Electricity Market Liberalisation in Advanced Developing Countries

An Alternative Approach

*Oxford Energy Seminar*

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*Dr John Bower*
Overview

Standard Liberalisation Model

Why SLM Fails

An Alternative ADC Model
Indian state owned power sector is jeopardising the industrial development of India

**ELECTRICITY AS A DEVELOPMENT PROBLEM**

- Around 2 billion people without electricity worldwide (500,000 million in India)
- Enhance productivity and competitiveness
- Enable education
- Improve water supplies & health

**BUT...**

- Require $200 billion new capital to provide just 100W to each person

**Standard Liberalisation Model**
Standard Liberalisation Model

India features the key issues facing many Advanced Developing Countries (ADCs)

INDIAN ELECTRICITY SECTOR PROBLEMS

- Market Structure: Inefficiency & Over-employment
- Tariff Policy: Subsidised agriculture/household and high industrial tariffs
- Grid Stability: Many regional transmission failures
- T&D losses: 20% technical and 30% non-technical (theft) in some states
- Financial: SEBs bankrupt and losing $9 billion p.a.
- Power Shortages: Rapid demand growth and peak loads not being met
Begun a 3 year study to look at alternatives to Standard Liberalisation Model (SLM)

GUJARAT PROJECT

- “100% electrification”
- 46% of rural houses have no service
- Per capita consumption p.a. = 834 kWh (354 kWh all India and 9859 kWh in USA)
Standard Liberalisation Model

Liberalisation means wholesale / retail markets replace government control and ....

STRUCTURE OF A LIBERALISED ELECTRICITY MARKET
Standard Liberalisation Model

.... in theory new entrants and increased efficiency should reduce consumer prices....

IMPACT OF LIBERALISATION IN ENGLAND & WALES 1990 - 2003

Oligopoly

Generators

-14%

Monopoly

RPI-X

Transmission

WHOLESALE MARKET

Competitive

Suppliers

0% / -17%

Monopoly

RPI-X

Consumers

RETAIL MARKET

Distribution

Physical Electricity Flow

Contract Flow
Standard Liberalisation Model

.... but this outcome is not guaranteed if firms can exercise market power …

ELECTRICITY MARKET PRICES IN ENGLAND & WALES 1990 - 2003

Source: OIES estimates based on E&W Pool, UKPX, DTI data

John Bower

Electricity Market Liberalisation in ADC: An Alternative Solution
Why SLM Fails

SLM will tend to fail (even in OECD countries) if critical success factors missing

**SLM SUCCESS FACTORS**

**ELECTROMECHANICAL**

1. Large system > 5 GW available generation capacity
2. Peak demand 15% < available generation capacity
3. Fully interconnected, reliable, and ‘overbuilt’ transmission and distribution system

**SOCIOPOLITICAL**

1. Existing retail prices must be above competitive future (unsubsidised) prices
2. Acceptance of less state control in energy and break-up of ‘national champions’
3. Separation of ‘social good’ from ‘economic input’ aspects
Why SLM Fails

Only 50-60 countries are big enough for SLM ….

COUNTRY RANKING OF INSTALLED GENERATION CAPACITY (GW)

<table>
<thead>
<tr>
<th></th>
<th>Country</th>
<th>Capacity (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>United States</td>
<td>812.7</td>
</tr>
<tr>
<td>2</td>
<td>China</td>
<td>329.9</td>
</tr>
<tr>
<td>3</td>
<td>Japan</td>
<td>234.5</td>
</tr>
<tr>
<td>4</td>
<td>Russia</td>
<td>204.2</td>
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<tr>
<td>5</td>
<td>Germany</td>
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<td>6</td>
<td>India</td>
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</tr>
<tr>
<td>7</td>
<td>France</td>
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<td>8</td>
<td>Canada</td>
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<tr>
<td>9</td>
<td>United Kingdom</td>
<td>76.3</td>
</tr>
<tr>
<td>10</td>
<td>Brazil</td>
<td>73.4</td>
</tr>
<tr>
<td>11</td>
<td>Italy</td>
<td>68.5</td>
</tr>
<tr>
<td>12</td>
<td>Ukraine</td>
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<tr>
<td>21</td>
<td>Taiwan</td>
<td>29.6</td>
</tr>
<tr>
<td>22</td>
<td>Norway</td>
<td>27.9</td>
</tr>
<tr>
<td>23</td>
<td>Turkey</td>
<td>27.3</td>
</tr>
<tr>
<td>24</td>
<td>Argentina</td>
<td>25.9</td>
</tr>
<tr>
<td>25</td>
<td>Saudi Arabia</td>
<td>23.8</td>
</tr>
<tr>
<td>26</td>
<td>Romania</td>
<td>22.6</td>
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<tr>
<td>27</td>
<td>Venezuela</td>
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<td>28</td>
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<td>Finland</td>
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<td>Switzerland</td>
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<td>Philippines</td>
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<td>Denmark</td>
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<td>Bulgaria</td>
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<td>44</td>
<td>Uzbekistan</td>
<td>11.7</td>
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<td>45</td>
<td>Portugal</td>
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<td>46</td>
<td>Greece</td>
<td>10.3</td>
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<td>Chile</td>
<td>9.7</td>
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<td>48</td>
<td>Yugoslavia</td>
<td>9.6</td>
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<td>49</td>
<td>Korea, North</td>
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<tr>
<td>50</td>
<td>Israel</td>
<td>9.1</td>
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<tr>
<td>51</td>
<td>New Zealand</td>
<td>8.5</td>
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<td>Kuwait</td>
<td>8.5</td>
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<td>53</td>
<td>Hungary</td>
<td>8.3</td>
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<td>54</td>
<td>Belarus</td>
<td>7.5</td>
</tr>
<tr>
<td>55</td>
<td>Slovakia</td>
<td>7.5</td>
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<tr>
<td>56</td>
<td>Paraguay</td>
<td>7.4</td>
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<tr>
<td>57</td>
<td>Singapore</td>
<td>6.7</td>
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<tr>
<td>58</td>
<td>Peru</td>
<td>6.1</td>
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<td>59</td>
<td>Algeria</td>
<td>6.0</td>
</tr>
<tr>
<td>60</td>
<td>Nigeria</td>
<td>5.9</td>
</tr>
</tbody>
</table>

