Conventional Facilities
NLC 2001 Configuration
Electric Power Systems
Two Existing 345 Kv Transmission Lines

New Eola Road Sub
345-34.5 Kv
Five Existing 230 Kv Transmission Lines
Parallel Pacific Power Transmission Corridor

Multiple Connections Over ~15 Mile Length

New 135d Sub
230-34.5 Kv
Modulator Substation

34.5 kV 60 Hz

Step Down 34.5 - 2.25 / 1.3 kV
5000 kVA

Switchgear w/Breakers,
Disconnects, Contactors,
Converters, Controls,
& Cable Getaways

9 Cubicles, 1 per Klystron 8-Pack

9 Each, 2.2 kV, 500 kw PWM DC Converters
Next Linear Collider – U.S. Collaboration

SLAC – FNAL – LBNL - LLNL

NLC 2001 Electric Power Systems

Modulator Substation Bus

2.25/1.3 kV 3 Phase 60 hertz

Circuit Breaker
Disconnect Switch
Current Limiting Fuse
Contactor
Solid State Controller
Transformer
Bridge & Regulator
Filter

Utility Pad
Klystron Gallery

Cable Terminator/Disconnect
HV Cable
Cable Terminator/Disconnect

8-Pack Solid State Induction Modulator

500 kW
Utility Cost Comparisons

<table>
<thead>
<tr>
<th>Electrical &amp; Mechanical Costs as a Percent of Total Project Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.S.Means Data 171 000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Type</th>
<th>Low 25%</th>
<th>Median</th>
<th>High 75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factory</td>
<td>20.4</td>
<td>28.1</td>
<td>34.5</td>
</tr>
<tr>
<td>Research Lab</td>
<td>23.9</td>
<td>35.6</td>
<td>41.7</td>
</tr>
<tr>
<td>Power Plant</td>
<td>28.8</td>
<td>32.5</td>
<td>52.6</td>
</tr>
</tbody>
</table>

- Large NLC Civil Construction Cost **Dilutes** Utility %
- High Power and Cooling Density Distributed Over Large Distances **Increases** Utility %
- One-Third of Total Facilities Cost is About Right
NLC 2001 Electric Power Systems

Power Roll-Up

<table>
<thead>
<tr>
<th>NLC Power Demands</th>
<th>Revision</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 TeV, 120 Hz</td>
<td>9.0</td>
<td>02.16.01</td>
</tr>
</tbody>
</table>

Heat losses in this section are released to outside air in Cut & Cover scheme. ~11.8 Mw
# NLC 2001 Electric Power Systems

## Power Roll-Up

### NLC Power Demands

<table>
<thead>
<tr>
<th>Description</th>
<th>RF (MW)</th>
<th>Cooling (MW)</th>
<th>Power (MW)</th>
<th>Total (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>e- Injectors</td>
<td>2.0</td>
<td>0.17</td>
<td>0.3</td>
<td>2.5</td>
</tr>
<tr>
<td>e+ Injectors</td>
<td>8.3</td>
<td>0.84</td>
<td>1.8</td>
<td>10.9</td>
</tr>
<tr>
<td>e- Damping Ring (1)</td>
<td>2.5</td>
<td>0.17</td>
<td>0.2</td>
<td>2.9</td>
</tr>
<tr>
<td>e+ Damping Rings (2)</td>
<td>5.0</td>
<td>0.51</td>
<td>4.2</td>
<td>9.7</td>
</tr>
<tr>
<td>Pre-Linacs, BC2 (2)</td>
<td>8.7</td>
<td>1.86</td>
<td>0.7</td>
<td>11.3</td>
</tr>
<tr>
<td>Main Linacs 22 Sectors</td>
<td>91.9</td>
<td>6.75</td>
<td>1.0</td>
<td>99.7</td>
</tr>
<tr>
<td>IR Transport</td>
<td>0.0</td>
<td>0.42</td>
<td>1.0</td>
<td>1.4</td>
</tr>
<tr>
<td>IR Hall (s)</td>
<td>0.0</td>
<td>0.17</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Detector (s)</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Campus</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Central CW Utility</td>
<td>0.0</td>
<td>6.70</td>
<td>0.0</td>
<td>6.7</td>
</tr>
<tr>
<td>Distributed CW Utility</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>MW SUM</strong></td>
<td>118.4</td>
<td>17.59</td>
<td>9.5</td>
<td>145.5</td>
</tr>
<tr>
<td>Motor Loss 5.9 %</td>
<td></td>
<td></td>
<td>1.04</td>
<td></td>
</tr>
<tr>
<td>Circuit Loss 3.0 %</td>
<td>3.6</td>
<td>0.53</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Transformer Loss 0.5-1.5 %</td>
<td>1.8</td>
<td>0.09</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>VFD - PWM Loss 2.0 %</td>
<td>2.4</td>
<td>0.35</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td><strong>MW (P) Total</strong></td>
<td>126.1</td>
<td>19.60</td>
<td>10.0</td>
<td>156.7</td>
</tr>
<tr>
<td>Power Factor Cos = 0.99</td>
<td>1.3</td>
<td>0.20</td>
<td>0.1</td>
<td>1.57</td>
</tr>
<tr>
<td>MVA (S) Demand Total</td>
<td>127.4</td>
<td>19.79</td>
<td>10.1</td>
<td>157.3</td>
</tr>
<tr>
<td>NEC Motor NP Incr 0.083</td>
<td>1.46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEC Motor Ckt 125 %</td>
<td></td>
<td>3.96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEC 80% NP Loading</td>
<td></td>
<td>4.75</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td><strong>Installed MVA Total</strong></td>
<td>152.8</td>
<td>29.96</td>
<td>12.1</td>
<td>195.0</td>
</tr>
</tbody>
</table>

