# 2006
# ANNUAL CONFERENCE
# Rydges Southbank

A PRESENTATION BY

**Tom Quirk**

TO THE AUSTRALIAN ENVIRONMENT FOUNDATION ANNUAL CONFERENCE SEPTEMBER 23RD 2006

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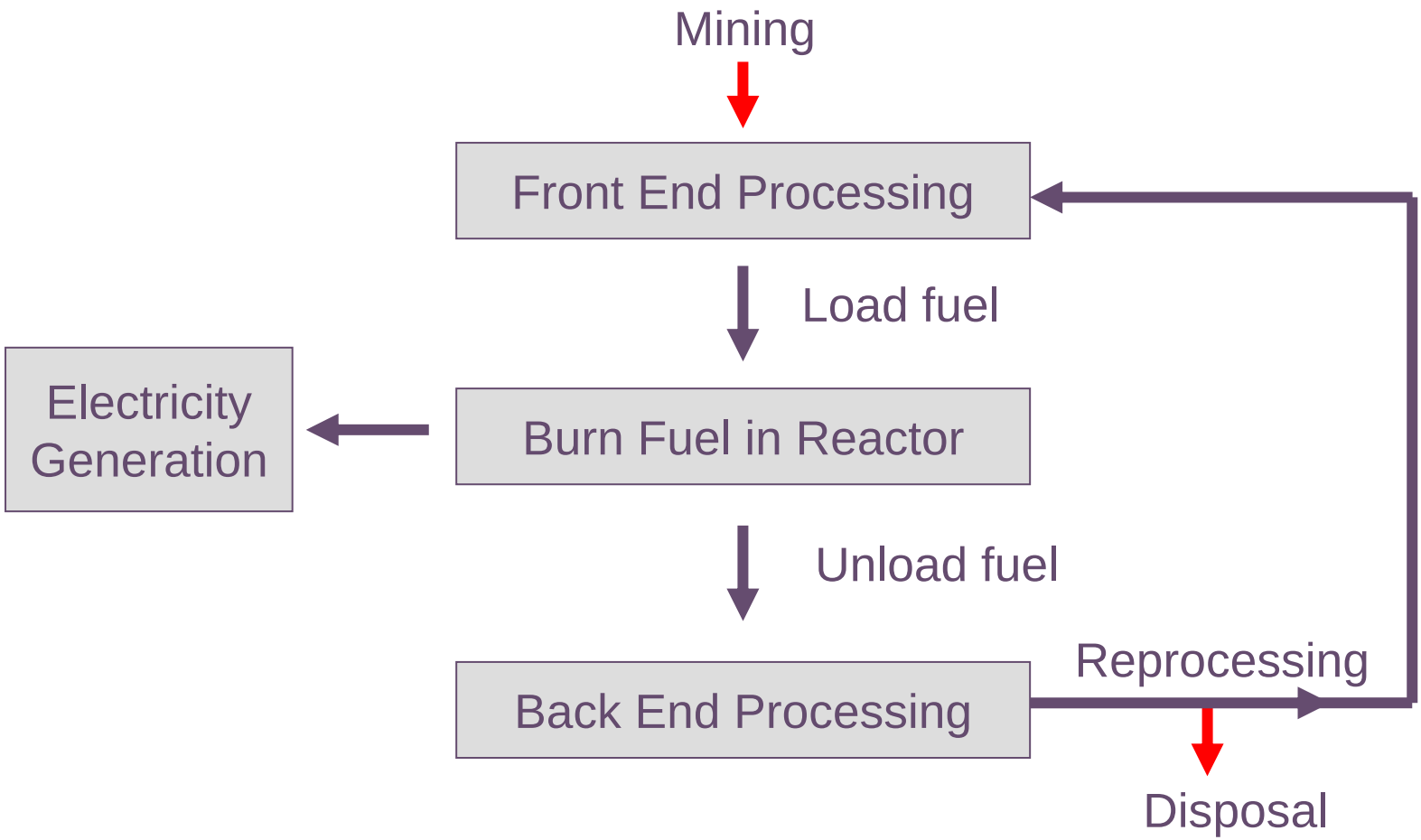
# Uranium: Birth to Death Cycle

"Everyone is entitled to their own opinion, but not their own facts"

Daniel Patrick Moynihan



# Mining

## Resources

- Australia possesses largest portion of presently known resources
- Resource availability determined by price
- Mines and deposits in Canada, Australia, Kazakhstan, Russia

## Demand

- Estimated to grow from 40,000t to 80,000t by 2030
- Small displacement by MOX (mixed oxide fuel)

