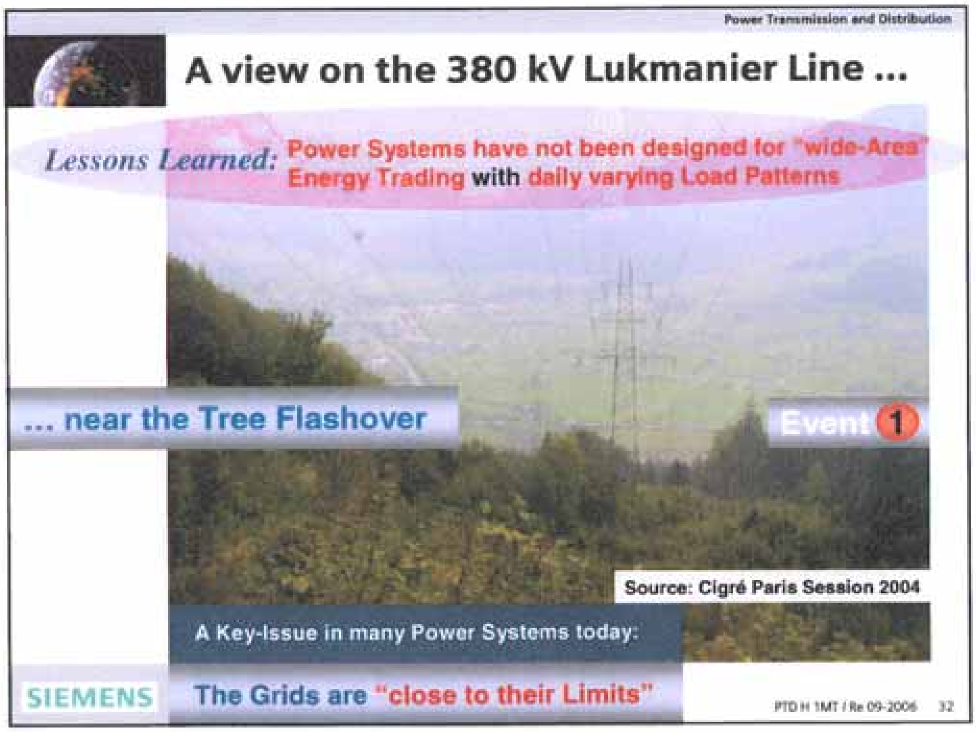


Power Transmission and Distribution
High Voltage
UCTE - however: more Steps for System Extension
1st UCTE Synchronous Zone
In synchronous Operation with 1st Zone
2nd UCTE Synchronous Zone
In synchronous Operation with 2nd Zone
Finally ... UCTE is going to be very large
NORDEL
Zone 1 & 2 "resynchronized" since 10.10.2004 ...
... since then, the Risk of large Inter-Area Oscillations in UCTE has been increased *
IPS/UPS
UCTE - 1
UCTE - 2
Options for Grid Interconnection
* depending on the actual Load Flow Situation
Turkey
AL MAGHREB
SIEMENS
PTD H 1MT / Re 09-2006 28


Power Transmission and Distribution
4. Blackouts in Europe
... similar Events and
Root Causes
SIEMENS
PTD H 1MT / Re 09-2006 29


Power Transmission and Distribution
6 Weeks after the US Blackout - a large Blackout in Italy ...
... the Risk for a Spread of Disturbance to UCTE was high
Europe needs Enhancements, too
... Similar Events and Root Causes
From "White Night" to "Black Night"
SIEMENS
Source: VDN/ETG Fachtagung 10.-11.-2-2004 Jena, Germany
PTD H 1MT / Re 09-2006 30


Power Transmission and Distribution
UCTE: Sequence of Events on the Interconnections
Sunday 28.09.2003: Sequence of events (line trippings)
starting at 03:01 a.m
20 min. after the 1st Line Trip: Loss of a 2nd Line ... and then a very fast cascading Sequence
Blackout in Italy
1. 380 kV Lavorgo-Mettlen (CH)
2. 380 kV Sils-Soazza (CH)
3. 220 kV Airolo-Mettlen (CH)
4. 220 kV Lienz-Soverzene (A-I)
5. 380 kV 2xAlbertville-Rondissone (F-I)
6. 220 kV Riddes-Avise/Valpelline (CH-I)
7. 380 kV Divacia-Redipuglia (SLO-I)
8. 380 kV Praz-La Coche (F)
9. 220 kV Robiei-Bavona (CH)
10. 220 kV Innertkirchen-Robiei (CH)
11. 380 kV Villarodin-Venaus (F-I)
12. 380 kV Soazza-Bulciago (CH-I)
Timeline: Initial UCTE Press Release 09-29-2003
SIEMENS
PTD H 1MT / Re 09-2006 31


Power Transmission and Distribution
A view on the 380 kV Lukmanier Line ...
Lessons Learned: Power Systems have not been designed for "wide-Area" Energy Trading with daily varying Load Patterns
... near the Tree Flashover
Event 1
Source: Cigré Paris Session 2004
A Key-Issue in many Power Systems today:
The Grids are "close to their Limits"
SIEMENS
PTD H 1MT / Re 09-2006 32

High Voltage

Effect of System Loading on Stability Margin

The transmission distance of considerable power transfer of 6.7 GW from the generation located in Central Europe to the consumers in Italy led to a relatively high phase angle difference in the stationary parallel operation between the UCTE main grid:

- the immediate reconnection of the line tripping first was not possible because of a steady state phase angle difference higher than expected
- the cascading line tripping evolved into a much more severe angle stability problem.

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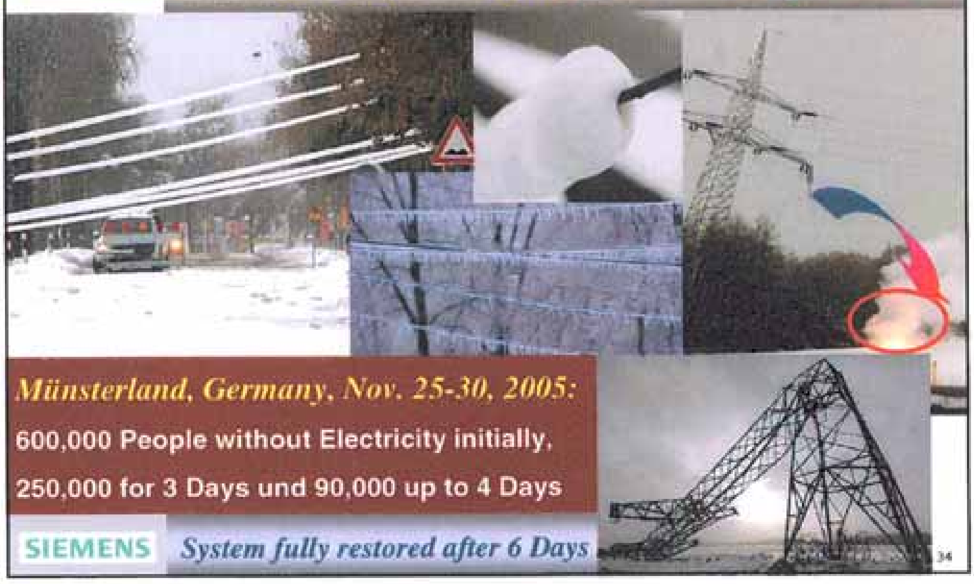
Source: UCTE Interim Report 10-27-2003

High Voltage

The "Blackout-Story" *goes on …*

When Ice, Snow and Storm exceed the "Design Criteria"



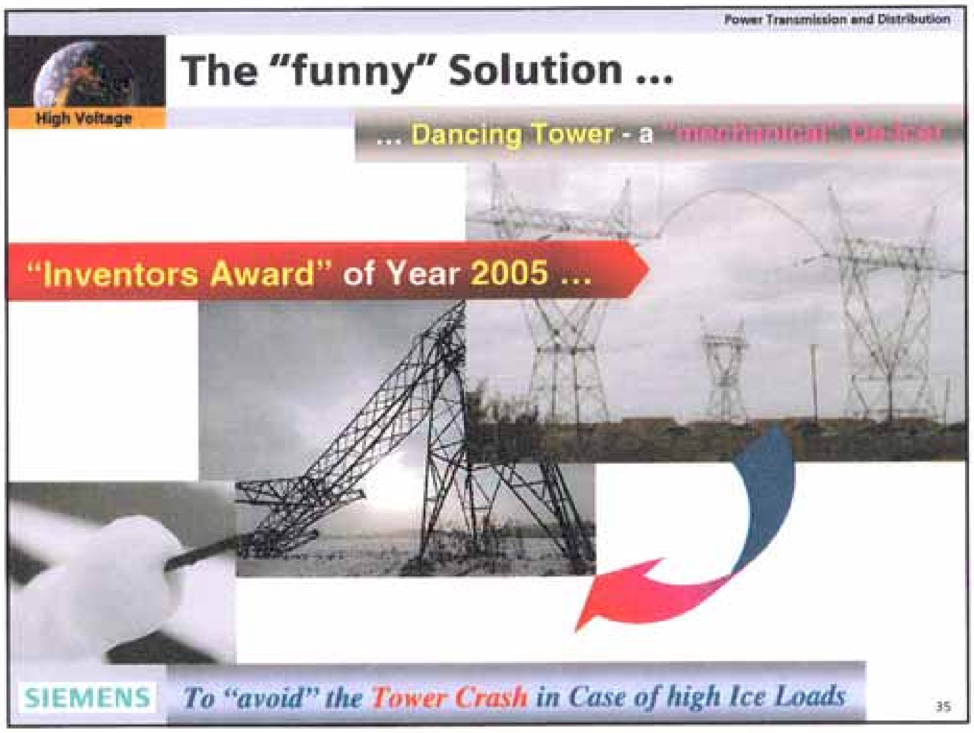
Münsterland, Germany, Nov. 25-30, 2005:

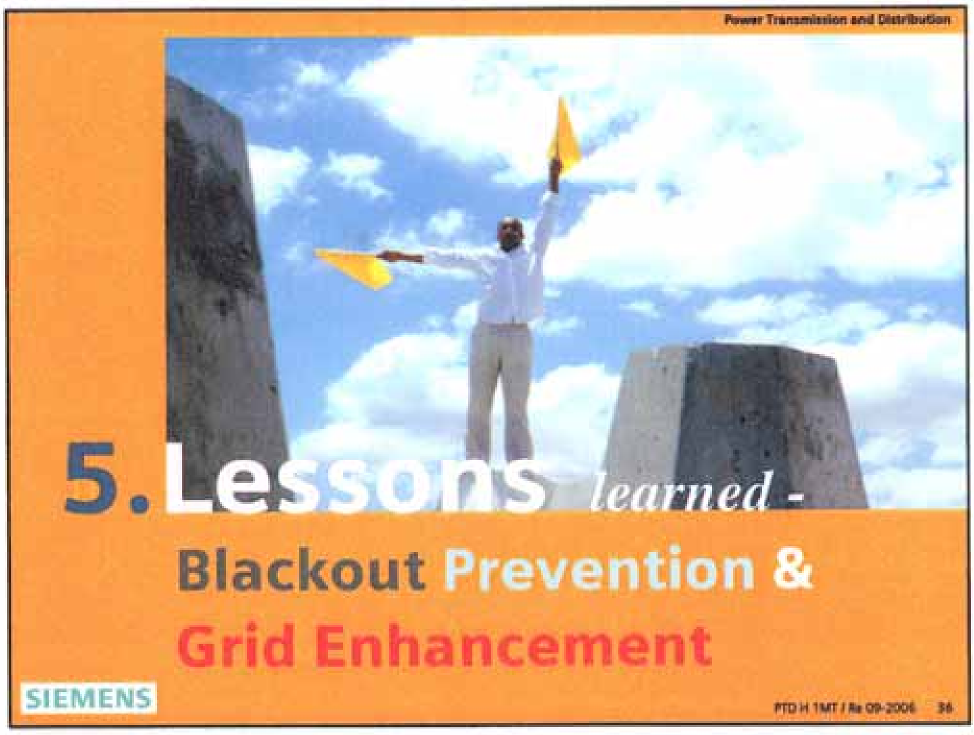
600,000 People without Electricity initially,

