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IPRO 302: Alternative Metropolitan Power Strategy

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Sarah, Yagoob, Akshay, Allen, Ray, Min, Li

Dr. Chmielewski, Dr. Gottlieb

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IPRO It takes a team! INTERPROFESSIONAL PROJECTS PROGRAM

- Interdisciplinary
- Topic Focused
  - Service
  - Sustainability
  - Energy
  - Business

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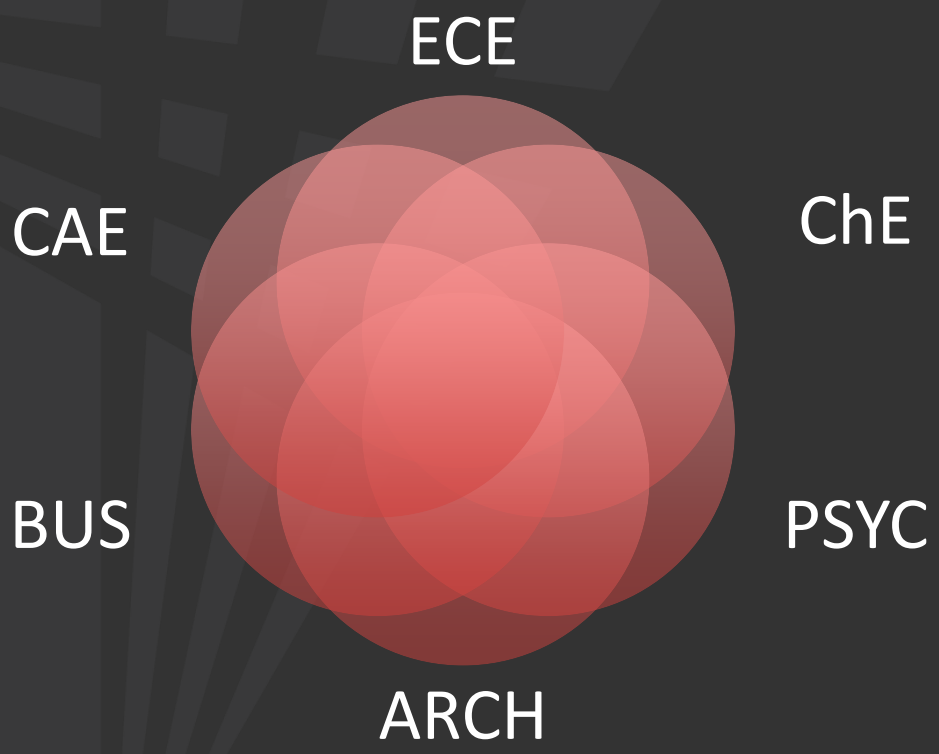
Diverse IPRO Group



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Outline

- Background
- Research process
- Design Costs
- Solution Design
- Cost Benefit Analysis
- The Future

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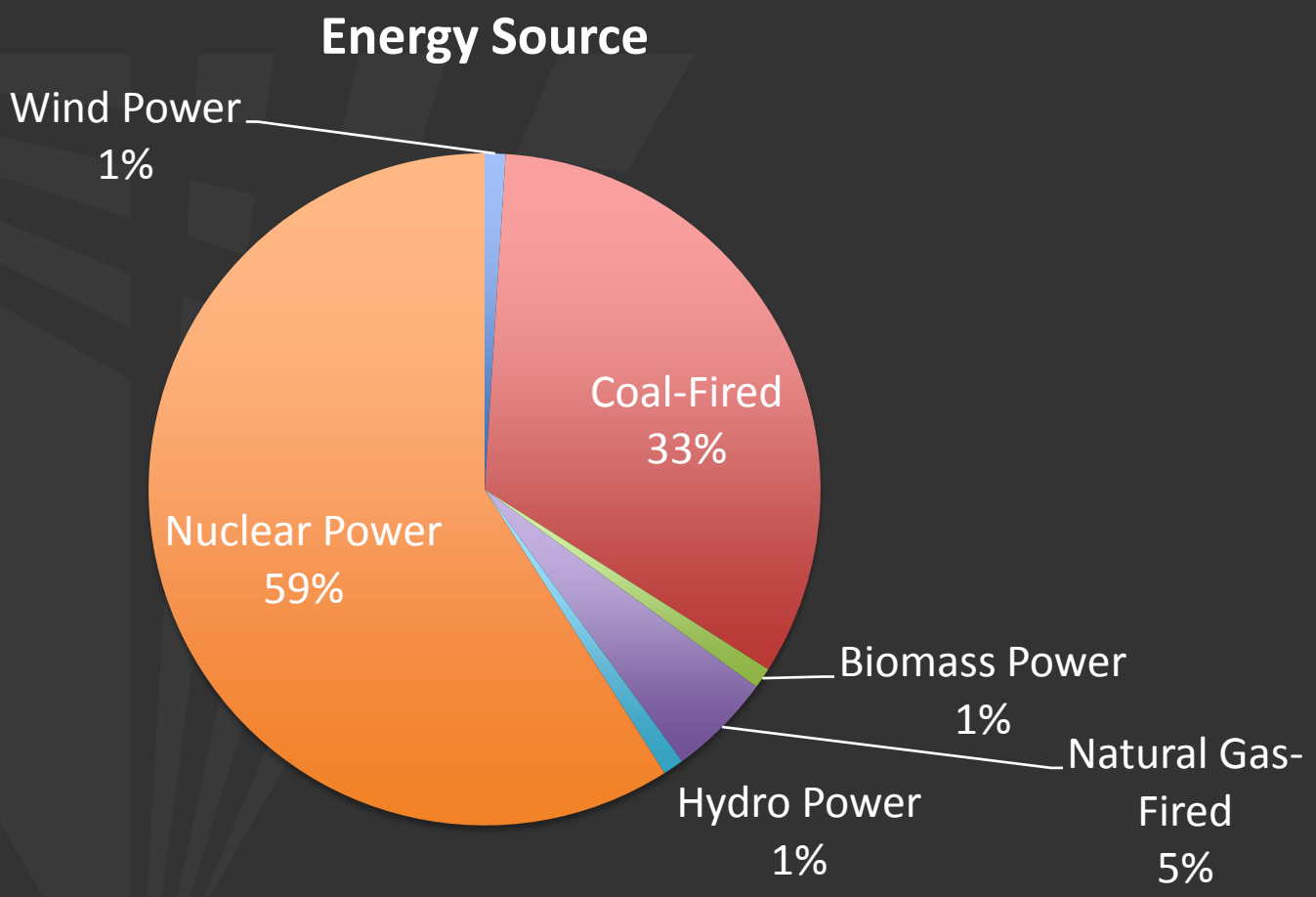
Current Problem