## Regulation

- Local, federal and international
- Future policy

# Energy Exports for 2003-04

| Fuel | Volume | Energy in petajoule | | Value in millions | |
|---|---|---|---|---|---|
| Black coal | 218.4 Mt | 6,208 | 53% | $10,882 | 57% |
| Crude oil | 17,526 Ml | 679 | 6% | $5,055 | 26% |
| LPG | 2,916 Ml | 75 | 1% | $647 | 3% |
| LNG | 7.914 Mt | 431 | 4% | $2,174 | 11% |
| Uranium oxide | 9,099 t | 4,277 | 37% | $365 | 2% |
| **Total** | | **11,669** | **100%** | **$19,123** | **100%** |

Source: ABS Year Book Australia 2006

# Fuel Costs

~$US cost to get 1kg of Uranium as $UO_2$ reactor fuel in mid April 2006:

| Process | Amount Required | Unit Cost | Cost | Fraction of Total |
|---|---|---|---|---|
| **Front end fuel** | | | | |
| $U_3O_8$ | 8kg | $90 | $720 | 27% |
| conversion | 7kg U | $12 | $84 | 3% |
| enrichment | 4.8 SWU | $122 | $586 | 22% |
| fuel fabrication | kg | | $240 | 9% |
| **Total fuel in** | | | **$1,630** | **62%** |
| **Fuel Back End** | | | | |
| Reprocessing/disposal | kg | | **$1,000** | **38%** |
| **Total Fuel Cycle** | | | **$2,630** | **100%** |

**Fuel cost: $8.20 / MWh for front and back ends**

# Conversion and Enrichment

## Conversion*

- 5 major suppliers with 60,000t U capacity
- USA, Canada, France, UK, Russia
- Plants 6,000 to 12,000t capacity

## Enrichment*

- Technology: Diffusion, Centrifuge (Laser – Silex Systems)
- 6 primary suppliers with 50m SWU's capacity
- USA, France, Europe, (UK, GER, NL), Russia, Japan, China
- Demand met by modular expansion
- Regulation

## Fabrication

- Mostly linked to reactor suppliers

* Capacity for about 10,000t fuel

# Nuclear Power Generation

## Power station characteristics

| | |
|---|---|
| Large | 1,000 to 1,500 MWe station size<br>500 to 1.000 MW units |
| High Capital Cost | $2m to $3m per MW |
| Low Fuel Cost | $8/MWh front & back ends (10-20% of costs) |