Source: Energy Information Administration (www.eia.doe.gov)
Why SLM Fails

.... as wholesale competition in small systems with big power plants is very difficult

SINGAPORE ELECTRICITY SYSTEM

Senoko Power 3300 MW
PowerSeraya 3100 MW
Tuas Power 2670 MW
SemCorp Cogen 900 MW
Island Power 800 MW
Kepel Merlimau 470 MW
NEA 130 MW
TOTAL CAPACITY

Why SLM Fails

Interconnecting markets to create competition is possible if security issues are solved.

INTERCONNECTED EUROPEAN TRANSMISSION SYSTEMS

Source: CENTREL Annual Report 2001 (www.centrel.org)
Why SLM Fails

... but isolated transmission systems and near monopolies mean SLM is likely to fail

**JAPANESE ELECTRIC UTILITIES (31 March 2002)**

<table>
<thead>
<tr>
<th>Company</th>
<th>Capacity (MW)</th>
<th>Interconnect (MW)</th>
<th>Interconnect (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hokkaido</td>
<td>5904</td>
<td>100</td>
<td>1.7%</td>
</tr>
<tr>
<td>Tohoku</td>
<td>16076</td>
<td>800</td>
<td>5.0%</td>
</tr>
<tr>
<td>Tokyo</td>
<td>60375</td>
<td>700</td>
<td>1.2%</td>
</tr>
<tr>
<td>Hokuriku</td>
<td>6759</td>
<td>200</td>
<td>3.0%</td>
</tr>
<tr>
<td>Chubu</td>
<td>32231</td>
<td>500</td>
<td>1.6%</td>
</tr>
<tr>
<td>Kansai</td>
<td>35585</td>
<td>1400</td>
<td>3.9%</td>
</tr>
<tr>
<td>Shikoku</td>
<td>6877</td>
<td>400</td>
<td>5.8%</td>
</tr>
<tr>
<td>Chugoku</td>
<td>12179</td>
<td>500</td>
<td>4.1%</td>
</tr>
<tr>
<td>Kyushu</td>
<td>19336</td>
<td>300</td>
<td>1.6%</td>
</tr>
</tbody>
</table>

Source: JEPC Annual Review 2003-03 (www.fepc.or.jp/english/erj/chap02.html)
Why SLM Fails

Liberalisation will only be politically supported if voters think prices will fall but….

HOUSEHOLD ELECTRICITY PRICE IN NORTH, CENTRAL AND SOUTH AMERICA (2000)

Source: OLADE (www.olade.org/idiomas/ingles/sieehome/estadisticas/precios_internos.html) and IEA (Energy Prices & Taxes Q1 2003)
Why SLM Fails

... demand exceeds supply and utilities bankrupt if retail price set below wholesale cost

**CALIFORNIA WHOLESALE PRICE AND DEMAND**

- **Demand (MWh)**
- **Price ($/MWh)**

Source: California ISO
An Alternative ADC Model

Previous policies failed in India but new Electricity Act will allow ‘bottom up’ reform

KEY ELEMENTS OF INDIAN ELECTRICITY ACT 2003

1. All power tariff subsidies must be explicitly in state budget (e.g. agriculture)

2. Special electricity theft tribunals

3. Interstate transmission rates set by CERC, NOT states → pit-head power export

4. Allows for reorganisation of the SEBs and creation of wholesale markets

5. License-free generation and distribution in rural areas, plus capital subsidies

6. Captive generation freely permitted

7. Open access to the T&D system

8. Phase out grid access surcharges
An Alternative ADC Model

Distributed generation (DG) is electricity production *near point of use* 3kW – 500MW…. 

