Cutting-Edge Modeling Tools to Enable Low Carbon Grids

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Estimated 2100 temperature:
4.2°C | 7.6°F
3.3°C | 6.0°F
1.8°C | 3.3°F
1.5°C | 2.8°F

April 2017, ClimateScoreboard.org
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ENERGY EFFICIENT LED TECHNOLOGIES
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FALLING COSTS OF WIND AND SOLAR PV
ENERGY EFFICIENT LED TECHNOLOGIES

FALLING COSTS OF WIND AND SOLAR PV

ELECTRIC VEHICLES
ENERGY EFFICIENT LED TECHNOLOGIES

FALLING COSTS OF WIND AND SOLAR PV

ELECTRIC VEHICLES

BATTERY STORAGE
Three major approaches to limit emissions from the energy sector are emerging
Three major approaches to limit emissions from the energy sector are emerging

- **Pursue Energy Efficiency**
- **Decarbonize Electricity Sector**
- **Electrify Transportation and Industry**
The future low carbon grid

DISPATCHABLE SUPPLY = VARIABLE DEMAND
The future low carbon grid
The future low carbon grid

DISPATCHABLE SUPPLY

VARIABLE SUPPLY

VARIABLE DEMAND

VARIABLE SUPPLY
The future low carbon grid

- Dispatchable supply
- Storage

=  

- Variable demand
- Variable supply
The future low carbon grid
The future low carbon grid
The future low carbon grid
Models for planning and analysis of electricity grids

SPATIAL PLANNING OF RENEWABLE ENERGY
Models for planning and analysis of electricity grids
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SPATIAL PLANNING OF RENEWABLE ENERGY

FUTURE DEMAND ANALYSIS

GENERATION AND TRANSMISSION CAPACITY INVESTMENT
Models for planning and analysis of electricity grids

- Spatial Planning of Renewable Energy
- Future Demand Analysis
- Generation and Transmission Capacity Investment
- System Operation – Unit Commitment Economic Dispatch
Models for planning and analysis of electricity grids

SPATIAL PLANNING OF RENEWABLE ENERGY

FUTURE DEMAND ANALYSIS

GENERATION AND TRANSMISSION CAPACITY INVESTMENT

SYSTEM OPERATION – UNIT COMMITMENT ECONOMIC DISPATCH

POWER FLOW AND RELIABILITY ANALYSIS
Models for planning and analysis of electricity grids

SPATIAL PLANNING OF RENEWABLE ENERGY

GENERATION AND TRANSMISSION CAPACITY INVESTMENT

SYSTEM OPERATION – UNIT COMMITMENT ECONOMIC DISPATCH

POWER FLOW AND RELIABILITY ANALYSIS

FUTURE DEMAND ANALYSIS
Challenge 1: Balance trade-offs between siting RE and environmental, social, and economic objectives

Source: www.wvgazetteemail.com; renews; PowerMagazine
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Research Area 1: Geospatial and economic methods and tools for sustainable planning of large-scale renewables

Geospatial Renewable Resource Assessment

Wind
Resource Quality
Wind³
- < 250
- 251 - 300
- 301 - 250
- 251 - 400
- > 400
Research Area 1: Geospatial and economic methods and tools for sustainable planning of large-scale renewables

Geospatial Renewable Resource Assessment

Potential Project Areas And Zones with Multiple Parameters
Research Area 1: Geospatial and economic methods and tools for sustainable planning of large-scale renewables

**Economic criteria**
- Levelized cost of energy
- Cost for transmission
- Cost for road

**Non-economic criteria**
- Proximity to load centers
- Environmental impact score
- Capacity value
- Water availability
- Co-location potential
Research Area 1: Geospatial and economic methods and tools for sustainable planning of large-scale renewables

Open-source data sets and GIS tools on MapRE portal (http://mapre.lbl.gov)
Research Area 1: Geospatial and economic methods and tools for sustainable planning of large-scale renewables

Open-source data sets and GIS tools on MapRE portal (http://mapre.lbl.gov)
1) Variable in time

1) Variable in time

![Graph showing WIND, SOLAR, and PV over time]


2) Variable in space

![Map showing distribution of energy resources]

1) Variable in time

2) Variable in space

3) Uncertain (forecast errors)

Challenge 2: Planning and operating an increasingly variable and uncertain generation supply

1) Variable in time

2) Variable in space

3) Uncertain (forecast errors)

Research Area 2: Power systems modeling for capacity investments and systems operations
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High spatial and temporal resolution mixed-integer linear optimization models
Research Area 2 Example: South Africa’s 2030 electricity system and alternatives to the Inga 3 dam
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![Graph showing new capacity](image.png)

### NEW CAPACITY

<table>
<thead>
<tr>
<th></th>
<th>With Inga 3</th>
<th>Without Inga 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity Factor</td>
<td>With 60%</td>
<td>With 70%</td>
</tr>
<tr>
<td></td>
<td>With 80%</td>
<td>Without N/A</td>
</tr>
</tbody>
</table>

- **Inga 3 Hydropower Project**
- **Solar PV-New**
- **Wind-New**
- **OCGT-New**
- **CCGT-New**

Legend:
- **Pumped Storage**
- **Biomass**
- **Biogas**
- **Solar PV**
- **Concentrated Solar Power**
- **Wind**
- **Hydro**
- **OCGT**
- **CCGT**
- **Nuclear**
- **Coal**

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Research Area 2 Example: South Africa’s 2030 electricity system and alternatives to the Inga 3 dam

NO NEW COAL

NEW CAPACITY

INSTALLED CAPACITY (MW)

With / Without Inga 3

Inga 3 Capacity Factor

With

Without

60%

70%

80%

N/A

With

Without

NEW CAPACITY

Inga 3 Hydropower Project
Solar PV-New
Wind-New
OCGT-New
CCGT-New

Pumped Storage
Biomass
Biogas
Solar PV
Concentrated Solar Power
Wind
Hydro
OCGT
CCGT
Nuclear
Coal

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Research Area 2 Example: Optimal shares of wind and solar in India’s 2030 low carbon electricity system
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Optimal shares: 75-50% Wind – 25-50% solar