## Base Load Station

Run 24 hours a day to maximise returns

## Integration into network

Optimum positions

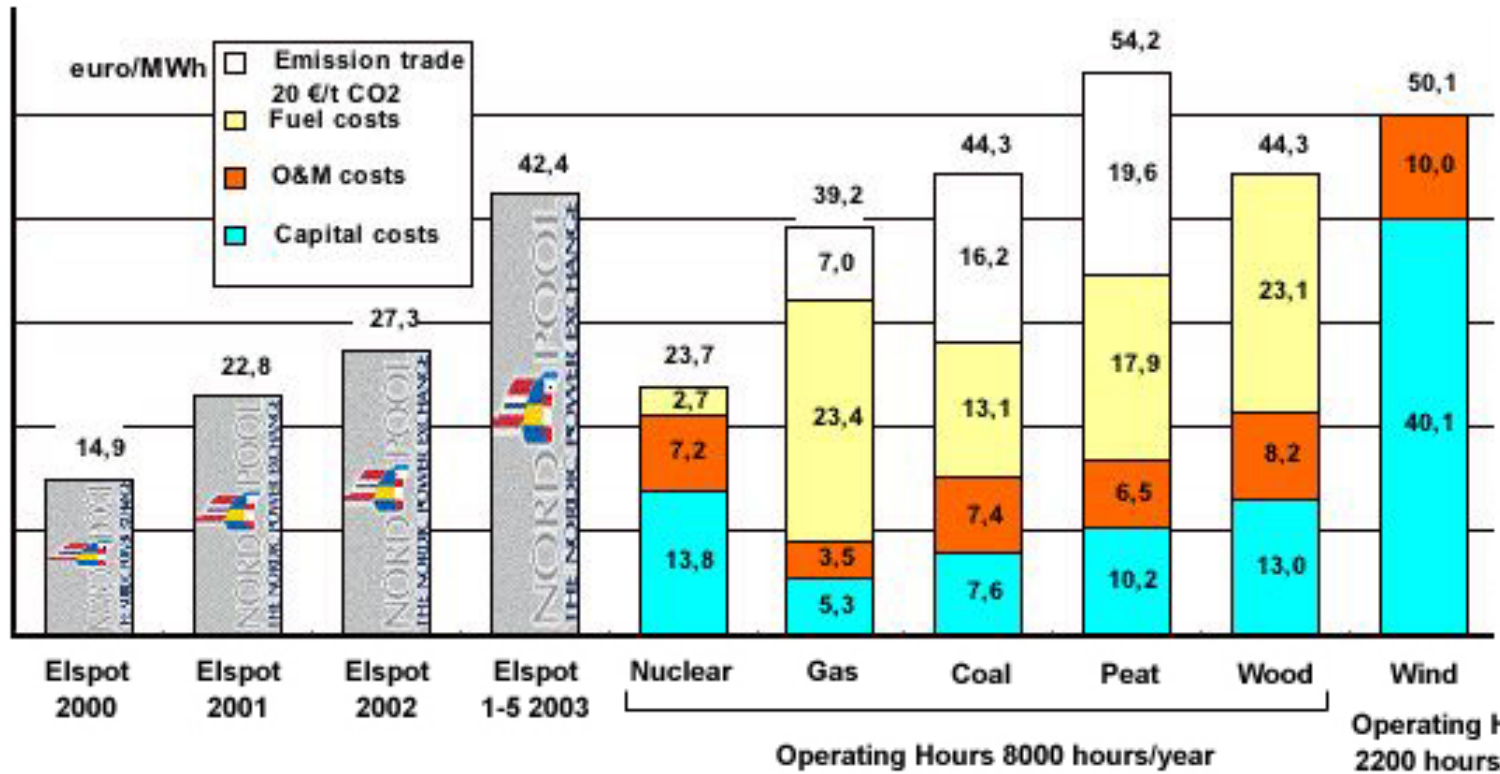
## Regulation

Siting and safety

## Co-products

Desalination

# Projected Electricity Prices – Finland 2003



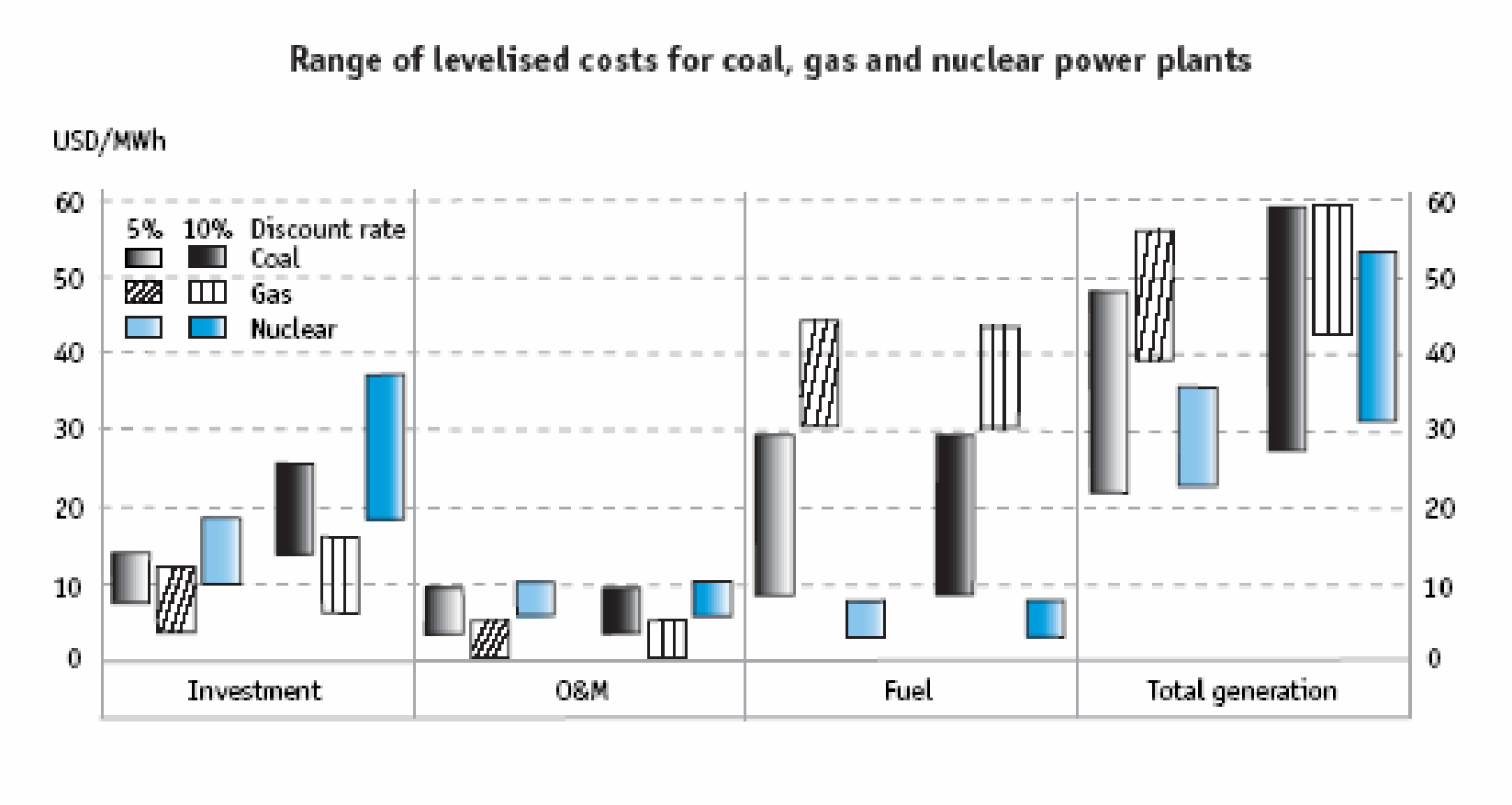