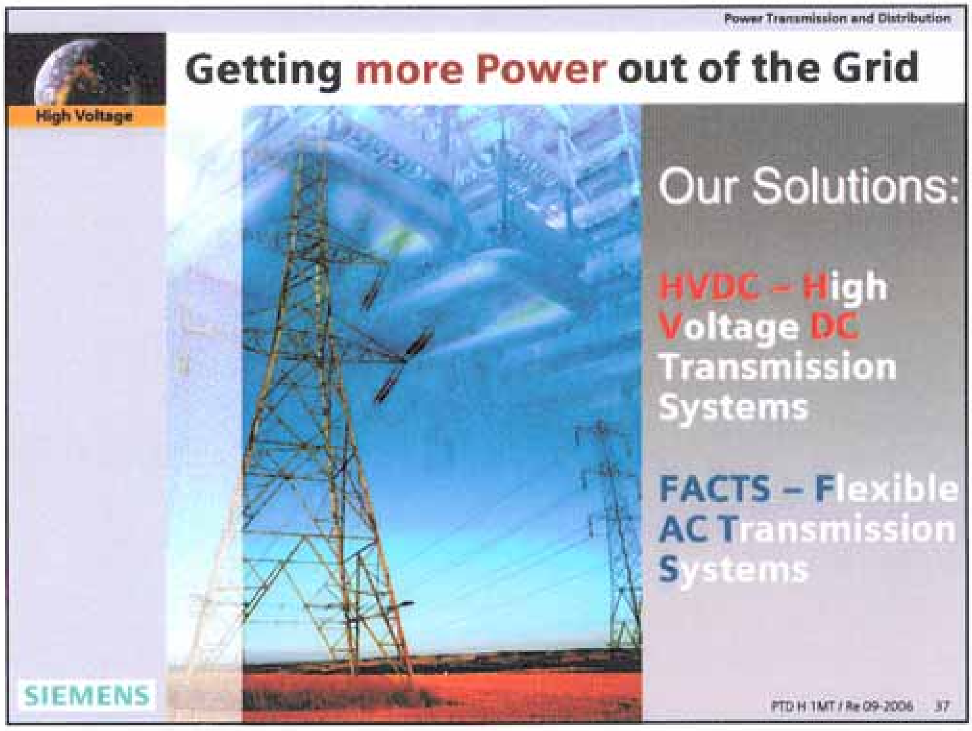
250,000 for 3 Days und 90,000 up to 4 Days

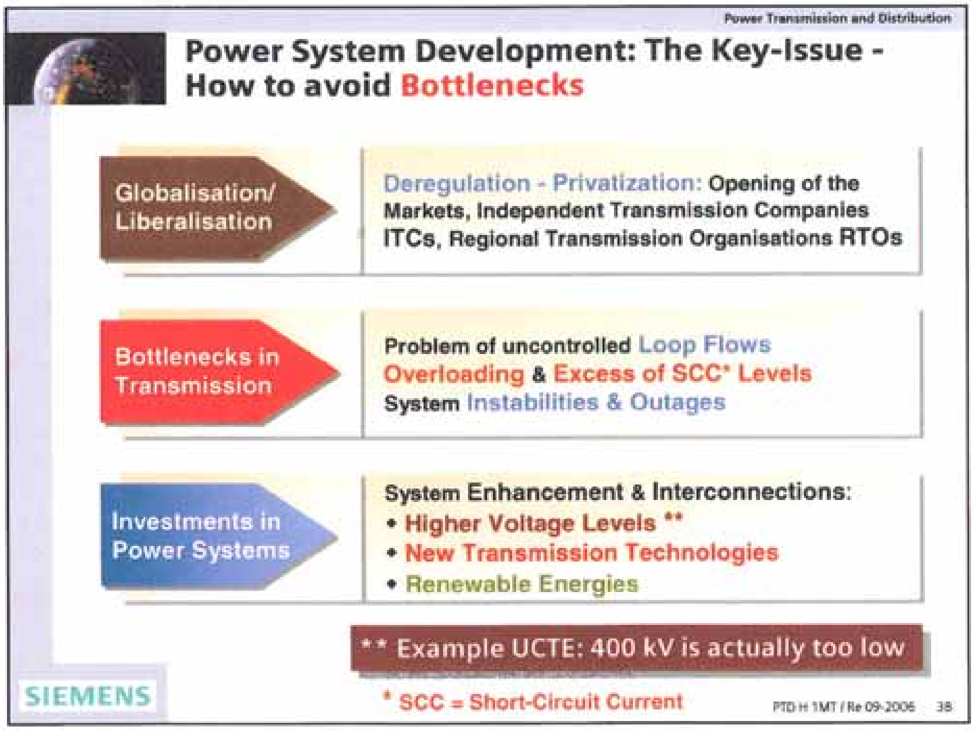
SIEMENS

System fully restored after 6 Days


Power Transmission and Distribution
The "funny" Solution ...
High Voltage
... Dancing Tower - a
"Inventors Award" of Year 2005 ...
SIEMENS
To "avoid" the Tower Crash in Case of high Ice Loads
35


Power Transmission and Distribution
5. Lessons learned -
Blackout Prevention &
Grid Enhancement
SIEMENS
PTD H 1MT / Re 09-2006 36


Power Transmission and Distribution
High Voltage
Getting more Power out of the Grid
Our Solutions:
HVDC – High Voltage DC Transmission Systems
FACTS – Flexible AC Transmission Systems
SIEMENS
PTD H 1MT / Re 09-2006 37


Power Transmission and Distribution
Power System Development: The Key-Issue - How to avoid Bottlenecks
Globalisation/ Liberalisation
Deregulation - Privatization: Opening of the Markets, Independent Transmission Companies ITCs, Regional Transmission Organisations RTOs
Bottlenecks in Transmission
Problem of uncontrolled Loop Flows
Overloading & Excess of SCC* Levels
System Instabilities & Outages
Investments in Power Systems
System Enhancement & Interconnections:
• Higher Voltage Levels **
• New Transmission Technologies
• Renewable Energies
** Example UCTE: 400 kV is actually too low
* SCC = Short-Circuit Current
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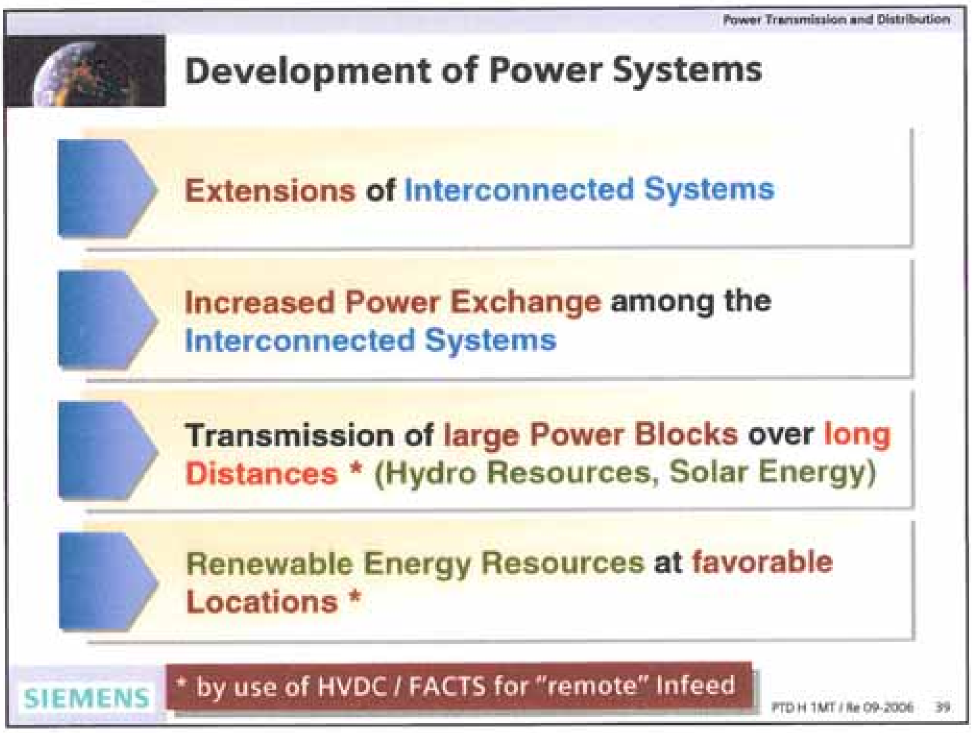
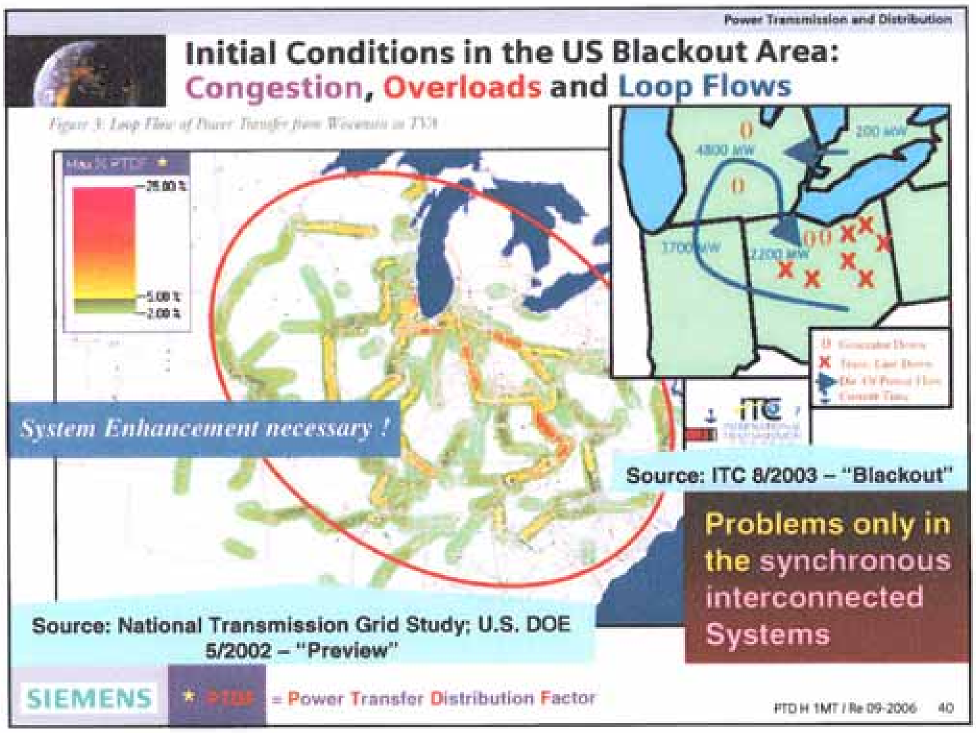
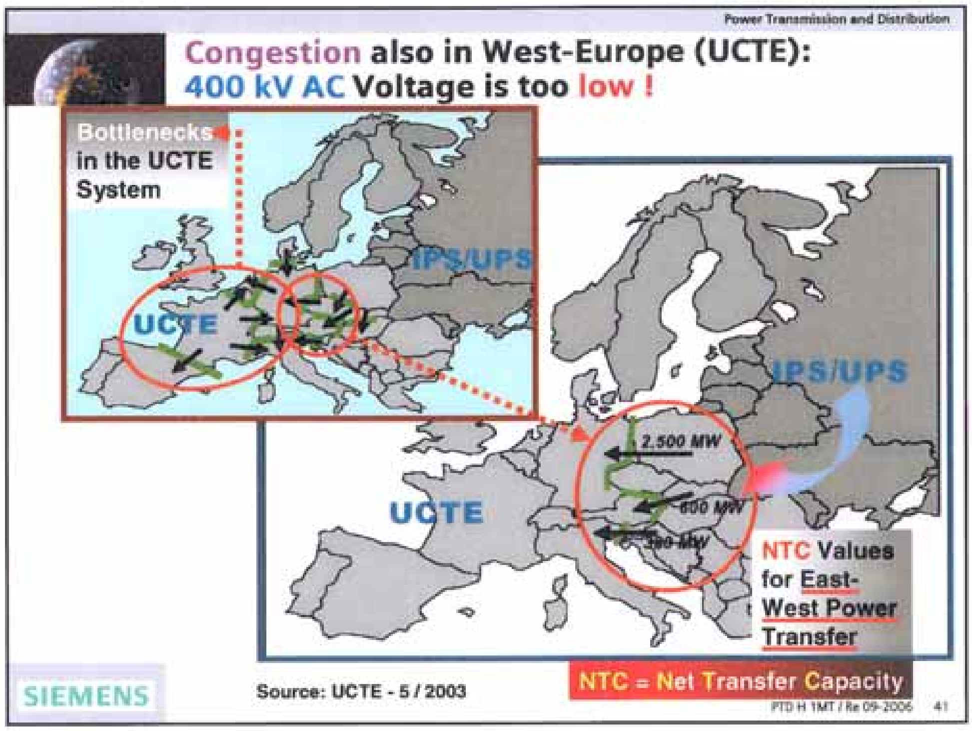
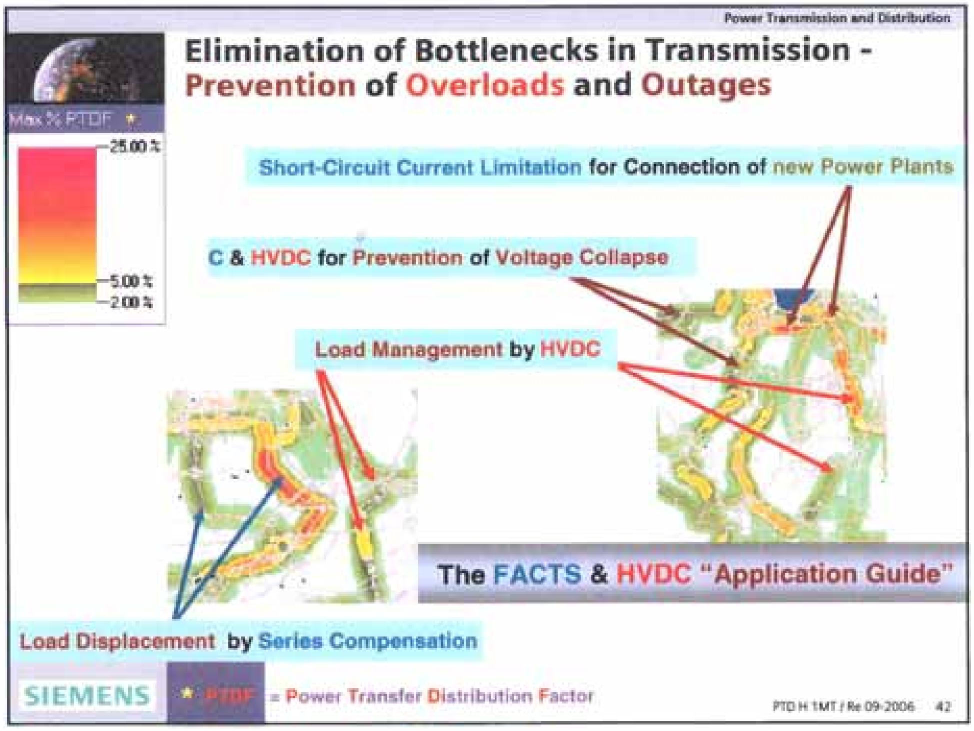
PTD H 1MT / Re 09-2006 38