**DECENTRALISED GENERATION**

- Microturbines
- Diesel engines
- Gas engines
- Steam turbines
- Photovoltaics
- Small hydro
- Wind

**Combined Heat & Power**

**Hybrid Systems**
An Alternative ADC Model

.... allows consumers to invest in and operate own DG as well as sell surplus power

CAPITAL COST AND CAPACITY OF DISTRIBUTED GENERATION

<table>
<thead>
<tr>
<th>Diesel Generator</th>
<th>Gas Engine</th>
<th>Industrial CHP</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 kW</td>
<td>500 kW</td>
<td>4 MW</td>
</tr>
<tr>
<td>$9,000</td>
<td>$70,000</td>
<td>$1M</td>
</tr>
<tr>
<td>$450/kW</td>
<td>$140/kW</td>
<td>$500/kW</td>
</tr>
</tbody>
</table>

50MW + Heat
$50M
$1000/kW
An Alternative ADC Model

Industrial load has a big incentive to quickly leave the system ....

GUJARAT TARIFF STRUCTURE AND DEMAND 2001/02

<table>
<thead>
<tr>
<th>$/kWh</th>
<th>Domestic</th>
<th>Commercial</th>
<th>Agriculture</th>
<th>Industrial</th>
<th>Rail</th>
<th>Other</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gujarat</td>
<td>0.040</td>
<td>0.077</td>
<td>0.004</td>
<td>0.078</td>
<td>0.093</td>
<td>0.034</td>
<td>0.040</td>
</tr>
<tr>
<td>India Avg</td>
<td>0.032</td>
<td>0.075</td>
<td>0.004</td>
<td>0.069</td>
<td>0.088</td>
<td>0.040</td>
<td>0.040</td>
</tr>
</tbody>
</table>

Comparative Costs

- New CHP: $0.040/kWh
- GEB ‘station gate’: $0.045/kWh
- New Grid Connected: $0.172/kWh
An Alternative ADC Model

… this would reduce total demand and increase supply of surplus power back to grid

SHORTFALL IN MEETING PEAK AND TOTAL DEMAND IN GUJARAT

<table>
<thead>
<tr>
<th>Period</th>
<th>Max Unrestricted Demand (MW)</th>
<th>Max Demand Catered (%)</th>
<th>Plant Load Factor (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 01 - Jan 02</td>
<td>8476</td>
<td>80.4</td>
<td>67.3</td>
</tr>
<tr>
<td>April 02 - Jan 03</td>
<td>9040</td>
<td>85.7</td>
<td>69.8</td>
</tr>
</tbody>
</table>
An Alternative ADC Model

Model based analysis shows hybrid (wind-diesel) rural DG systems are economic…

RURAL DG SOLUTION

OPTIONS

Grid Power with T&D Connection

Diesel Generator

Renewable Energy

DRAWBACKS

High cost of delivered power from low population/load density and high line loss & theft

- High operating costs
- Fuel transportation
- Short operational lifetime
- Interruptible supply

SOLUTION

HYBRID SYSTEM

- High investment costs
- Specialized maintenance
- Intermittent energy resources
An Alternative ADC Model

…. as T&D loses make grid connected power expensive especially in remote rural areas

**BREAKEVEN RURAL GRID CONNECTION VERSUS DG**

![Graph showing breakeven grid extension distance versus grid power cost](image-url)

- Blue line: 1000 $/km
- Red line: 4000 $/km
- Green line: 8000 $/km
‘Bottom-up’ liberalisation provides new incentives and demand to be segmented....

POTENTIAL OUTCOME

- Luxury Demand
- Concrete Factory
- Village Load
- Basic Service Load

- SEB + industry surplus
- Build own generation
- Form local co-op
- SEB subsistence
An Alternative ADC Model

... but incumbent SEB and politicians will also have incentives to counteract

THE DEVILS IN THE DETAIL

- State governments and SERCs will implement - diverting federal government objective
- SEBs can thwart change using ‘technical’ issues – hindering access to grid
- SEB ‘electrification’ obligations reduced – slowing ‘rural’ versus ‘urban’ development
- Big rural loads can be ‘cherry-picked’ – making rural household load uneconomic
- Small rural loads (agriculture) has little incentive to invest as power is subsidised

CAREFUL ONGOING REGULATION AND LEGISLATION REQUIRED
**Speaker**

**John Bower** is a Senior Research Fellow at the Oxford Institute for Energy Studies which is an independent research charity affiliated to Oxford University and dedicated to advanced research in the social science aspects of energy. John joined OIES in November 2001 and his research interest is in the emergence and evolution of integrated cross-border electricity and gas markets. Specifically; the development of efficient pricing and investment mechanisms for energy, transmission capacity, and emissions.

Before joining the OIES, John completed his PhD at London Business School and his previous career was in the commodity industry. His experience ranges from energy trading, at Marc Rich & Co, to risk management consultancy, with Coopers & Lybrand, advising commodity traders, producers and processors in base metal, precious metal, ‘softs’ and energy markets. Immediately prior to his PhD he was Global Controller Metals/Commodities at Deutsche Morgan Grenfell.

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