**Real Interest Rate 0.5%**

**March 2003 Prices**

R. Tarjanne & K. Luostarinen 03.07.2003
Lappeenranta University of Technology

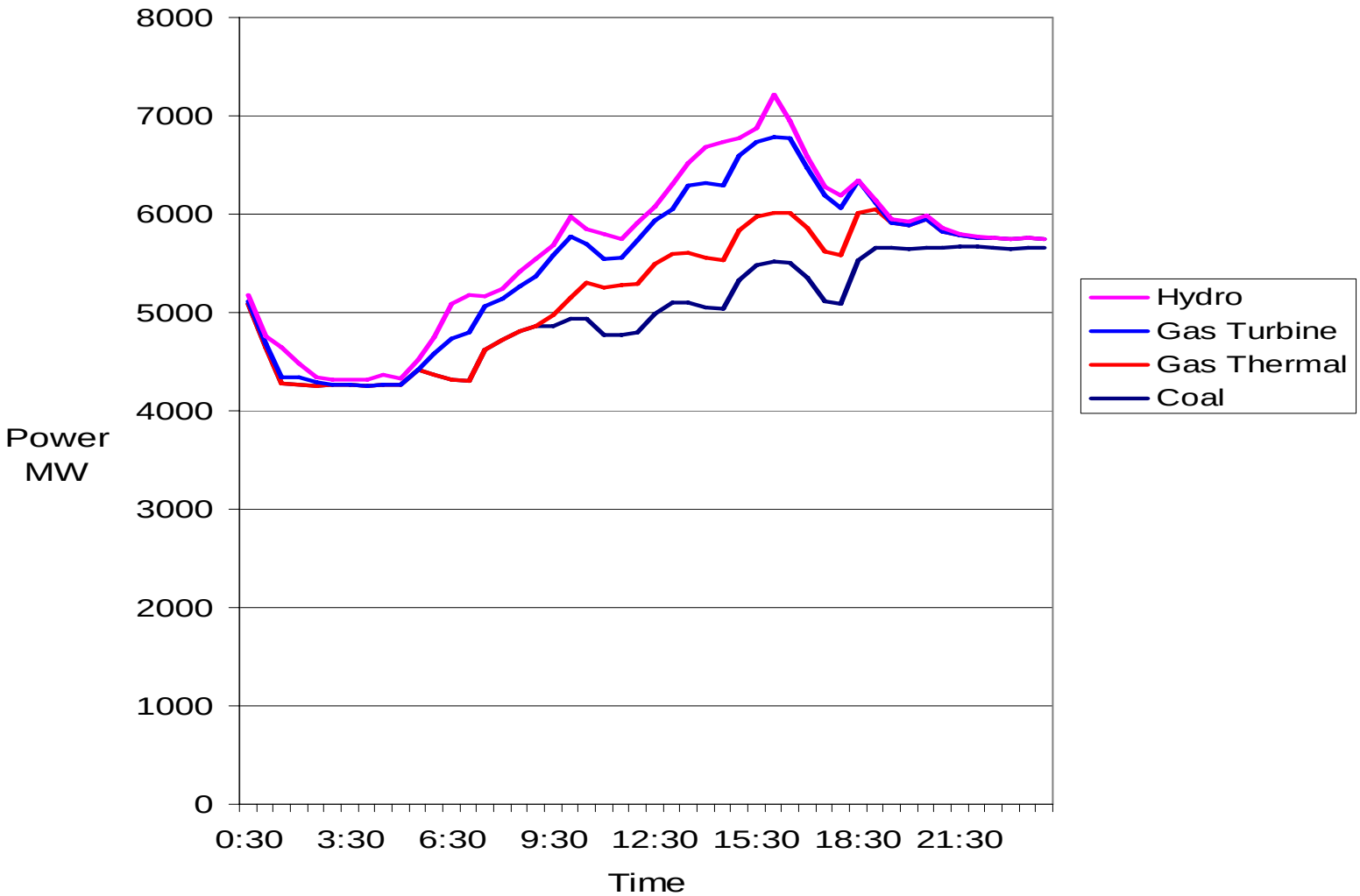
Generation Costs without investment subsidy and the return of electricity tax (wood and wind)