Power Transmission and Distribution
Development of Power Systems
Extensions of Interconnected Systems
Increased Power Exchange among the Interconnected Systems
Transmission of large Power Blocks over long Distances * (Hydro Resources, Solar Energy)
Renewable Energy Resources at favorable Locations *
SIEMENS
* by use of HVDC / FACTS for "remote" Infeed
PTD H 1MT / Re 09-2006 39

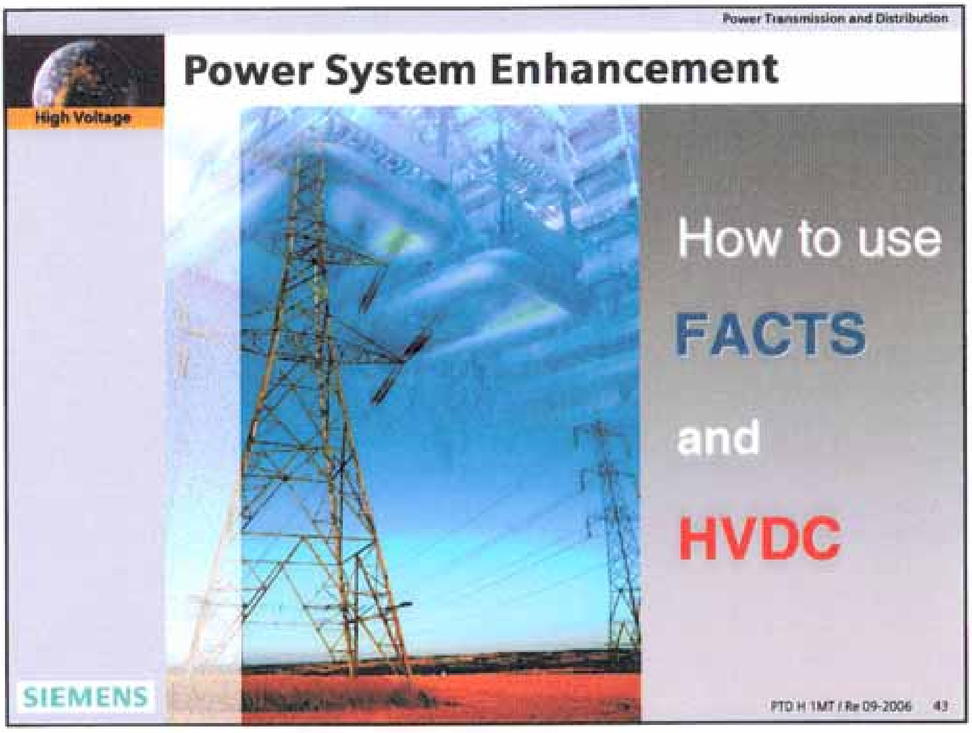

Power Transmission and Distribution
Initial Conditions in the US Blackout Area:
Congestion, Overloads and Loop Flows
4800 MW
200 MW
1700 MW
2200 MW
System Enhancement necessary !
Source: ITC 8/2003 – "Blackout"
Problems only in the synchronous interconnected Systems
Source: National Transmission Grid Study; U.S. DOE 5/2002 – "Preview"
SIEMENS
* PTDF = Power Transfer Distribution Factor
PTD H 1MT / Re 09-2006 40