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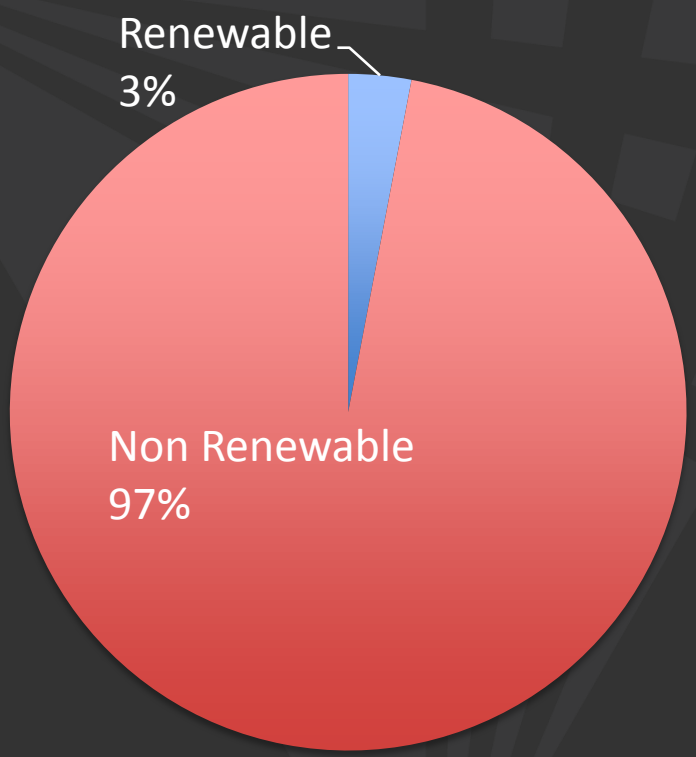
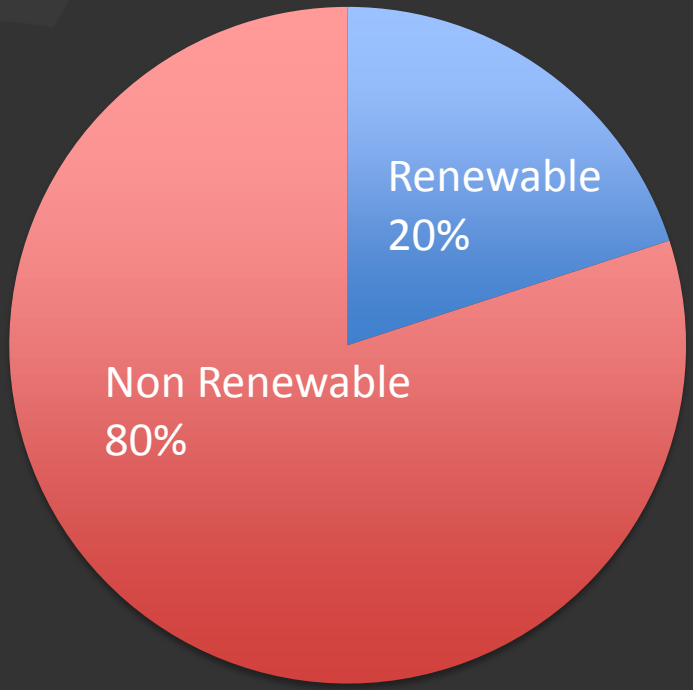
Current Problem

Current



Future



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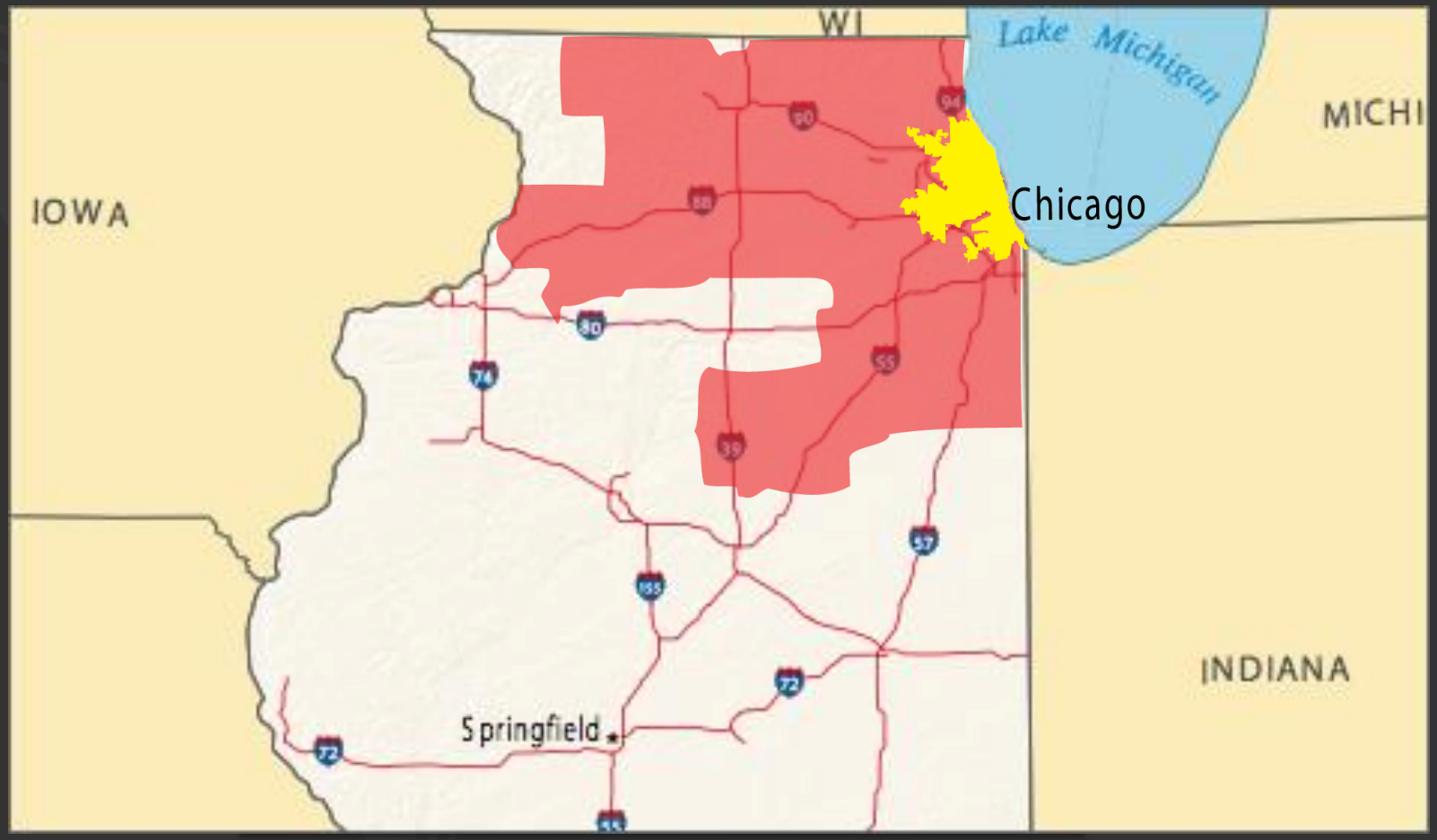
Power Supply in Chicago