# OECD Projected Costs 2005



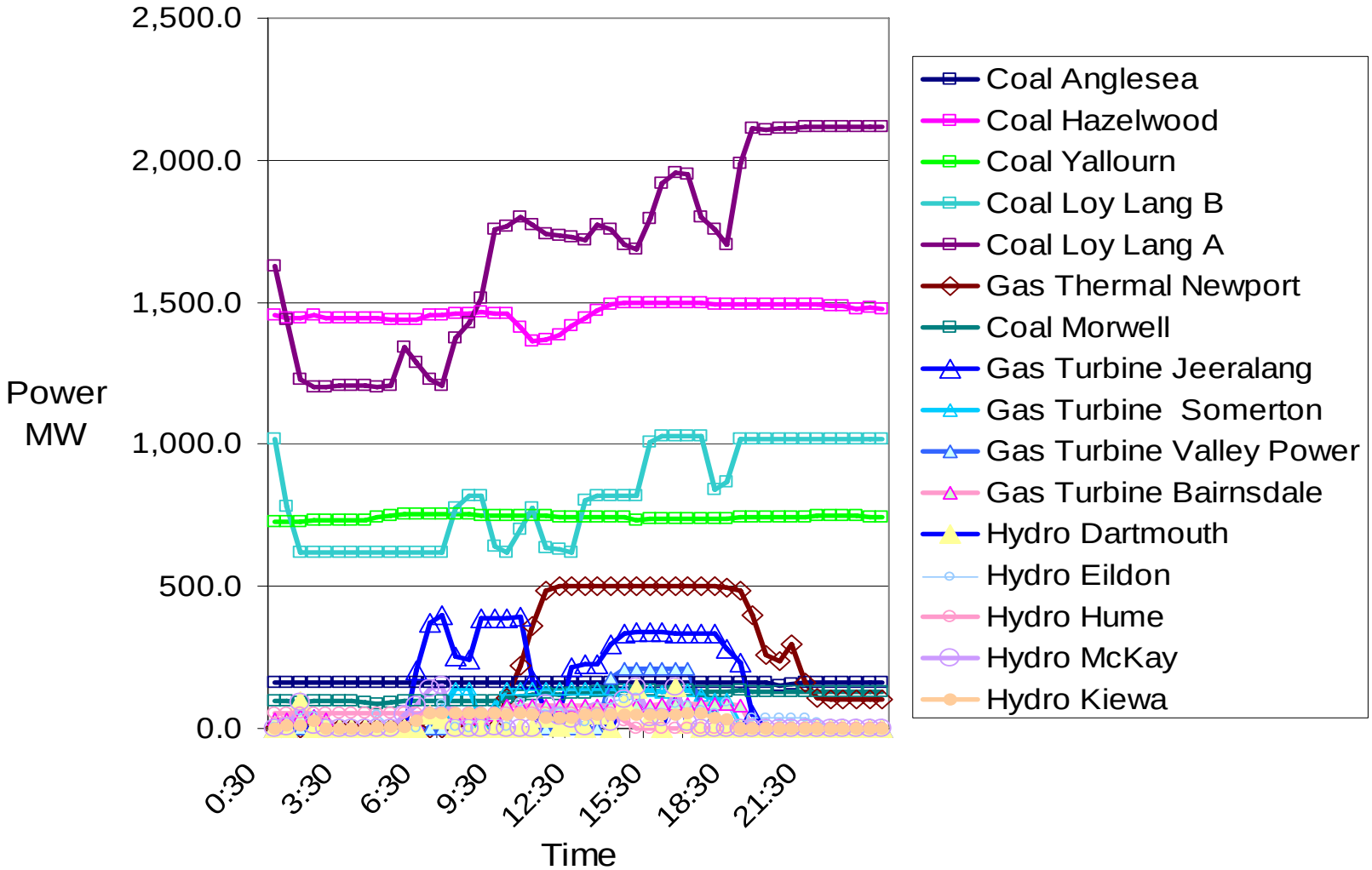
# 24 Hour Electricity Generation

Cumulative Victoria 23 January 2006

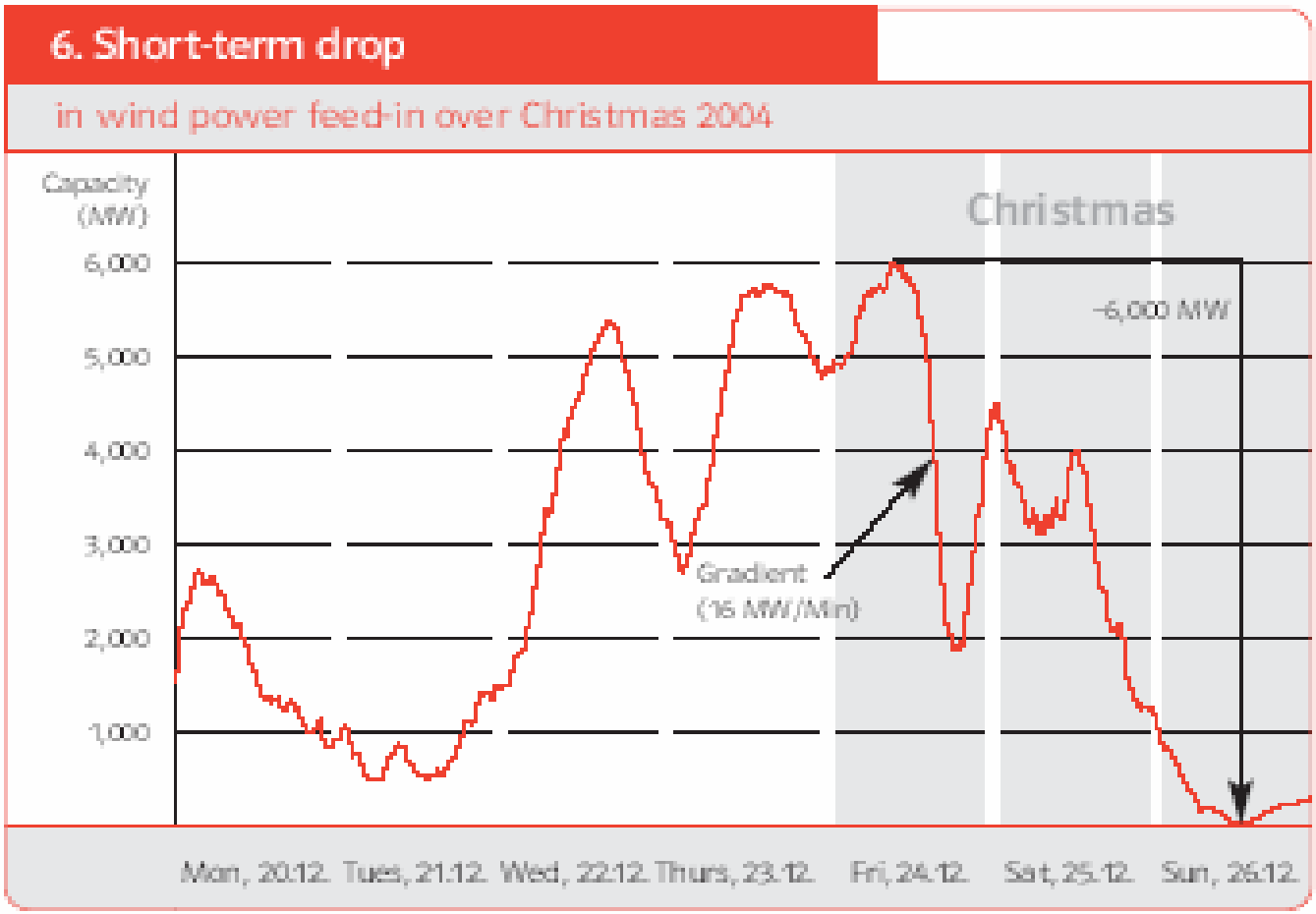


# 24 Hour Electricity Generation

Individual