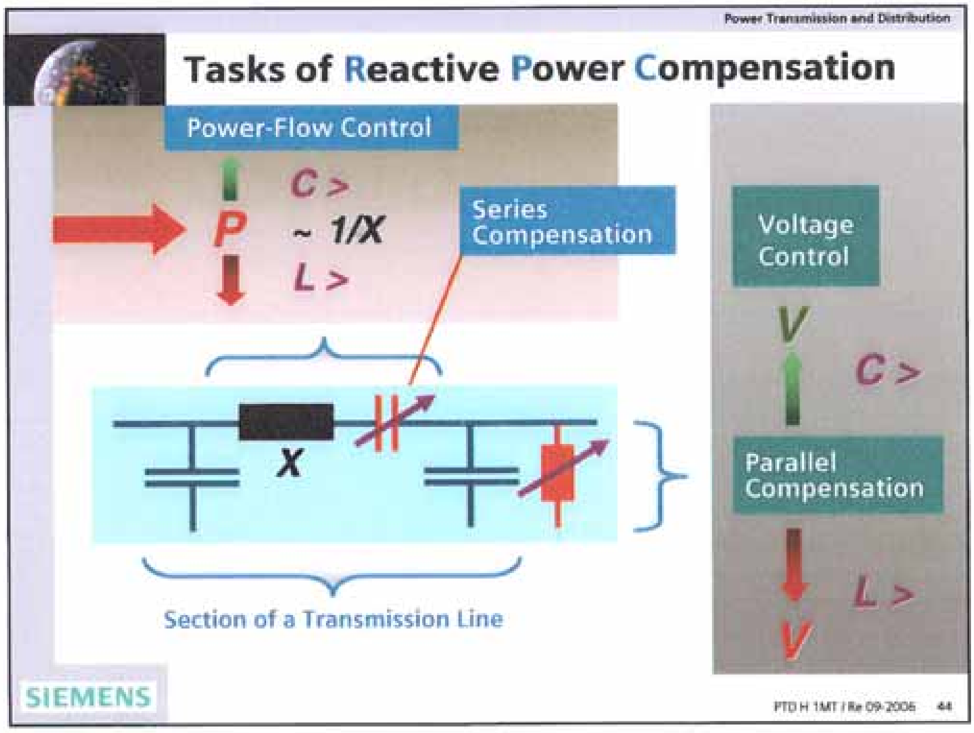


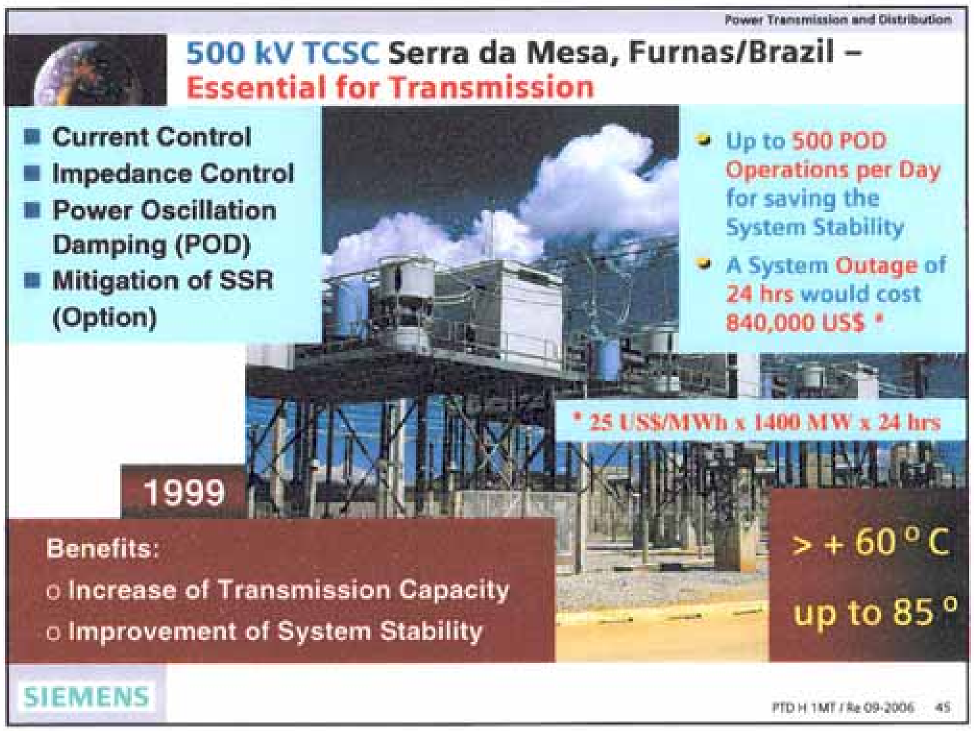
Power Transmission and Distribution
Congestion also in West-Europe (UCTE):
400 kV AC Voltage is too low !
Bottlenecks in the UCTE System
UCTE
IPS/UPS
IPS/UPS
UCTE
2,500 MW
600 MW
NTC Values for East-West Power Transfer
SIEMENS
Source: UCTE - 5 / 2003
NTC = Net Transfer Capacity
PTD H 1MT / Re 09-2006 41

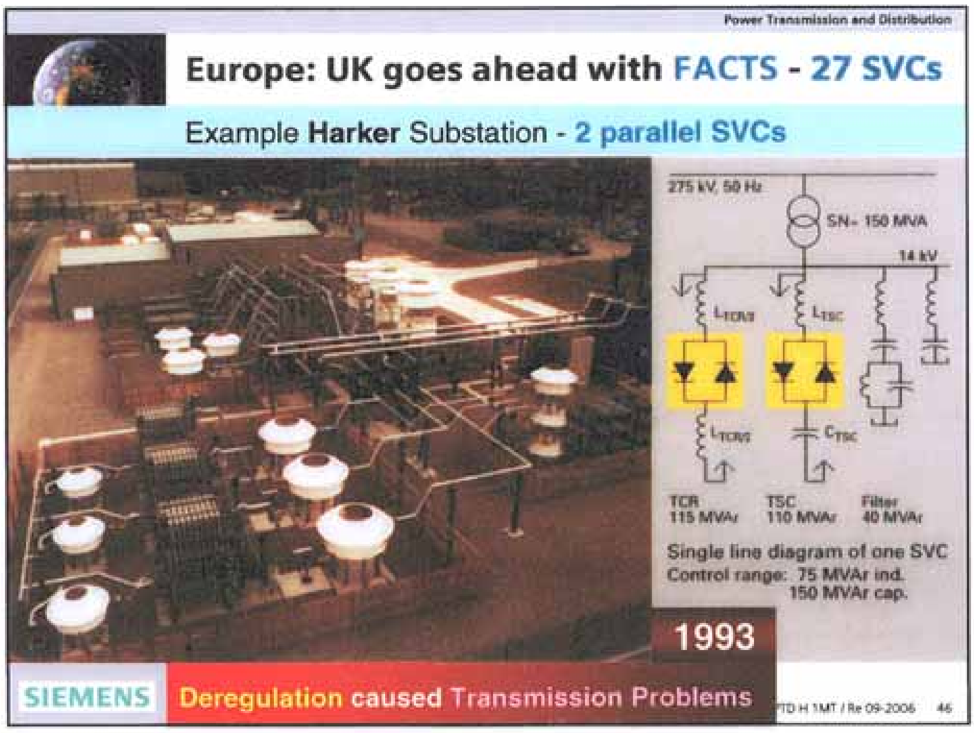


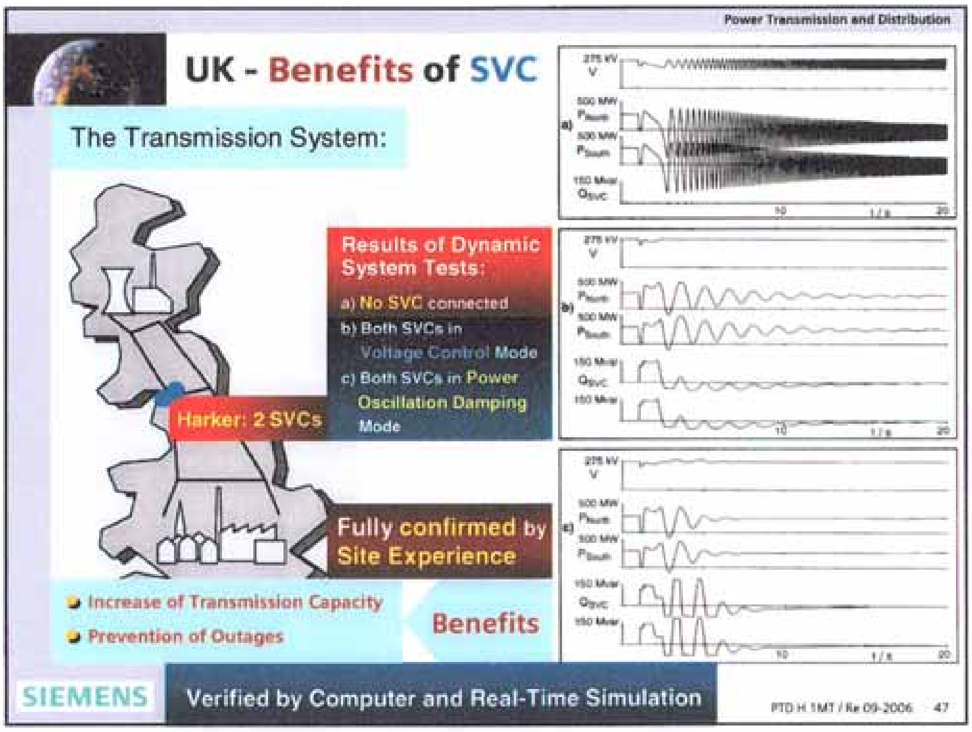
Power Transmission and Distribution
Elimination of Bottlenecks in Transmission -
Prevention of Overloads and Outages
Max % PTDF *
25.00 %
5.00 %
2.00 %
Short-Circuit Current Limitation for Connection of new Power Plants
C & HVDC for Prevention of Voltage Collapse
Load Management by HVDC
The FACTS & HVDC "Application Guide"
Load Displacement by Series Compensation
SIEMENS
* PTDF = Power Transfer Distribution Factor
PTD H 1MT / Re 09-2006 42

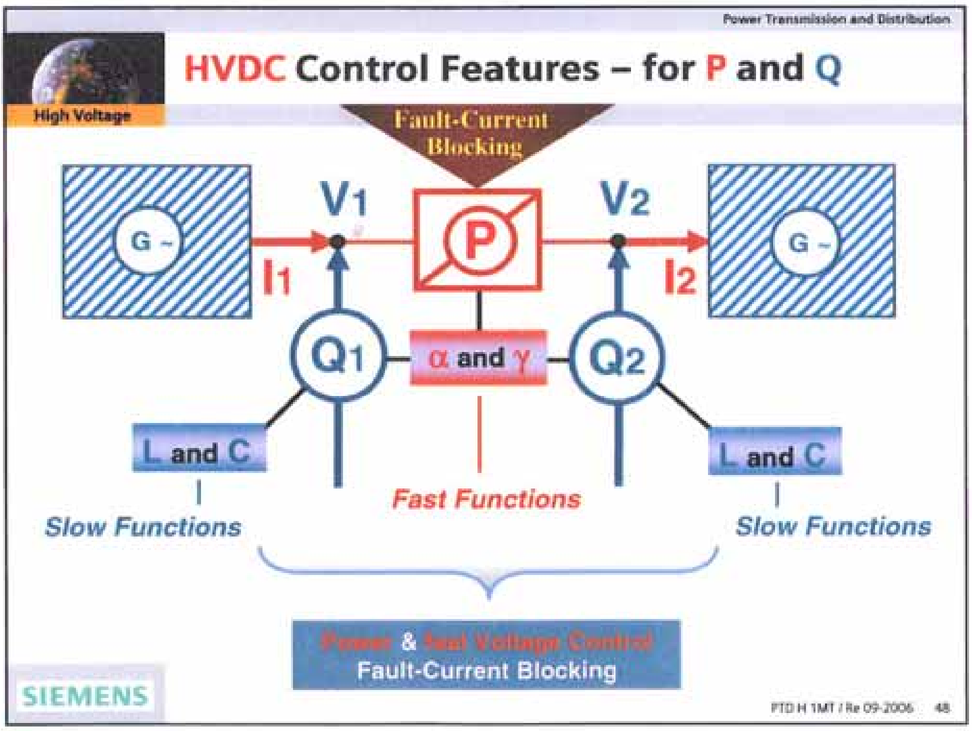

Power Transmission and Distribution
High Voltage
Power System Enhancement
How to use
FACTS
and
HVDC
SIEMENS
PTD H 1MT / Re 09-2006 43

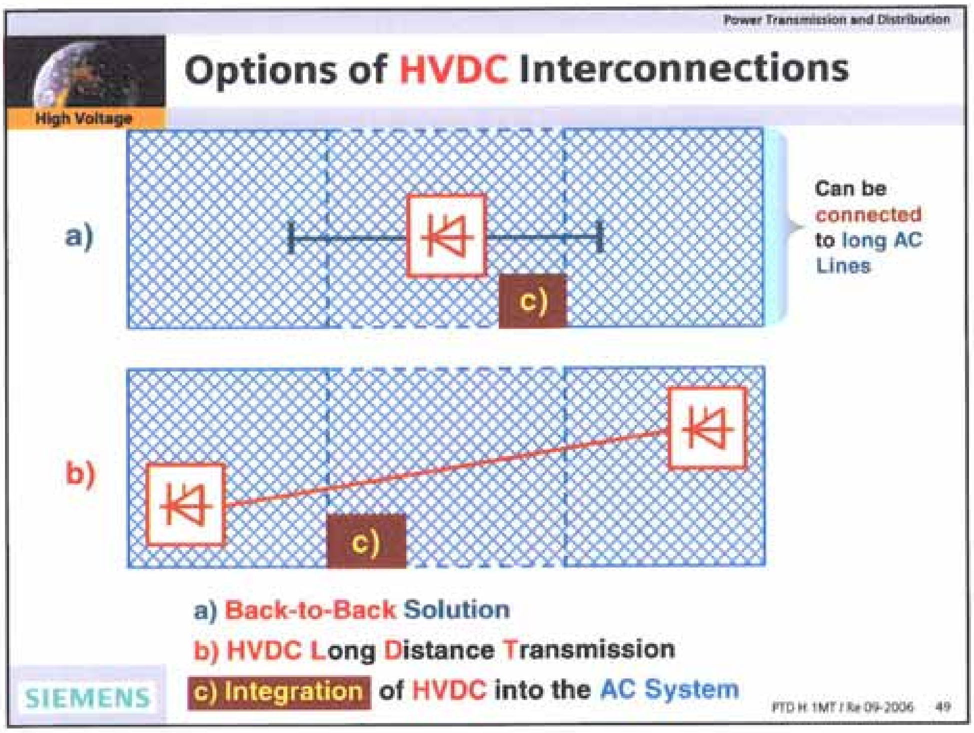

Power Transmission and Distribution
Tasks of Reactive Power Compensation
Power-Flow Control
C >
P ~ 1/X
L >
Series Compensation
X
Section of a Transmission Line
Voltage Control
V
C >
Parallel Compensation
L >
V
SIEMENS
PTD H 1MT / Re 09-2006 44