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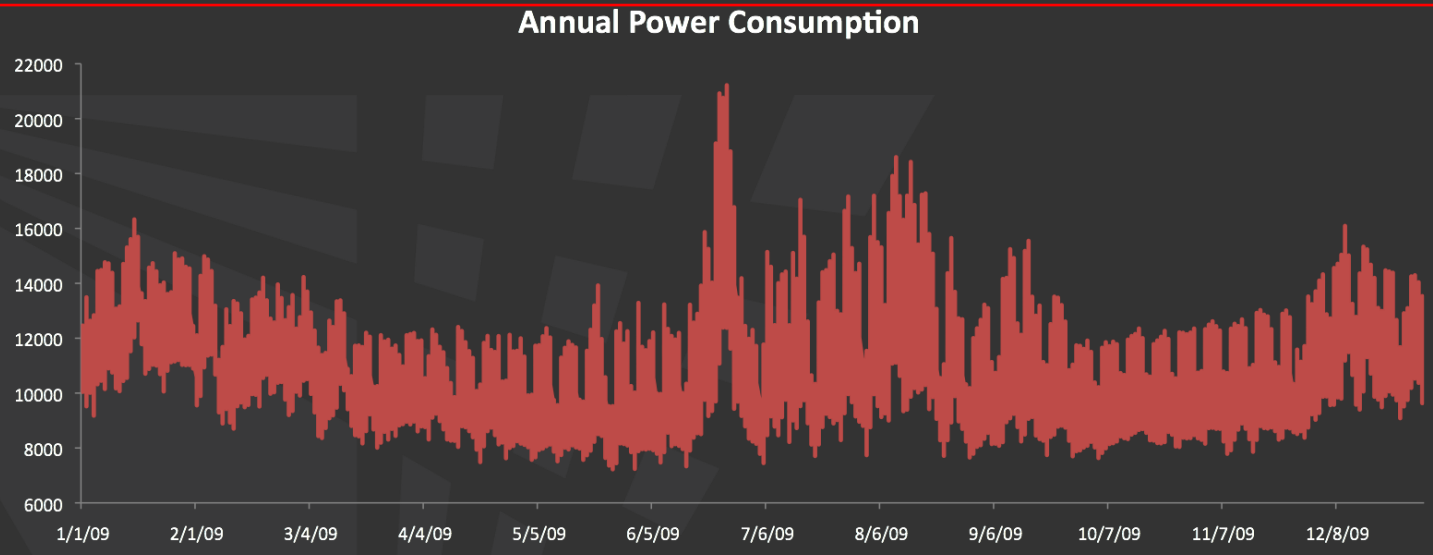
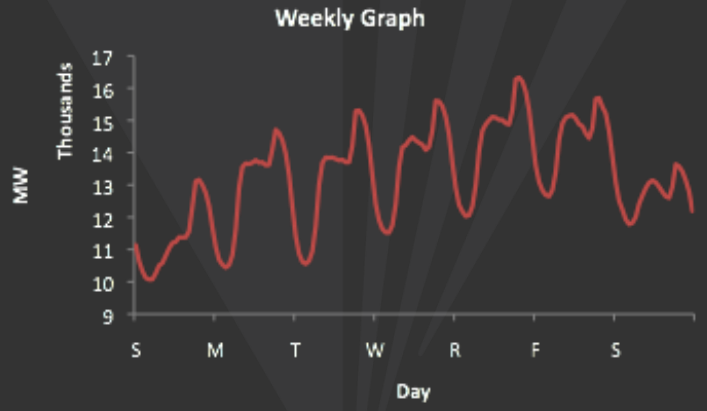
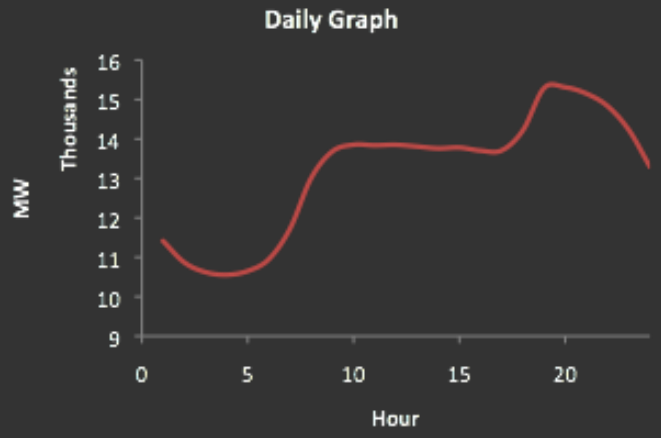
Energy Demand







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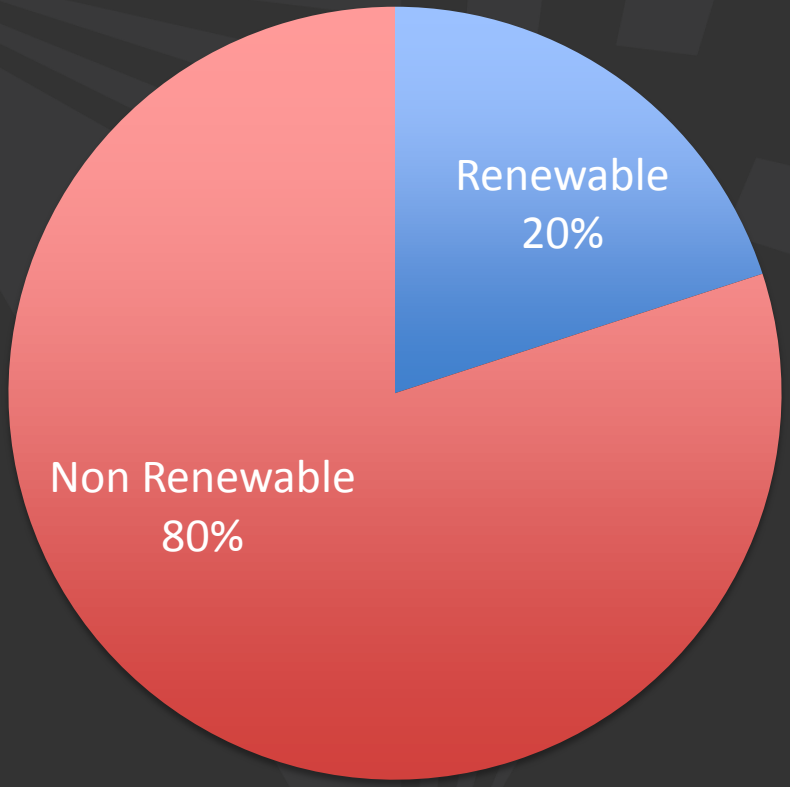
Energy Demand