Power Stations Victoria 23 January 2006



# Wind Power Supply E.ON Netz 2005



# Reprocessing and Disposal

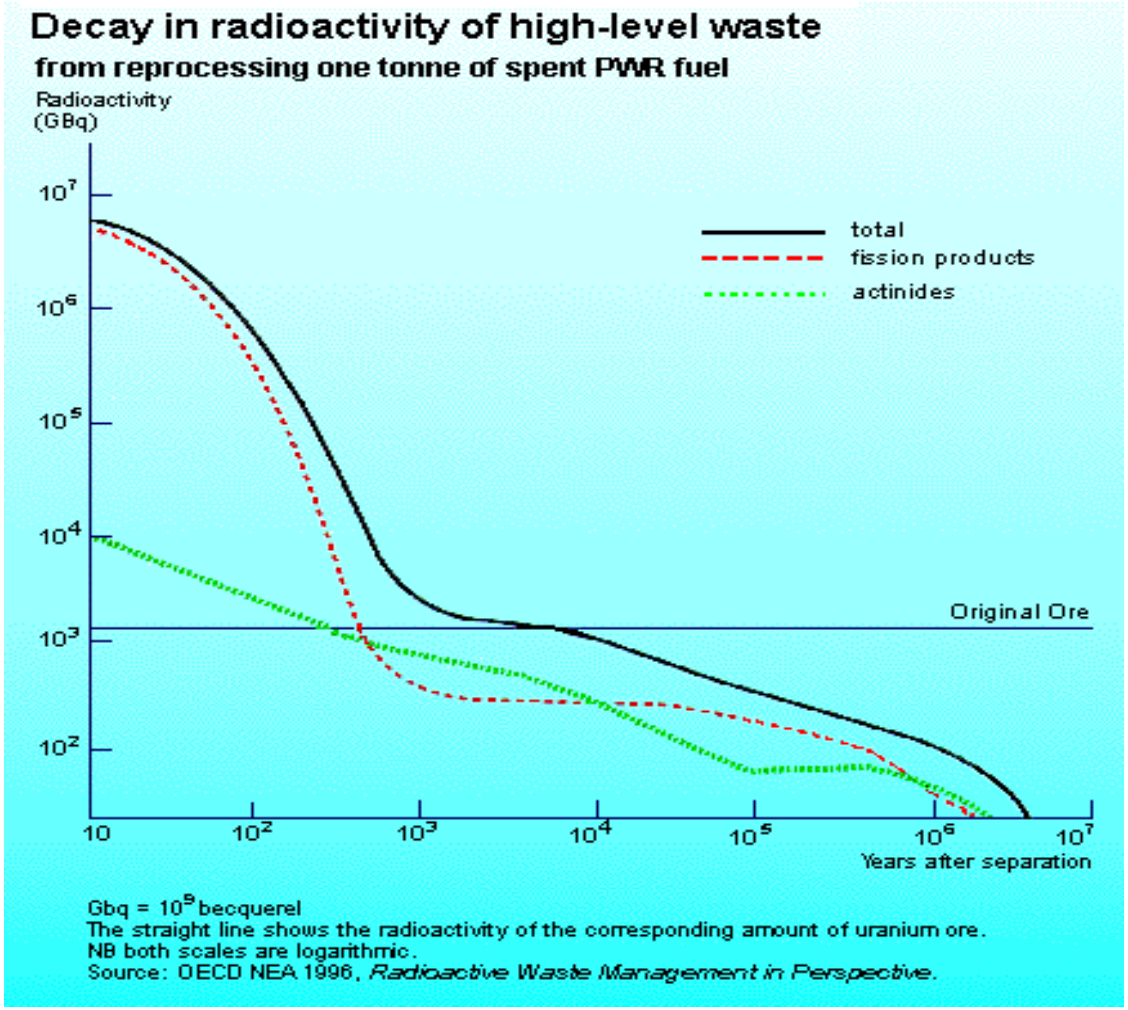
## Reprocessing

- Technology – Australian Synroc not in use (yet)
- Standard vitrified waste
- Plants in France and UK serve customers worldwide
- Customers take back waste and stripped fuel (for MOX)

## Disposal

- Deep geological burial preferred
- Europe (Finland, Sweden) and US repositories (Yucca Mountain)