Power Transmission and Distribution
500 kV TCSC Serra da Mesa, Furnas/Brazil – Essential for Transmission
Current Control
Impedance Control
Power Oscillation Damping (POD)
Mitigation of SSR (Option)
Up to 500 POD Operations per Day for saving the System Stability
A System Outage of 24 hrs would cost 840,000 US$ *
* 25 US$/MWh x 1400 MW x 24 hrs
1999
Benefits:
o Increase of Transmission Capacity
o Improvement of System Stability
> + 60 ° C
up to 85 °
SIEMENS
PTD H 1MT / Re 09-2006 45

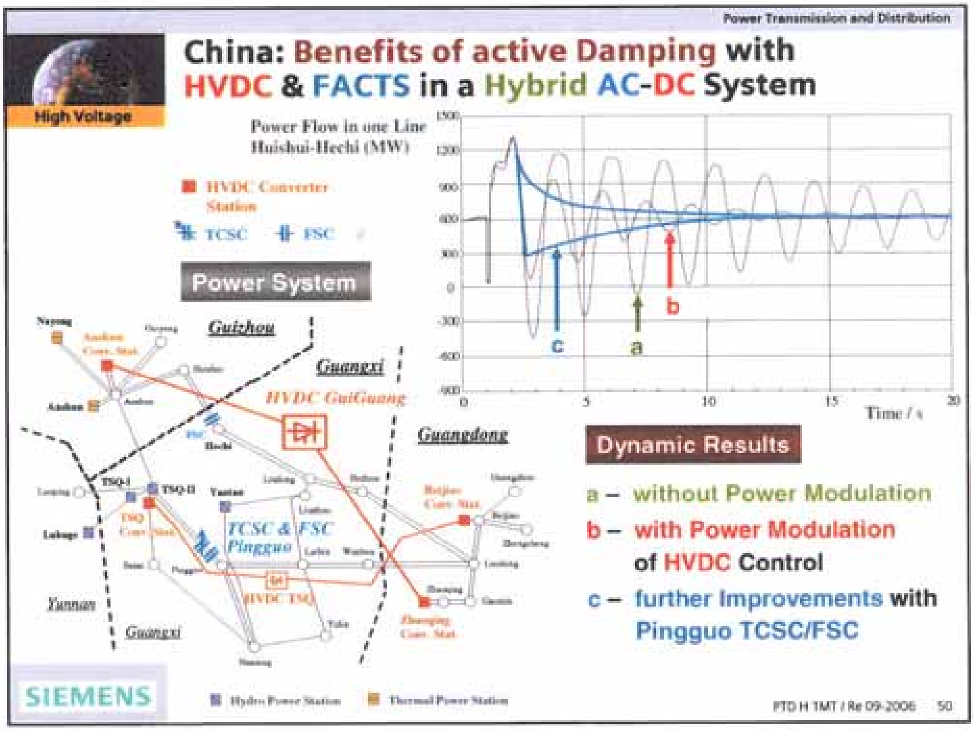

Power Transmission and Distribution
Europe: UK goes ahead with FACTS - 27 SVCs
Example Harker Substation - 2 parallel SVCs
275 kV, 50 Hz
SN= 150 MVA
14 kV
TCR 115 MVAr
TSC 110 MVAr
Filter 40 MVAr
Single line diagram of one SVC
Control range: 75 MVAr ind.
150 MVAr cap.
1993
SIEMENS
Deregulation caused Transmission Problems
PTD H 1MT / Re 09-2006 46


Power Transmission and Distribution
UK - Benefits of SVC
The Transmission System:
Results of Dynamic System Tests:
a) No SVC connected
b) Both SVCs in Voltage Control Mode
c) Both SVCs in Power Oscillation Damping Mode
Harker: 2 SVCs
Fully confirmed by Site Experience
Increase of Transmission Capacity
Prevention of Outages
Benefits
SIEMENS
Verified by Computer and Real-Time Simulation
PTD H 1MT / Re 09-2006 47


Power Transmission and Distribution
High Voltage
HVDC Control Features – for P and Q
Fault-Current Blocking
V1
V2
P
G ~
G ~
I1
I2
Q1
Q2
α and γ
L and C
L and C
Fast Functions
Slow Functions
Slow Functions
Fault-Current Blocking
SIEMENS
PTD H 1MT / Re 09-2006 48



Power Transmission and Distribution
High Voltage
Options of HVDC Interconnections
a)
b)
c)
c)
Can be connected to long AC Lines
a) Back-to-Back Solution
b) HVDC Long Distance Transmission
c) Integration of HVDC into the AC System
SIEMENS
PTD H 1MT / Re 09-2006 49



Power Transmission and Distribution
High Voltage
China: Benefits of active Damping with HVDC & FACTS in a Hybrid AC-DC System
Power Flow in one Line Huishui-Hechi (MW)
HVDC Converter Station
TCSC
FSC
Power System
Guizhou
Guangxi
HVDC GuiGuang
Guangdong
TCSC & FSC Pingguo
HVDC TSQ
Yunnan
Guangxi
Time / s
c
a
b
Dynamic Results
a – without Power Modulation
b – with Power Modulation of HVDC Control
c – further Improvements with Pingguo TCSC/FSC
Hydro Power Station
Thermal Power Station
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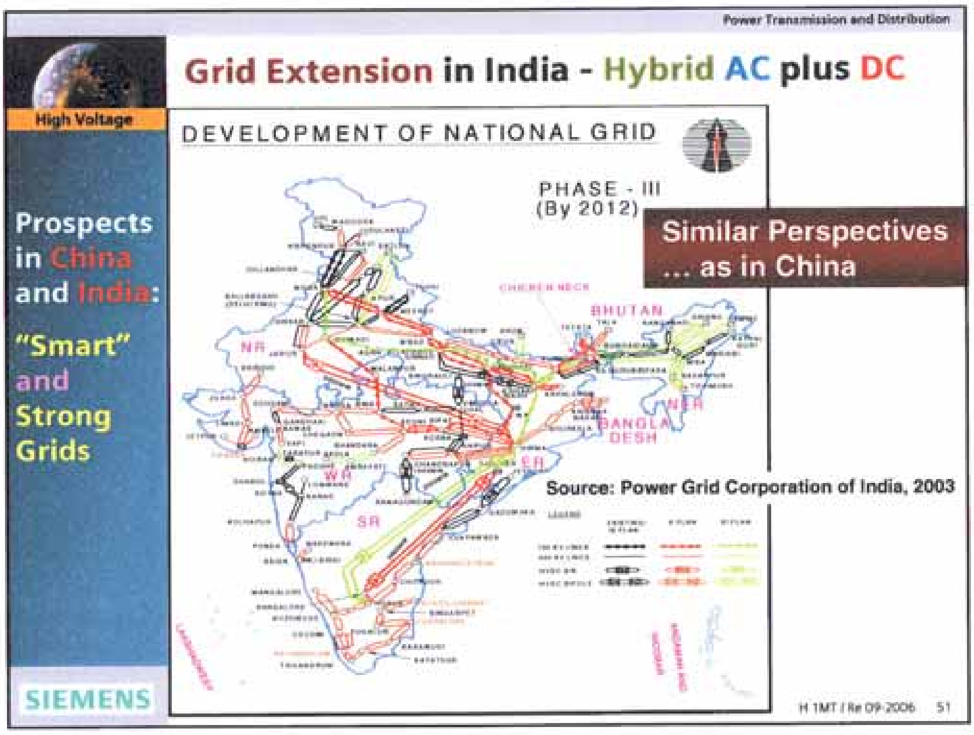
PTD H 1MT / Re 09-2006 50


Power Transmission and Distribution
High Voltage
Grid Extension in India - Hybrid AC plus DC
Prospects in China and India:
"Smart" and Strong Grids
DEVELOPMENT OF NATIONAL GRID
PHASE - III
(By 2012)
Similar Perspectives
... as in China
BHUTAN
NR
WR
SR
ER
NER
BANGLA DESH
Source: Power Grid Corporation of India, 2003
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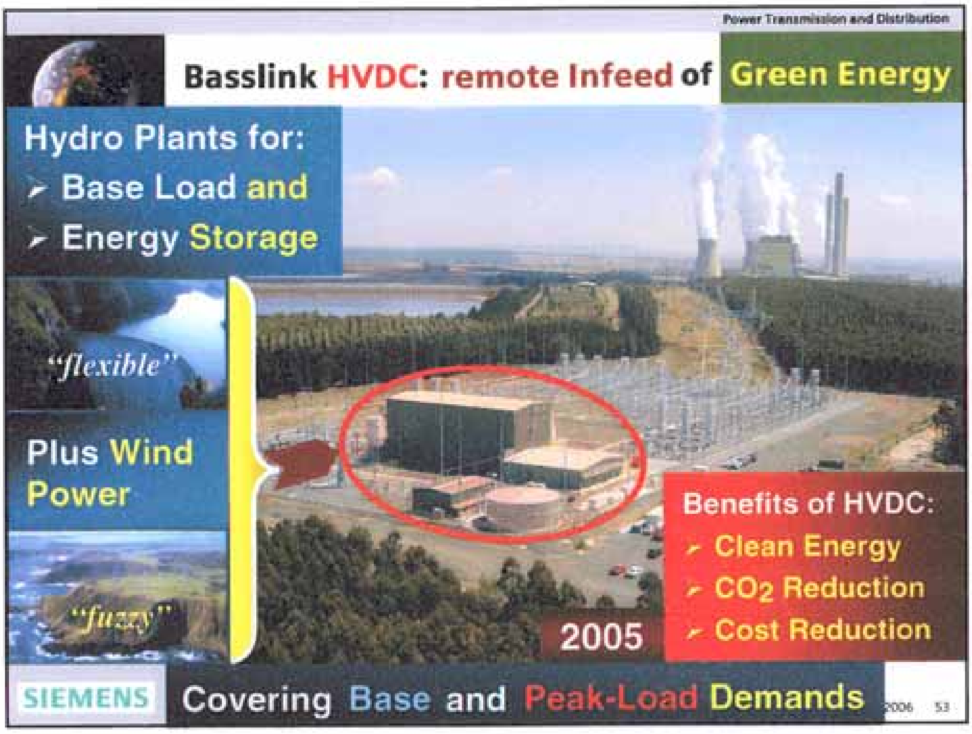
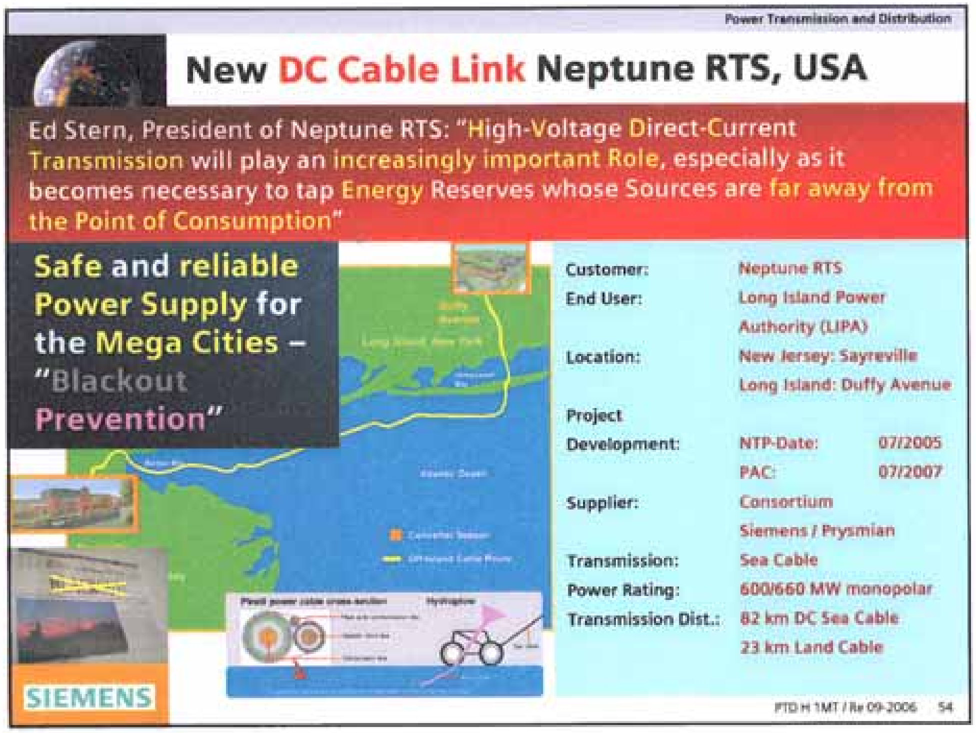
H 1MT / Re 09-2006 51