= 3,143 GWHr Annually

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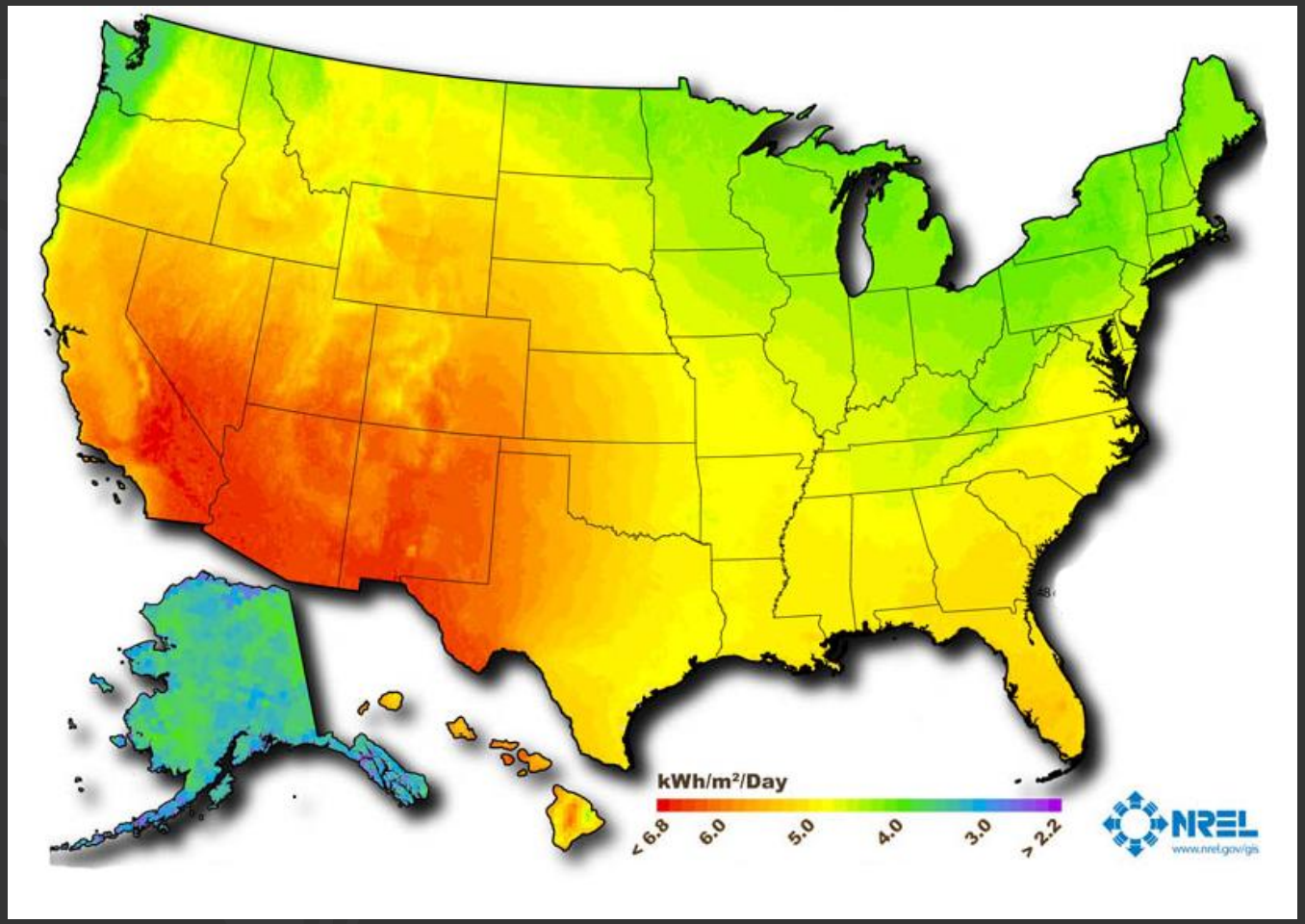
Environmental Data



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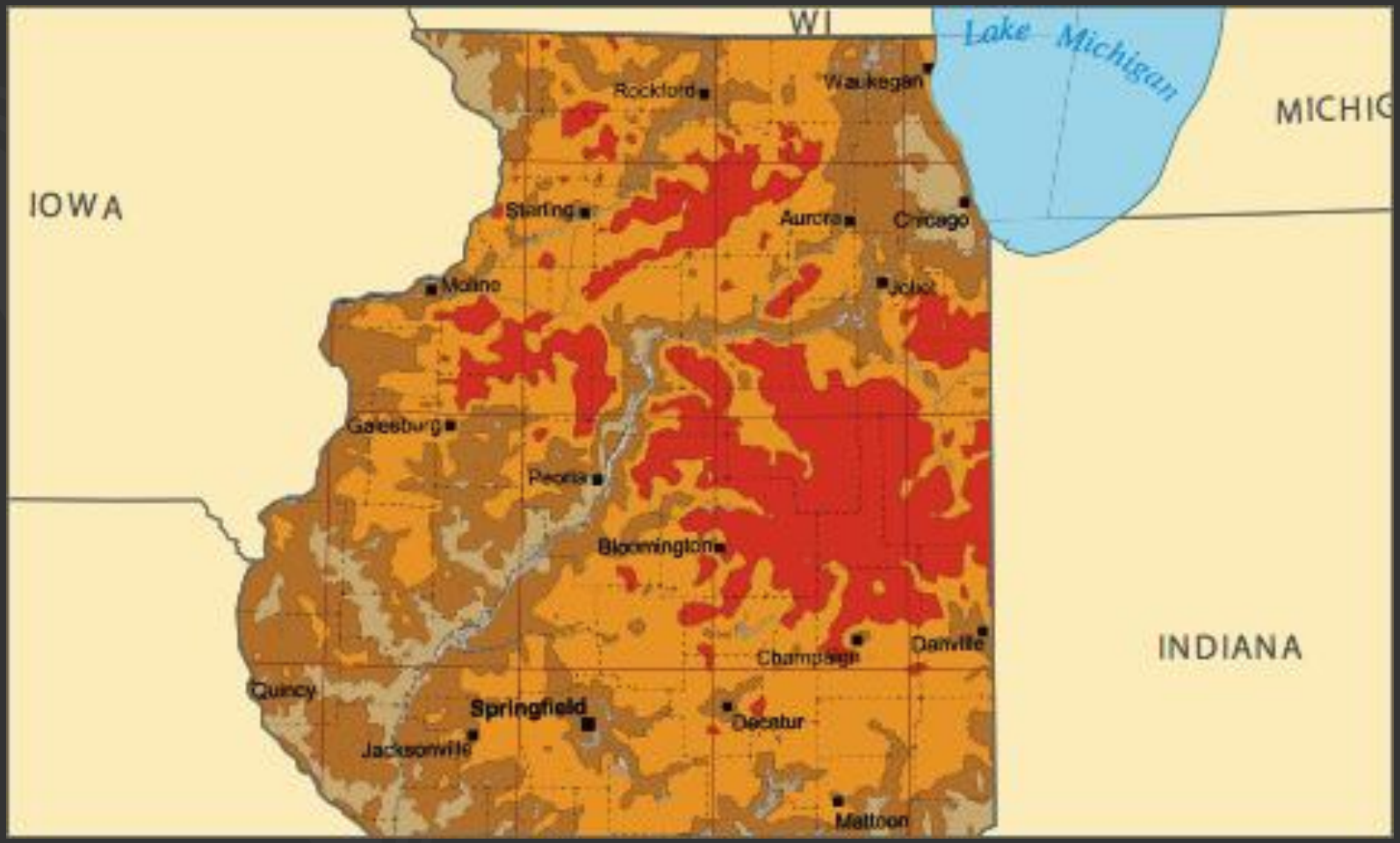
Environmental Data