**Tech Systems** 145 MW  
**Ops. Power Bill** 157 MVA  
**Cost Estimate** 195 MVA
Additional Power Demand Adjustments

- **Campus** +
- **Experimental Detectors** +
- **Central & De-Centralized Injectors** ±
- **Parallel Support Tunnel Ventilation & Cooling** +
- **Add ~ 9 Mw Max** ?

- **Develop Power Resources to Offset Demand Peak**
- **Subtract ~ 150 Mw @ 4 Hours/Day** ? Why > Ops $
# January Power Bills FNAL & SLAC

## FNAL JAN-01

<table>
<thead>
<tr>
<th></th>
<th>$/Kw</th>
<th>$/Kw-Hr</th>
<th>Kw</th>
<th>Kwhr</th>
<th>Amount</th>
<th>$/Mw-Hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>33 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kw Demand</td>
<td>1.92</td>
<td></td>
<td>42377</td>
<td></td>
<td>$81,363.65</td>
<td></td>
</tr>
<tr>
<td>Off-Peak Kw-Hr</td>
<td>0.01925</td>
<td></td>
<td>14535833</td>
<td></td>
<td>$279,814.79</td>
<td></td>
</tr>
<tr>
<td>On-Peak Kw-Hr</td>
<td>0.03522</td>
<td></td>
<td>8482710</td>
<td></td>
<td>$298,761.05</td>
<td></td>
</tr>
<tr>
<td>Trans Kw-Hr</td>
<td>0.01221</td>
<td></td>
<td>23030073</td>
<td></td>
<td>$281,197.19</td>
<td></td>
</tr>
<tr>
<td>Total Kw-Hr</td>
<td>Off+On Peak</td>
<td>46048616</td>
<td></td>
<td></td>
<td>$941,136.67</td>
<td>$20.44</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
<td></td>
<td>-9290.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Jan01 Bill</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$931,846.65</td>
<td></td>
</tr>
</tbody>
</table>

## SLAC JAN-01

<table>
<thead>
<tr>
<th></th>
<th>$/Kw</th>
<th>$/Kw-Hr</th>
<th>Kw</th>
<th>Kwhr</th>
<th>Amount</th>
<th>$/Mw-Hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>31 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kw Demand</td>
<td>3.38</td>
<td></td>
<td>32630</td>
<td></td>
<td>$110,288.99</td>
<td></td>
</tr>
<tr>
<td>Energy Kw-Hr</td>
<td>0.01122</td>
<td></td>
<td>20644920</td>
<td></td>
<td>$231,636.00</td>
<td></td>
</tr>
<tr>
<td>Total Kw-Hr</td>
<td></td>
<td></td>
<td>20644920</td>
<td></td>
<td>$341,925.00</td>
<td>$16.56</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$12,726.00</td>
<td></td>
</tr>
<tr>
<td>Total Jan01 Bill</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$354,651.00</td>
<td></td>
</tr>
</tbody>
</table>
Why Develop Generation Resources?

- Peak Demand Power costs $250 - $1000 (spot) / MwHr for ~ 4 Hours a Day with CA Stage 3 $ Caps Removed
- FNAL Pays ~ $20 / MwHr for 24 Hours
- SLAC Pays ~ $17 / MwHr for 24 Hours
- Residential (CA) Pays ~ $28 / MwHr w/o Caps, ~ $15 / MwHr w/Caps
**Typical 24 Hour California Load Profile**