Power Transmission and Distribution
High Voltage
India: East-South HVDC Interconnector
2003
DC Station Kolar – close to Bangalore
SIEMENS
PTD H 1MT / Re 09-2006 52


Power Transmission and Distribution
Basslink HVDC: remote Infeed of Green Energy
Hydro Plants for:
Base Load and
Energy Storage
"flexible"
Plus Wind Power
"fuzzy"
2005
Benefits of HVDC:
Clean Energy
CO2 Reduction
Cost Reduction
SIEMENS
Covering Base and Peak-Load Demands
2006 53


Power Transmission and Distribution
New DC Cable Link Neptune RTS, USA
Ed Stern, President of Neptune RTS: "High-Voltage Direct-Current Transmission will play an increasingly important Role, especially as it becomes necessary to tap Energy Reserves whose Sources are far away from the Point of Consumption"
Safe and reliable Power Supply for the Mega Cities – "Blackout Prevention"
Customer: Neptune RTS
End User: Long Island Power Authority (LIPA)
Location: New Jersey: Sayreville
Long Island: Duffy Avenue
Project Development: NTP-Date: 07/2005
PAC: 07/2007
Supplier: Consortium Siemens / Prysmian
Transmission: Sea Cable
Power Rating: 600/660 MW monopolar
Transmission Dist.: 82 km DC Sea Cable
23 km Land Cable
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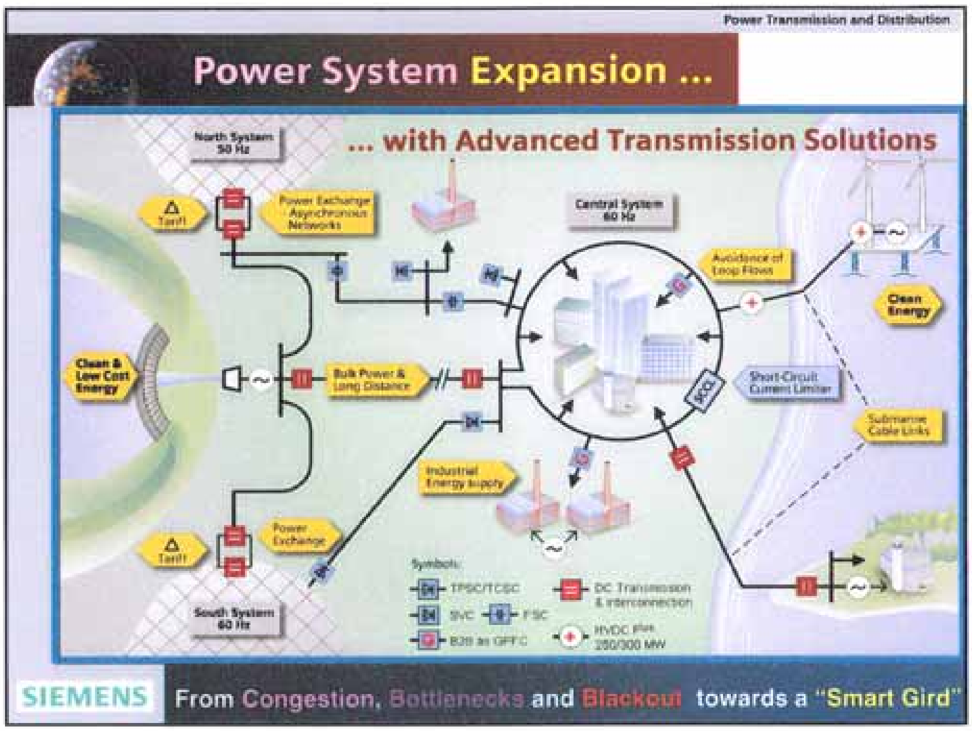
PTD H 1MT / Re 09-2006 54


Power Transmission and Distribution
Power System Expansion ...
... with Advanced Transmission Solutions
North System 50 Hz
Central System 60 Hz
South System 60 Hz
Tariff
Power Exchange Asynchronous Networks
Clean & Low Cost Energy
Bulk Power & Long Distance
Avoidance of Loop Flows
Clean Energy
Short-Circuit Current Limiter
SCCL
Submarine Cable Links
Industrial Energy supply
Tariff
Power Exchange
Symbols:
TPSC/TCSC
SVC
FSC
B2B as GPFC
DC Transmission & interconnection
HVDC plus 250/300 MW
SIEMENS
From Congestion, Bottlenecks and Blackout towards a "Smart Gird"

The Enhancing Energy Security and Mitigating Fossil Risk: The Role of Renewables

Shimon Awerbuch, Ph.D.
Energy Economics and Finance
www.awerbuch.com

SPRU Energy Group • University of Sussex
Brighton, UK

- ENERGIE 2050 -

Bundesministerium für Verkehr, Innovation und Technologie (BMVIT)
Bundesministerium für Wirtschaft und Arbeit (BMWA)
IEA

Vienna: 29-30 Nov 2006

Renewables Provide *Micro* and *Macro* Economic Benefits

- ***Micro*: Renewables *reduce* generating cost by mitigating financial risk**
  - e.g.: Risk of future fossil volatility
  - Individual investors can hedge, but not society
- ***Macro* Benefits- Energy Security: Oil/Gas volatility hurts GDP growth**
  - Cannot be effectively hedged
  - Renewables can *reduce* this risk

Macroeconomic Consequences of Fossil Price Risk: A major cost

- Fossil volatility hurts employment & GDP growth in oil consuming & producing nations
- Macroeconomic cost of 2000-04 oil spikes in EU: €400 Billion +/-
- Exceeds total estimated renewables investment needed to meet 2020 / 20% EU targets

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3

Market Risk Affects KWH Cost Estimates

- Risk affects *value* and economic *expectations*
- Engineering kWh cost estimates ignore risk
  - Have no economic interpretation
  - Should carry no weight in policy making

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How to Estimate Meaningful Risk-Adjusted kWh Generating Costs for Gas and Wind Over the Generating Asset's Life

- **Invite a large number of investors to submit *firm* 20-year price bids**
  – Binding- no adjustments, no re-openers, no discharge in bankruptcy
- **Assuming no collusion, these bids will represent a reasonably unbiased estimate of true kWh generating cost for each technology**

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5

Such an Experiment Would be Extremely Valuable

- **Meaningful KWH cost estimates must mimic bids investors would submit when facing future cost risk**
- **Differs from engineering KWH cost estimates**
  -- Produce "rule-of-thumb" valuations that ignore risk differentials (and taxes)
- **Fossil prices vary *systematically* – non-diversifiable risk**
  - Costs of passive/capital-intensive renewables are systematically riskless
  - Mimic Financial properties of US Treasury obligations

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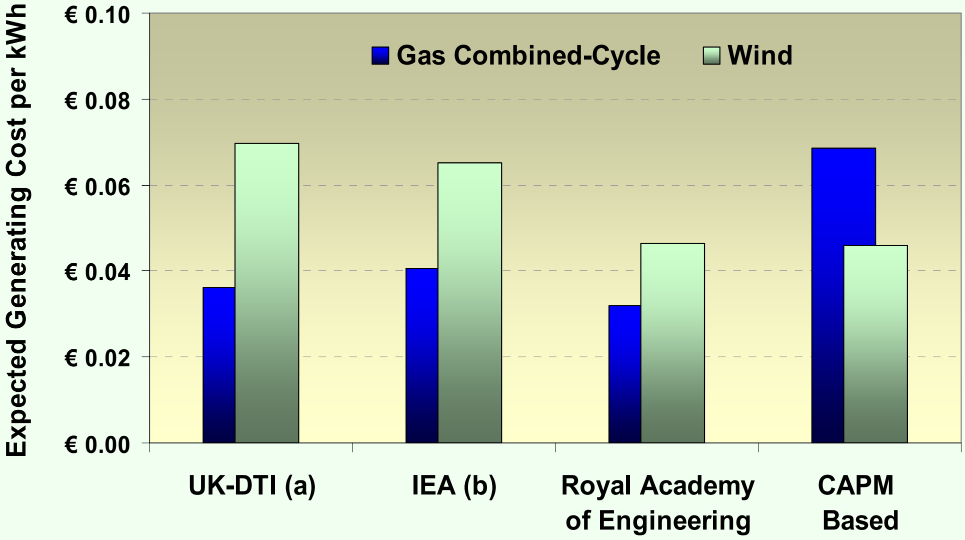
Engineering Versus Finance (CAPM) Based Generating Cost Estimates - 2005



(a) Adjusted for inflation
(b) Average of 23 planned gas and 19 planned wind projects

Source: S. Awerbuch, *Renewable Energy World*, 2006

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7

Policymakers: Take a Cue From Financial Investors

- **Are used to dealing with risk**
- **Hold efficient, diversified, balanced portfolios**
- **Is gas cheaper than RE?….. it matters little**
  - Even if true, picture could change dramatically
  - RE *reduces* portfolio cost-risk– even if it costs more
- **RE question not _if_ – but only _how much_**
  - Relative cost dictates make-up of optimized mix