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Renewable Technologies

Wind

Solar Photovoltaic

Solar Thermal

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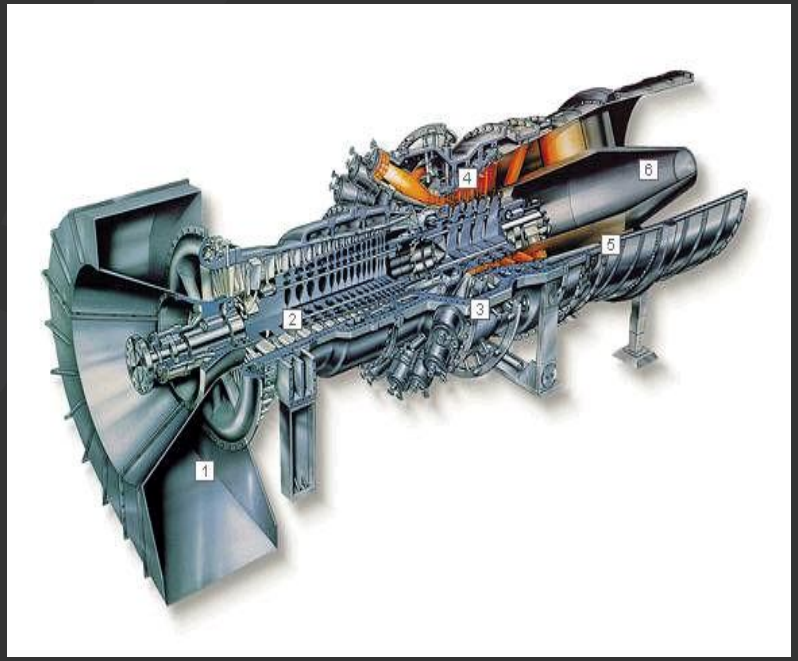
CT

- 2 simple cycle turbines (85MW and 279 MW)
- Relatively low installation cost
- Low emissions
- Starts up quickly
- High heat recovery



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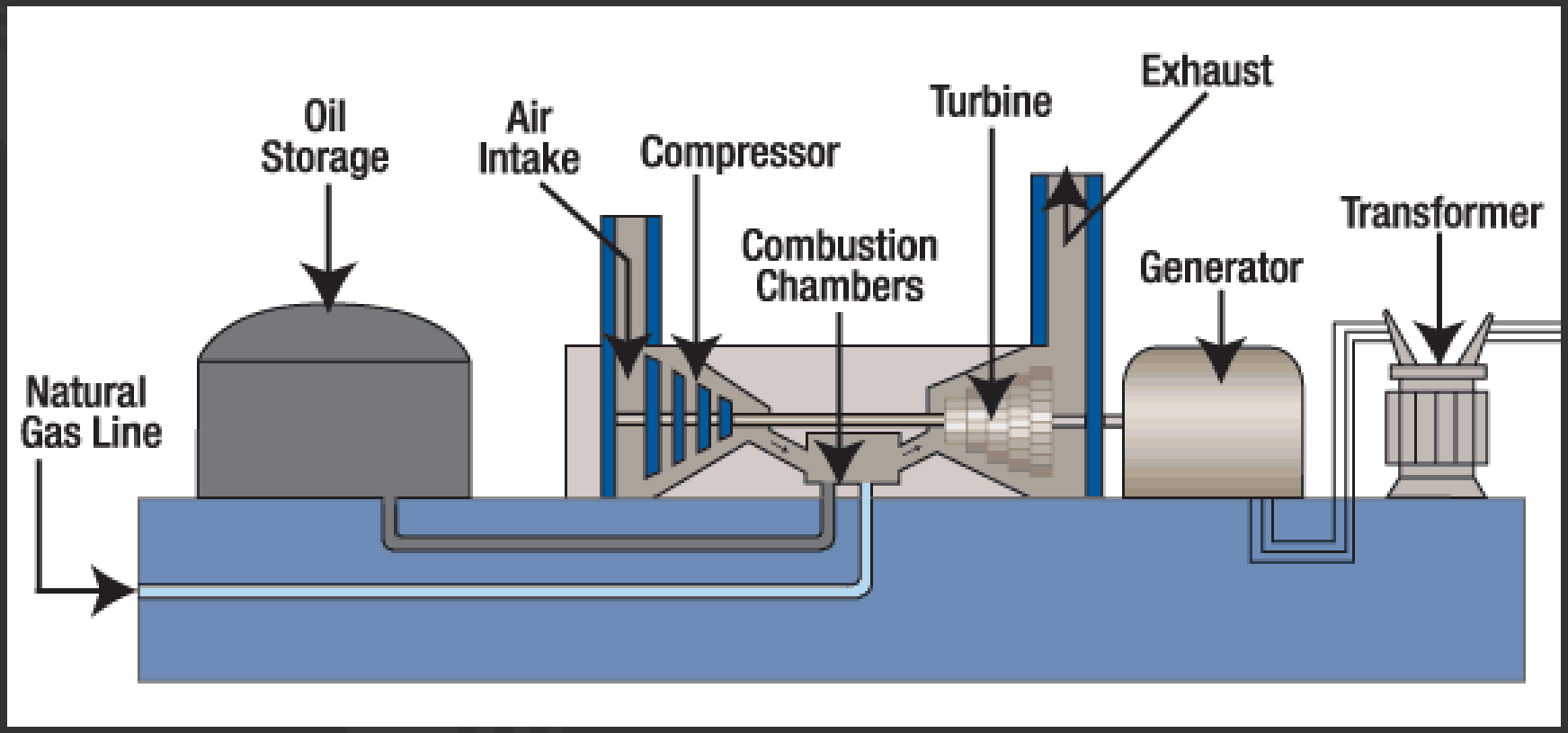
CT Power Plant



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Design Calculations

- Capital Cost
- Operating & Maintenance
- Insurance and Legal Fees
- Fuel
- Land
- Transmission Costs