# High Level Waste Radioactivity



# Capital Costs

| Stage | Plant capacity | Plant output | Capital Cost million | Revenue million | Asset intensity / $ sales |
|---|---|---|---|---|---|
| Conversion | 6,000t | 6,000t | $125 | $75 | 1.7 |
| Enrichment | 8,000,000 SWU | 1,500t | $2,750 | $900 | 3.1 |
| Fuel Fabrication | | | | | |
| Reprocessing | 1,500t | 1,500t | $3,300 | $1,500 | 2.2 |
| Disposal | 1,500t | | $2,700 | $1,500 | 1.8 |
| Power Station | 1,000 MW | 7,900 GWh | $2,500 | $315 | 7.9 |

# National and International Issues

Public Perception

- Three Mile Island
- Chernobyl
- Waste Disposal

Weapons proliferation

Contribution to international problems

Regulation in Australia

# Risk Mitigation

| Activity | Range of Costs per Fatality averted in $US | | | |
|---|---|---|---|---|
| **Medical screening and care** | Cancer screening | $20,000 | Kidney Dialysis | $400,000 |
| **Traffic safety** | Highway maintenance | $40,000 | Tyre inspection | $800,000 |
| **Miscellaneous** | Smoke alarms in homes | $500,000 | Coke fume hazards | $9,000,000 |
| **Very hazardous occupations** | Coal mining | $40,000,000 | Other Mining | $70,000,000 |
| **Radiation related activities** | X-Ray equipment | $7,200 | High level waste | $400,000,000 |

# Accident Rates

| | No. Immediate fatalities / GW year |
|---|---|
| Coal | 0.876 |
| Oil | 0.436 |
| Natural Gas | 0.093 |
| Hydro | 4.265 (0.561 excl Chinese dam collapse) |
| Nuclear | 0.006 |

## Thomas W. Quirk

**M.Sc., D.Phil., M.A. (Oxon), SMP (Harv.).**

Tom Quirk - 66, is a principal of Quirk Partners. He has interests in venture capital, fund raising and investment management as well as business advisory work.

He is Chairman of Virax Holdings, an immunotherapy based biotechnology company currently trialling a therapeutic AIDS vaccine. He was, until December 2004, chairman of the Victorian Rail Track Corporation, a $5 Billion Victorian State Government business managing the statewide third party rights and property opportunities of the rail and tram systems, rail depots, telecommunications and an advertising portfolio. He has been a director of Biota Holdings Ltd, which, in partnership with GlaxoSmithKline, has developed Relenza, an anti-influenza drug. He has served as deputy chairman of Peptech, a Sydney based biotech company with interests in monoclonal antibodies. Also he has been an independent director and deputy chairman of VENCorp, which is involved in the energy markets for electricity and gas. In addition, he is a director of a number of companies in areas that range from medical investment to publishing. He was a founding shareholder in Pangea, the internationally sponsored company for nuclear waste disposal.

Prior to 1987, he was Chief Consultant (General Manager) in the mining company, CRA and spent 1985 to 1986 seconded to work in the $70 m. venture capital fund run by James D. Wolfensohn in New York. He operated in the fund in the role of a general partner, initiating deals, setting terms and helping the management of investor companies. He was on the Board of Applied Electron in Albuquerque, New Mexico.

Between 1981 and 1985 he worked in a new business group in CRA that initiated business development before it was passed onto other management groups within the company. During this time he helped start CRA's involvement in Biotechnology Australia and initiated Nilcra, the high performance ceramic business.

He first joined CRA in 1978, working first at Bougainville Copper in New Guinea and then at CRA headquarters.

Prior to this, he spent 15 years in the U.K. and USA as an experimental research physicist, a University Lecturer and Fellow of three Oxford Colleges. During this time he worked in the United States with colleagues at Harvard and Chicago and in Europe at Geneva and Hamburg.

He is a member of the board of the Institute of Public Affairs.

He has been on the Council of the Museum of Modern Art in Oxford, chairman of two Oxford college arts committees, Chairman of the Australian Sculpture Triennial, Chairman of the Australian Centre for Contemporary Art and a member of Board of the Biennale of Sydney. He was Chairman of the Heide Museum of Modern Art during its first expansionary phase.

He has been a member of the Council and Board of Management of Trinity College, University of Melbourne and the Genomic Disorders Research Centre, a new research institution established at St Vincent's Hospital. He is a member of the Industrial Advisory Group to the Dean of Science at the University of Melbourne.

Tom Quirk has an SMP degree from the Harvard Business School, Master of Science from the University of Melbourne and Master of Arts and Doctor of Philosophy from the University of Oxford.

He was awarded the Commonwealth Centenary Medal in 2002.