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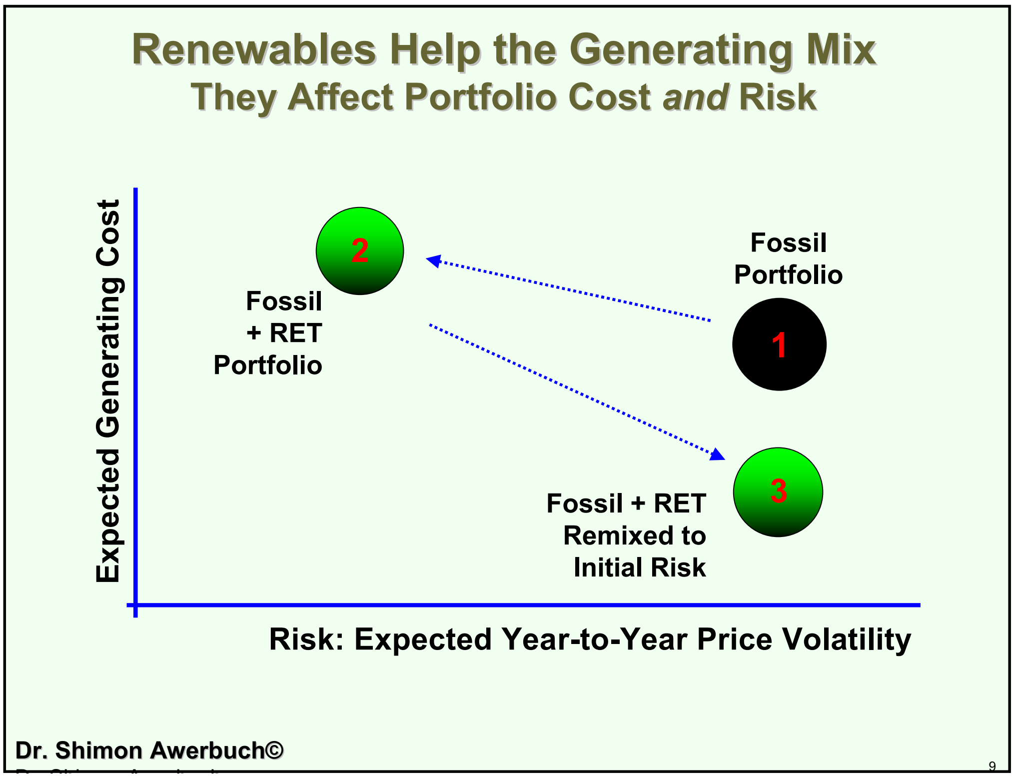
Renewables Help the Generating Mix
They Affect Portfolio Cost *and* Risk
Expected Generating Cost
2
Fossil
+ RET
Portfolio
Fossil
Portfolio
1
3
Fossil + RET
Remixed to
Initial Risk
Risk: Expected Year-to-Year Price Volatility
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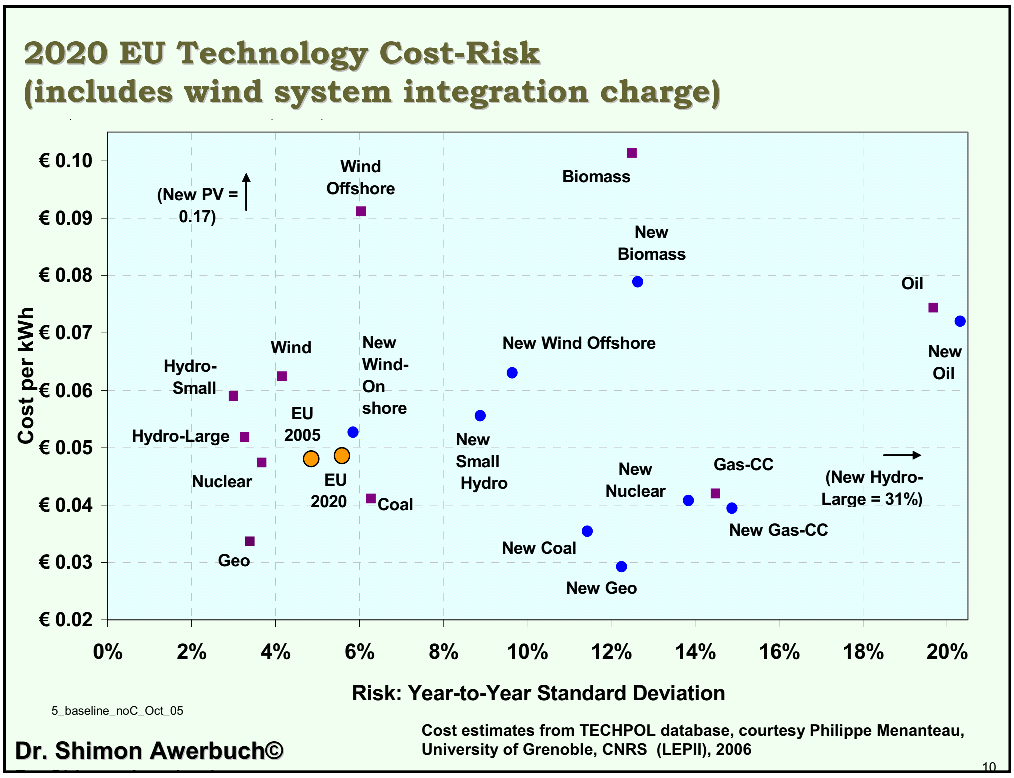
9


2020 EU Technology Cost-Risk
(includes wind system integration charge)
Cost per kWh
€ 0.10
€ 0.09
€ 0.08
€ 0.07
€ 0.06
€ 0.05
€ 0.04
€ 0.03
€ 0.02
0%
2%
4%
6%
8%
10%
12%
14%
16%
18%
20%
Risk: Year-to-Year Standard Deviation
(New PV = 0.17)
Wind Offshore
Biomass
New Biomass
Oil
New Oil
Wind
New Wind-On shore
New Wind Offshore
Hydro-Small
Hydro-Large
EU 2005
EU 2020
Nuclear
Coal
Geo
New Small Hydro
New Nuclear
Gas-CC
New Gas-CC
(New Hydro-Large = 31%)
New Coal
New Geo
5_baseline_noC_Oct_05
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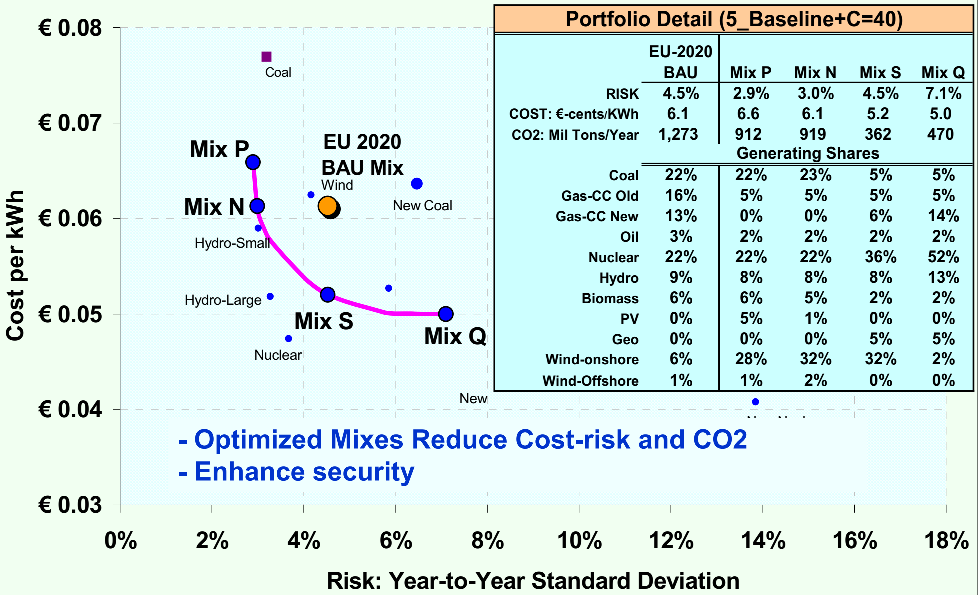
Cost estimates from TECHPOL database, courtesy Philippe Menanteau, University of Grenoble, CNRS (LEPII), 2006
10

Minimally Constrained EU 'Baseline' Optimized Results



Portfolio Detail (5_Baseline+C=40)

	EU-2020 BAU	Mix P	Mix N	Mix S	Mix Q
RISK	4.5%	2.9%	3.0%	4.5%	7.1%
COST: €-cents/KWh	6.1	6.6	6.1	5.2	5.0
CO2: Mil Tons/Year	1,273	912	919	362	470
		Generating Shares			
Coal	22%	22%	23%	5%	5%
Gas-CC Old	16%	5%	5%	5%	5%
Gas-CC New	13%	0%	0%	6%	14%
Oil	3%	2%	2%	2%	2%
Nuclear	22%	22%	22%	36%	52%
Hydro	9%	8%	8%	8%	13%
Biomass	6%	6%	5%	2%	2%
PV	0%	5%	1%	0%	0%
Geo	0%	0%	0%	5%	5%
Wind-onshore	6%	28%	32%	32%	2%
Wind-Offshore	1%	1%	2%	0%	0%

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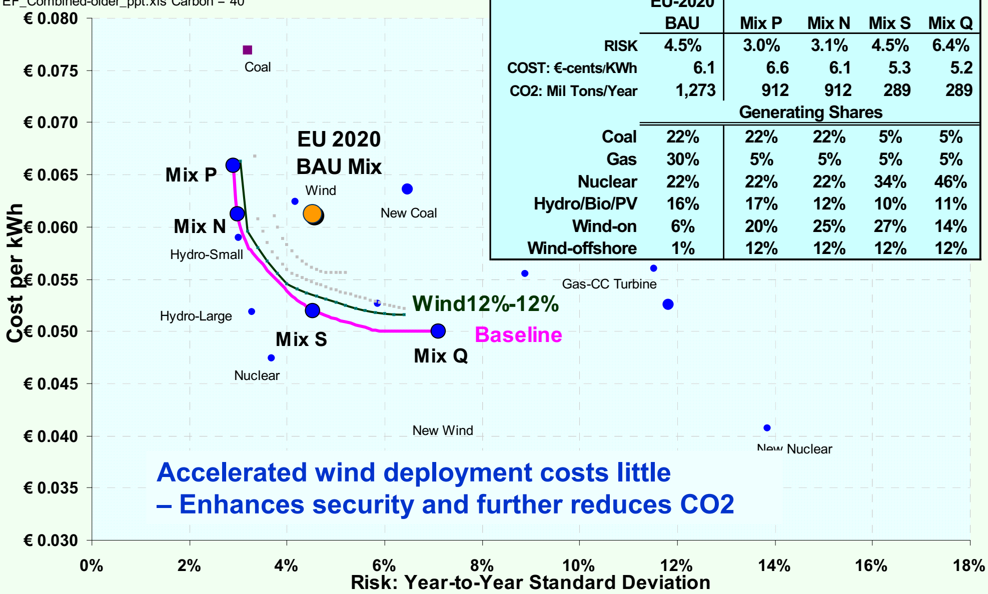
Accelerated Wind '12-12' Deployment