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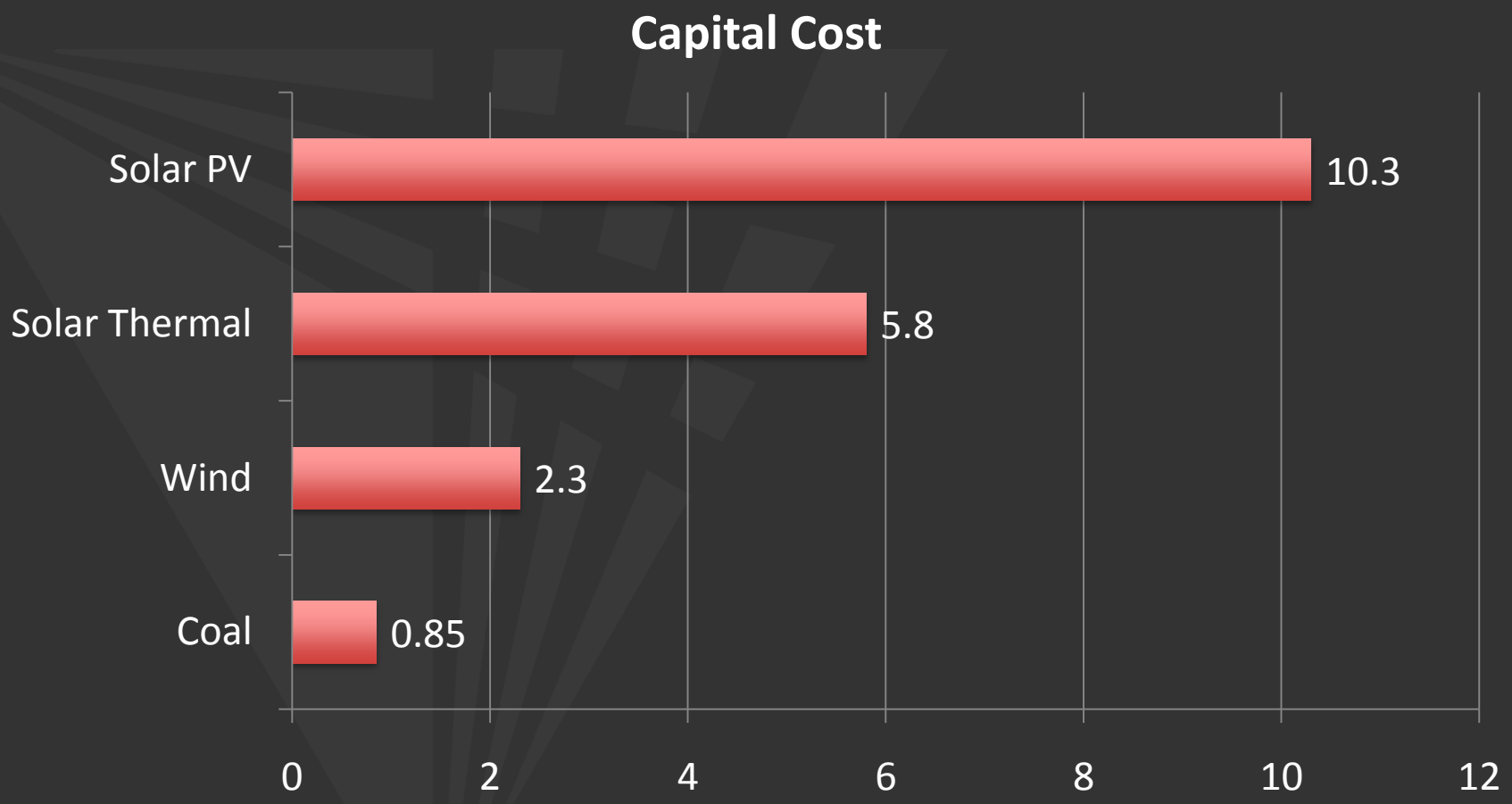
System Capital Costs



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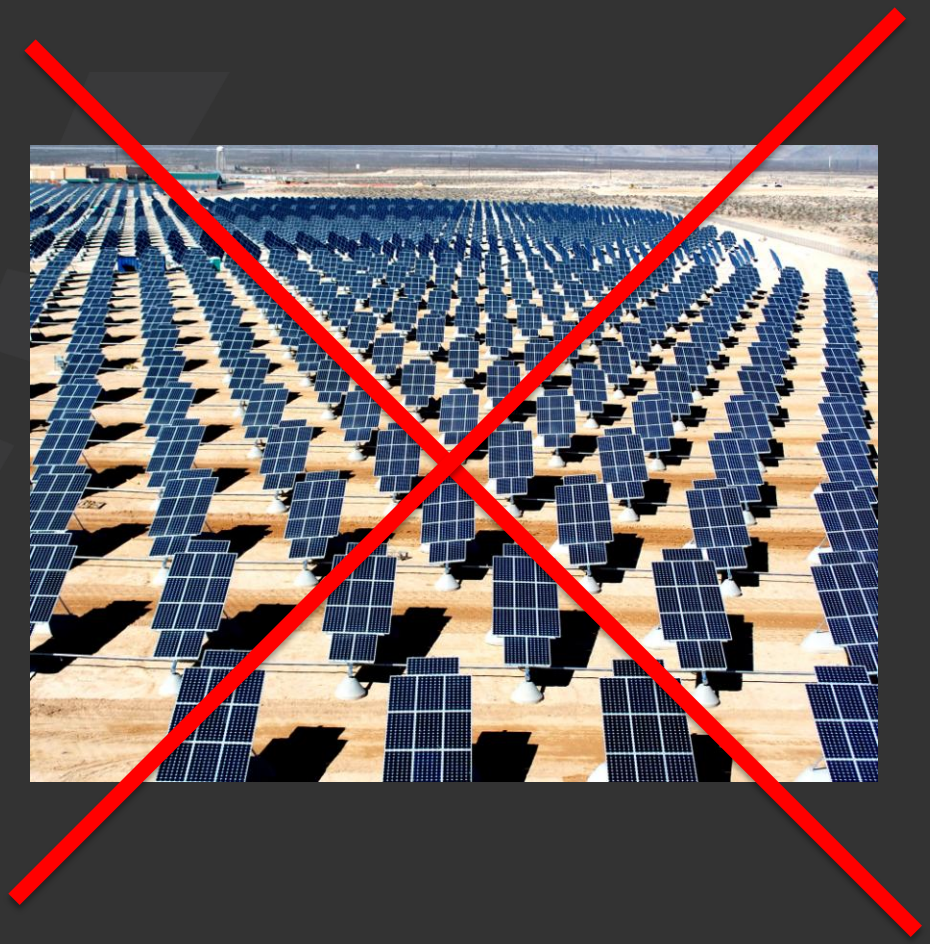
Solar is Too Expensive

- Solar would require a $5 to $10 billion capital investment
- It's too expensive to consider further