<table>
<thead>
<tr>
<th>Hour</th>
<th>(MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20178.00</td>
</tr>
<tr>
<td>2</td>
<td>19457.00</td>
</tr>
<tr>
<td>3</td>
<td>19370.00</td>
</tr>
<tr>
<td>4</td>
<td>19594.00</td>
</tr>
<tr>
<td>5</td>
<td>20521.00</td>
</tr>
<tr>
<td>6</td>
<td>23411.00</td>
</tr>
<tr>
<td>7</td>
<td>26810.00</td>
</tr>
<tr>
<td>8</td>
<td>27951.00</td>
</tr>
<tr>
<td>9</td>
<td>28499.00</td>
</tr>
<tr>
<td>10</td>
<td>28628.00</td>
</tr>
<tr>
<td>11</td>
<td>28416.00</td>
</tr>
<tr>
<td>12</td>
<td>28034.00</td>
</tr>
<tr>
<td>13</td>
<td>27668.00</td>
</tr>
<tr>
<td>14</td>
<td>27426.00</td>
</tr>
<tr>
<td>15</td>
<td>27028.00</td>
</tr>
<tr>
<td>16</td>
<td>26740.00</td>
</tr>
<tr>
<td>17</td>
<td>27507.00</td>
</tr>
<tr>
<td>18</td>
<td>30623.00</td>
</tr>
<tr>
<td>19</td>
<td>30273.00</td>
</tr>
<tr>
<td>20</td>
<td>29542.00</td>
</tr>
<tr>
<td>21</td>
<td>28252.00</td>
</tr>
<tr>
<td>22</td>
<td>25933.00</td>
</tr>
<tr>
<td>23</td>
<td>23403.00</td>
</tr>
<tr>
<td>24</td>
<td>21469.00</td>
</tr>
<tr>
<td>25</td>
<td>0.00</td>
</tr>
</tbody>
</table>

19 Gigawatts @ 2am vs. 30 Gigawatts @ 6pm
Typical 24 Hour Power Demand

Daily Peak
@ $250+ / MwHr
Next Linear Collider – U.S. Collaboration

SLAC – FNAL – LBNL - LLNL

NLC 2001 Electric Power Systems

Power Development Strategy

• Develop Power Resources to Offset Demand Peak

• Combined Cycle NG Turbine - IL & CA

• Pumped Storage Hydroelectric CA Reservoir
Green Leaf-Sutter
580 MW Plant
On Line FY 2001

NLC 200 Mw
Combined Cycle Turbine Site

Sites/NLC Off Stream Storage DWR Project 75-150-230 Mw Hydro
Sites Reservoir Development Topography Model

- 3 Stages, 1.2 / 1.8 / 1.1 = 4.1 M Acre-Feet Total
- Power Output, 75 / 150 / 230 Mw @ 4 Hours/Day
- US/CA Development $ 230 / 450 / 1140 Million
NLC Combined Cycle Turbine Project 200 Mw
How a Combined Cycle Plant works

Electricity out

Air Intake

Gas Turbine

Combustion Chamber

Fuel

Heat Recovery Steam Generator

Exhaust Stack

Steam

Water

Warm Water

Cooling Water

Generator

Steam Turbine

Condenser
Next Linear Collider – U.S. Collaboration
SLAC – FNAL – LBNL - LLNL

NLC 2001 Electric Power Systems

Heat Recovery Steam Generator

1. Inlet Duct
2. Distribution grid
3. HP Superheater 1
4. Burner
5. Split Superheater
6. HP Superheater 2
7. CO Catalyst
8. HP Steam Drum
9. Top Supports
10. SCR Catalyst
11. LP Steam Drum
12. HRSG Cassing
13. Deareator
14. Stack
15. Preheater
16. DA Evaporator
17. HP/IP Economizer
18. IP Evaporator
19. IP Superheater
20. HP Economizer
21. Ammonia Injection Grid
22. HP Evaporator
Conventional Facilities
NLC 2001 Configuration
Electric Power Systems
End
Conventional Facilities
NLC 2001 Configuration
Electric Power Systems
California Deregulation
NLC 2001 Electric Power Systems

Status of Deregulation in Each State (as of July 2000)

Legend:
- Light blue: Studies undertaken but no legislation or regulatory action
- Yellow: Pursuing legislation or regulations to implement restructuring
- Light green: Timetable established
- Blue: Implementation underway
- Dark green: Fully competitive market
Structure of the Traditional Utility

- Utility A
  - Generators
  - Substations
  - Control Center
  - Retail Territory A

- Utility B
  - Generators
  - Substations
  - Control Center
  - Retail Territory B

- Utility C
  - Generators
  - Substations
  - Control Center
  - Retail Territory C

3rd Party Generation

Electric Power Systems
Calif. Power (Dutch) Auction Process

Bid Stack: Hour 0600

Most Expensive

4000 MW @ 3c

3000 MW @ 2.5c

4000 MW @ 2c

2500 MW @ 1.5c

3000 MW @ 1c

5000 MW @ 0c

Cheapest

Winners

2000 MW

2500 MW

3000 MW

5000 MW

12,500 megawatts are needed to meet demand

The Market Clearing Price is 2c/MW to all winning bidders

Bids form Six Generators are Ranked Least to Most Expensive

NLC 2001 Electric Power Systems
Conventional Facilities
NLC 2001 Configuration
Electric Power Systems
California Deregulation
End