EF_Combined-older_ppt.xls Carbon = 40



Portfolio Details - Wind 12-12

	EU-2020 BAU	Mix P	Mix N	Mix S	Mix Q
RISK	4.5%	3.0%	3.1%	4.5%	6.4%
COST: €-cents/KWh	6.1	6.6	6.1	5.3	5.2
CO2: Mil Tons/Year	1,273	912	912	289	289
		Generating Shares			
Coal	22%	22%	22%	5%	5%
Gas	30%	5%	5%	5%	5%
Nuclear	22%	22%	22%	34%	46%
Hydro/Bio/PV	16%	17%	12%	10%	11%
Wind-on	6%	20%	25%	27%	14%
Wind-offshore	1%	12%	12%	12%	12%

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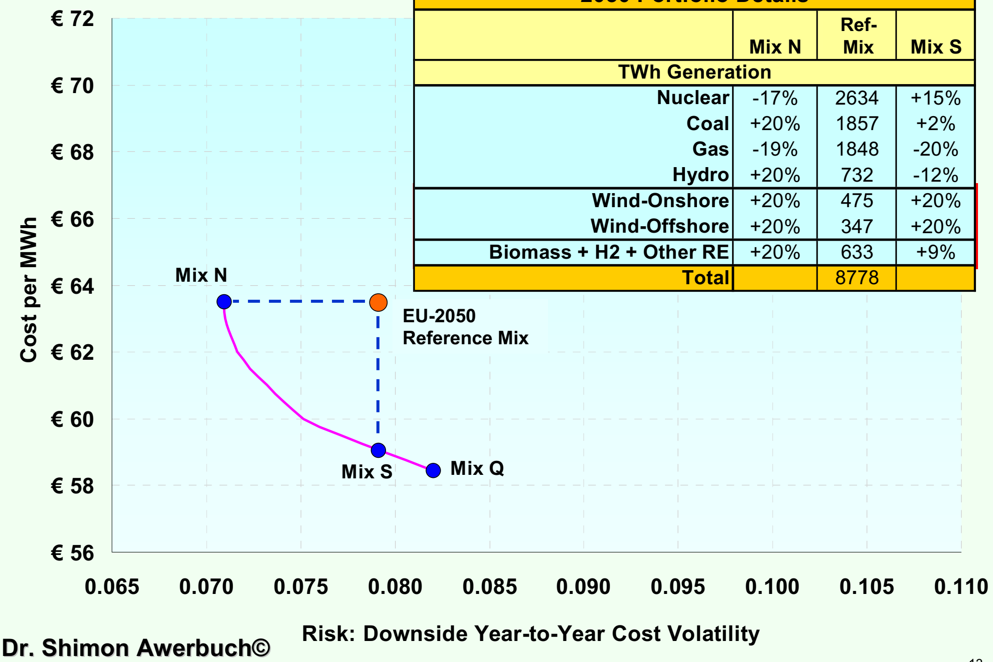
EU-2050 Reference and Optimized Mixes



2050 Portfolio Details	Mix N	Ref-Mix	Mix S
TWh Generation			
Nuclear	-17%	2634	+15%
Coal	+20%	1857	+2%
Gas	-19%	1848	-20%
Hydro	+20%	732	-12%
Wind-Onshore	+20%	475	+20%
Wind-Offshore	+20%	347	+20%
Biomass + H2 + Other RE	+20%	633	+9%
Total		8778	

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Mean-Variance Risk vs. *Uncertainty* & *Ignorance*

Knowledge About Likelihoods & Outcomes and the Resulting Type and Degree of Incertitude

KNOWLEDGE ABOUT LIKELIHOODS	KNOWLEDGE ABOUT OUTCOMES: Well-Defined Outcomes	KNOWLEDGE ABOUT OUTCOMES: Poorly-Defined Outcomes
	DEGREE/TYPE OF INCERTITUDE	
Some Basis for Probabilities	Risk	Ambiguity
No Basis for Probabilities	Uncertainty	Ignorance

Based on: Andy Stirling, 2003

- **Mean-variance portfolio optimization manages *Risk***
- **Portfolio *Diversity* Hedges *Uncertainty* & *Surprise***
  - Diversity = Euclidean distance of disparity attributes

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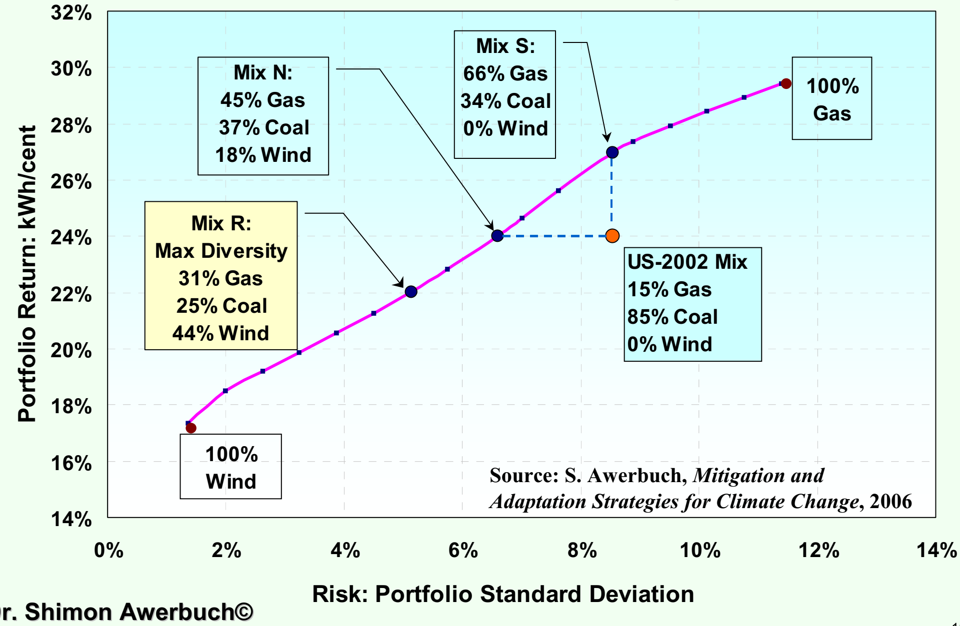
Diversity Vs. Mean-Variance

Risk-Return and *Diversity* for Illustrative US Generating Mix



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Energy Security: A Powerful Joint Benefit of Optimized Generating Mixes

- **Energy security concerns focus on catastrophic supply interruptions**
- **Exposure to fossil volatility: more powerful *market-based* security concept**
- ***Optimized* generating mixes:**
  - Minimize generating cost
  - Minimize exposure to Oil/Gas-GDP induced macro-economic losses
- **Energy Security costs *less***
  - Like *quality* in manufacturing

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Where markets do not function

- **Renewables Investors cannot capture risk-mitigation benefits they provide for generating portfolio**
  - Leads to *under*-investment in RE relative to optimal societal levels
- **Gas investors in many countries have sufficient market power to externalize fuel risk to consumers**
  - Creates *over*-investment in gas relative to optimal societal levels
- **These imperfections arguably create economic basis for publicly supporting renewables**

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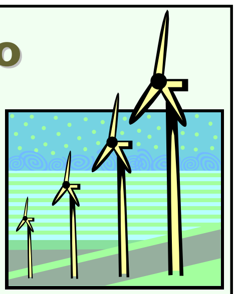
Why Integrate Renewables into European Power Networks?



- **Promote EU energy security / diversity**
  - Mitigate Oil-GDP Losses
  - Provide *Counter-cyclical* Benefits
    - "National insurance" (R.C. Lind-J.K.Arrow, 1984)
- **Create Sizeable Portfolio Benefits**
  - *Reduce* overall generating cost and risk
- **Reduce Market Power**
  - Help open markets & unlock promised benefits of liberalization

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18

wallner schauer

Entwicklung von Zukunftsbildern `Energie 2050' – Großgruppenarbeit mit Akteuren aus Forschung und Entwicklung

Am zweiten Tag der ENERGIE 2050 Konferenz - **Sichere Energieversorgung – Strategien und Technologien für die Zukunft** – wird den TeilnehmerInnen ein interaktiver Kommunikationsraum angeboten. Mit der Großgruppenkonferenz-Methode „World Café" können AkteurInnen ihre Ideen und Beiträge zur Energiezukunft einbringen, diskutieren und intensiv vernetzen. Zahlreiche kleine Gruppen von 8 bis 10 Personen arbeiten gemeinsam „all-in-one-room" an visionären Zukunftsbildern für das Programm Energie 2050. Aus den verschiedenen Zukunftsbildern werden erste Skizzen für Umsetzungspfade erarbeitet. Die Ergebnisse dieses partizipativen Prozesses werden in die weitere Entwicklung des Programms „ENERGIE 2050" aufgenommen.

Die Konferenz ENERGIE 2050 bietet neben der traditionellen Weise der Konferenzgestaltung mit Vorträgen und Podiumsdiskussionen auch einen zweiten, interaktiven Teil. Die Grundannahmen dabei lauten:

- Menschen wollen in Entwicklungsprozesse stärker einbezogen werden und ihre Ideen einbringen.
- Die gelebte Partizipation setzt komplexe und netzwerkartige Organisationsformen in der Konferenz voraus, die ein Setting in Kleingruppen erfordern.
- Die Form der Kommunikation muss hierarchiefrei und stark vernetzt sein.
- Das World Café entspricht den neuen Anforderungen an Kommunikation.

Das World Café, wie es am zweiten Tag von ENERGIE 2050 eingesetzt wird, ist ein Dialog, um das Wissen und die Intelligenz vieler Menschen für das komplexe Thema der Energiezukunft zu nutzen. Die Methode World Café eignet sich besonders für die komplexen Fragestellungen zu Entwicklungen der Zukunft, wo sehr unterschiedliche Ideen und Vorstellungen aufeinander treffen. In der gemeinsamen Arbeit im World Café kann zunächst das Bewusstsein für das Thema geschärft werden. In einer angenehmen und inspirierenden Atmosphäre können mutige Ideen zusammenfinden und sich wechselseitig stärken. *„Es ist die unglaubliche Vielfalt der Perspektiven der Menschen, die mich fasziniert hat. Mein Bild zum Thema hat sich in den intensiven Diskussionen sehr gewandelt. Ich fühle mich bereichert und sehr motiviert! Schade, dass es nicht öfter Gelegenheiten gibt, in einer so dichten Atmosphäre gemeinsam zu arbeiten*", so eine Teilnehmerin am Sustainability Café 2005, in Wien.

Die neuen Energiestrategien können nur erfolgreich sein, wenn trotz aller wichtigen Unterschiede in den individuellen Vorstellungen der AkteurInnen, auch eine Basis für ein gemeinsames Verständnis geschaffen wird. Das World Café im Prozess ENERGIE 2050 wird einen ersten Schritt in diese Richtung gehen. Die VeranstalterInnen bitten um eine rege Teilnahme und freuen sich auf einen intensiven Tag und auf spannende Ideen.

"*The World Cafe is more than just a methodology bringing people together and to harness the collective knowing on a topic. It is also the means by which we can edge our way through the doorway into a brighter future.*" (www.theworldcafe.com).

Das World Café wird von Heinz Peter Wallner und Kurt Schauer, Wallner & Schauer GmbH (www.zukunftsberater.at) begleitet, moderiert und dokumentiert.

e 2050

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Ein Unternehmen der Austrian Research Centers.

ENERGIE 2050 – Eine Initiative des BMVIT

Verantwortung: Abteilung Energie- und Umwelttechnologien
Leitung: DI Michael Paula
A 1010 Wien, Renngasse 5

www.NachhaltigWirtschaften.at

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