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Wind

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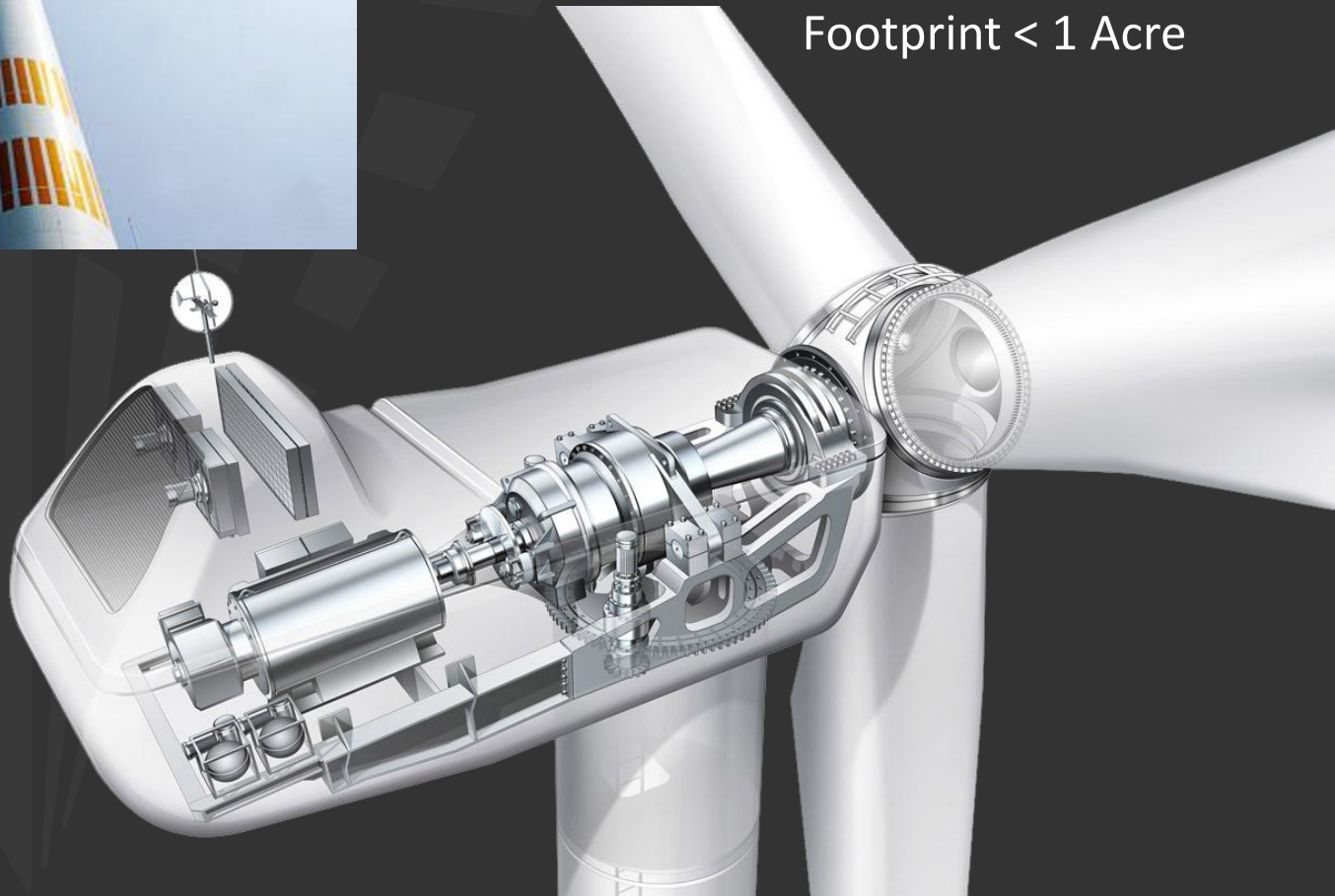
General Electric 2.5 MW wind turbine
Rotor Diameter: 100 Meters
Tower Height: 100 Meters
Footprint < 1 Acre



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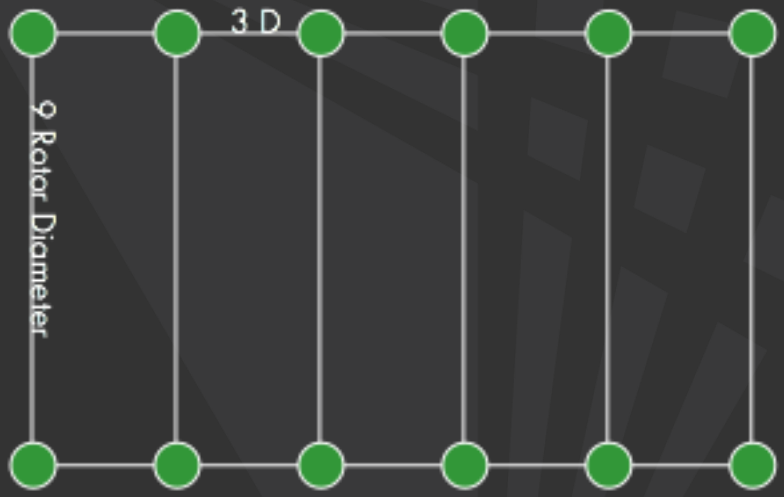
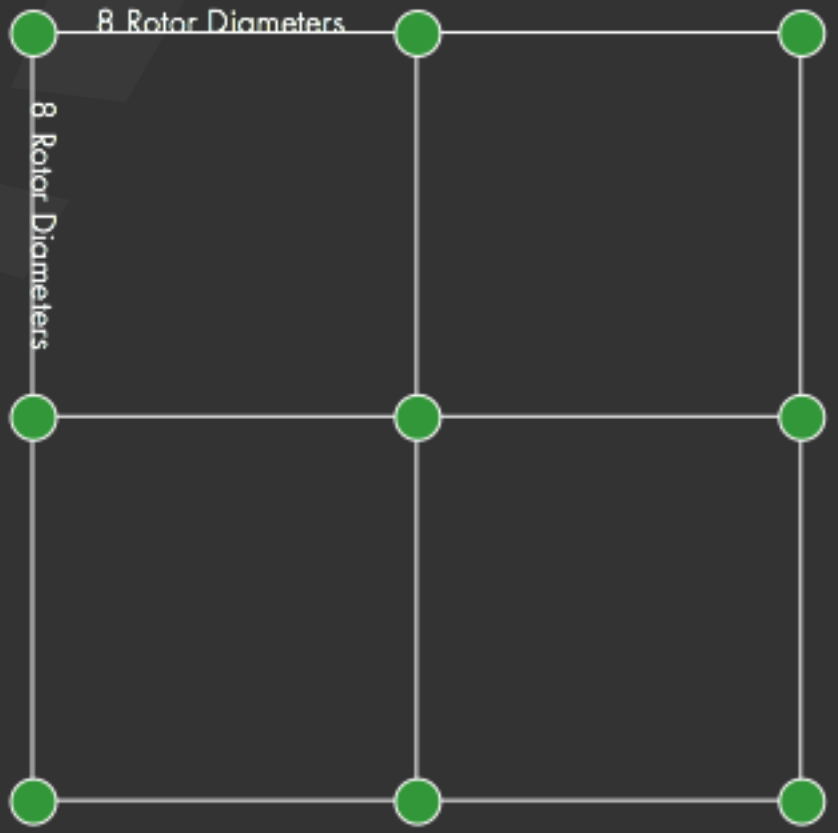
Land Use Requirements

Fixed Turbine



Rotating Turbine



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Wind Strategy

- 500 Turbines
- 5 Farms
  - 100 Turbines Each
- 1,250 MW Combined Generation
  - 30% Assumed capacity factor
  - 375 MW Average output

Location of Facilities

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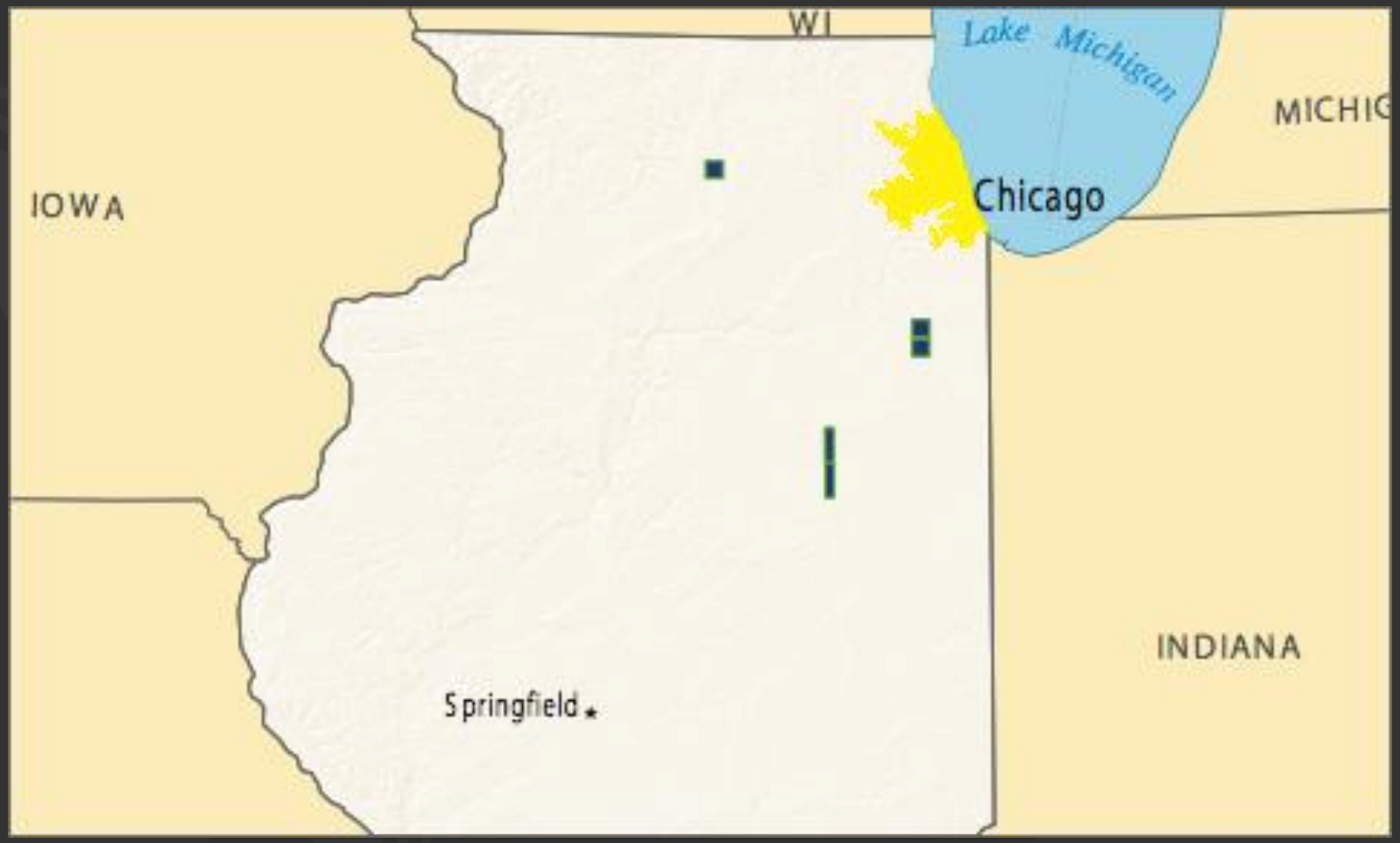

Location of Facilities

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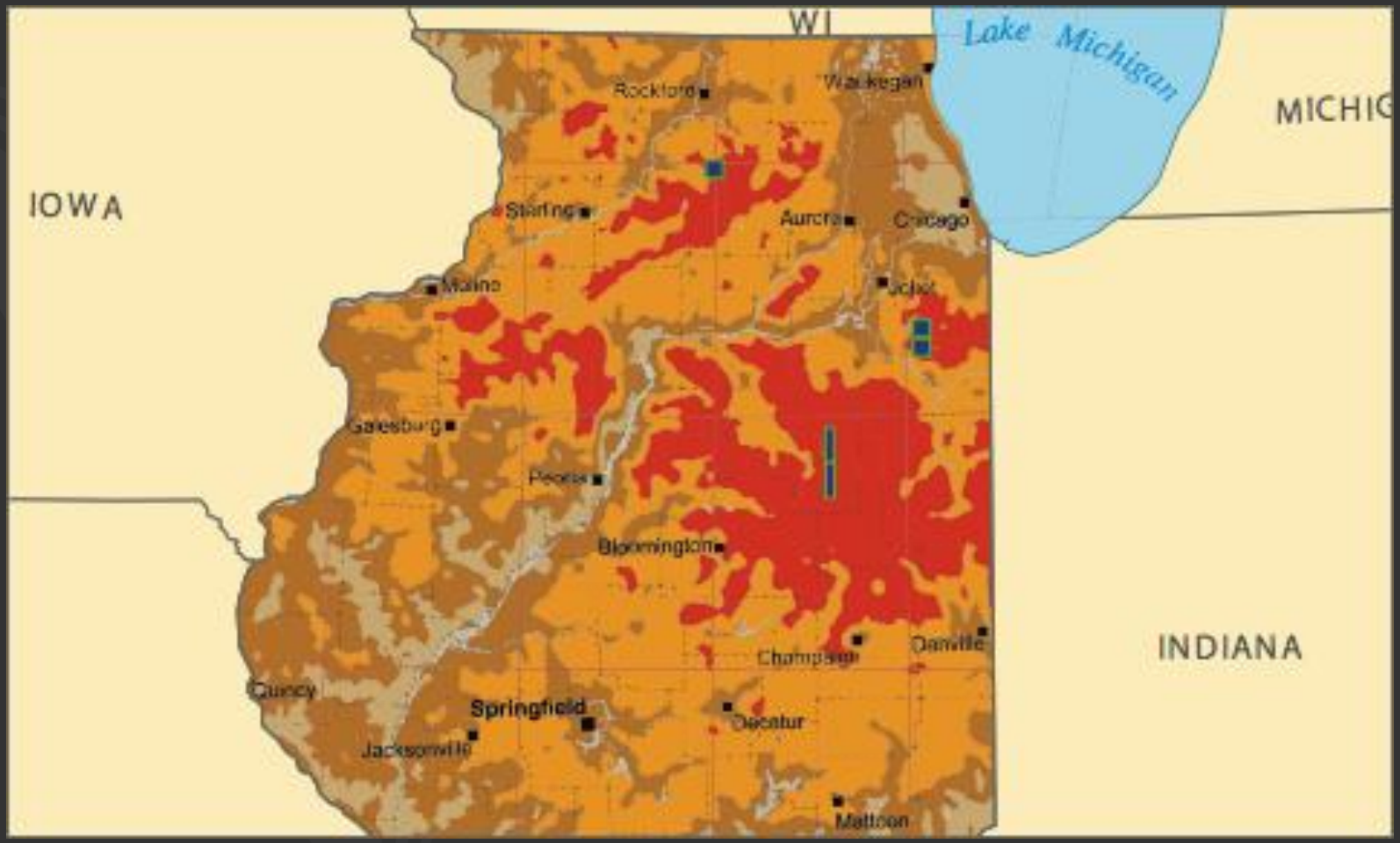

Location of Facilities

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Cost-Benefit Assumptions

- 5 year Depreciation Schedule
- 40% Tax Rate
- 3% Inflation
- 20 Year Evaluation period
- 1 year for capital development

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Cost-Benefit Analysis

- Accounts for
  - Initial Investment (Capital)
  - Sales (Cost per kWh)
  - Cost of Sales (O&M)
  - Depreciation
  - Taxes
  - Inflation

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Internal Rate of Return (IRR)

- Based on bond investment ratings based on risk
- Typical Rates
  - Coal investment 7% IRR
  - Wind 8-10%
  - Solar PV and Thermal (12-25%)

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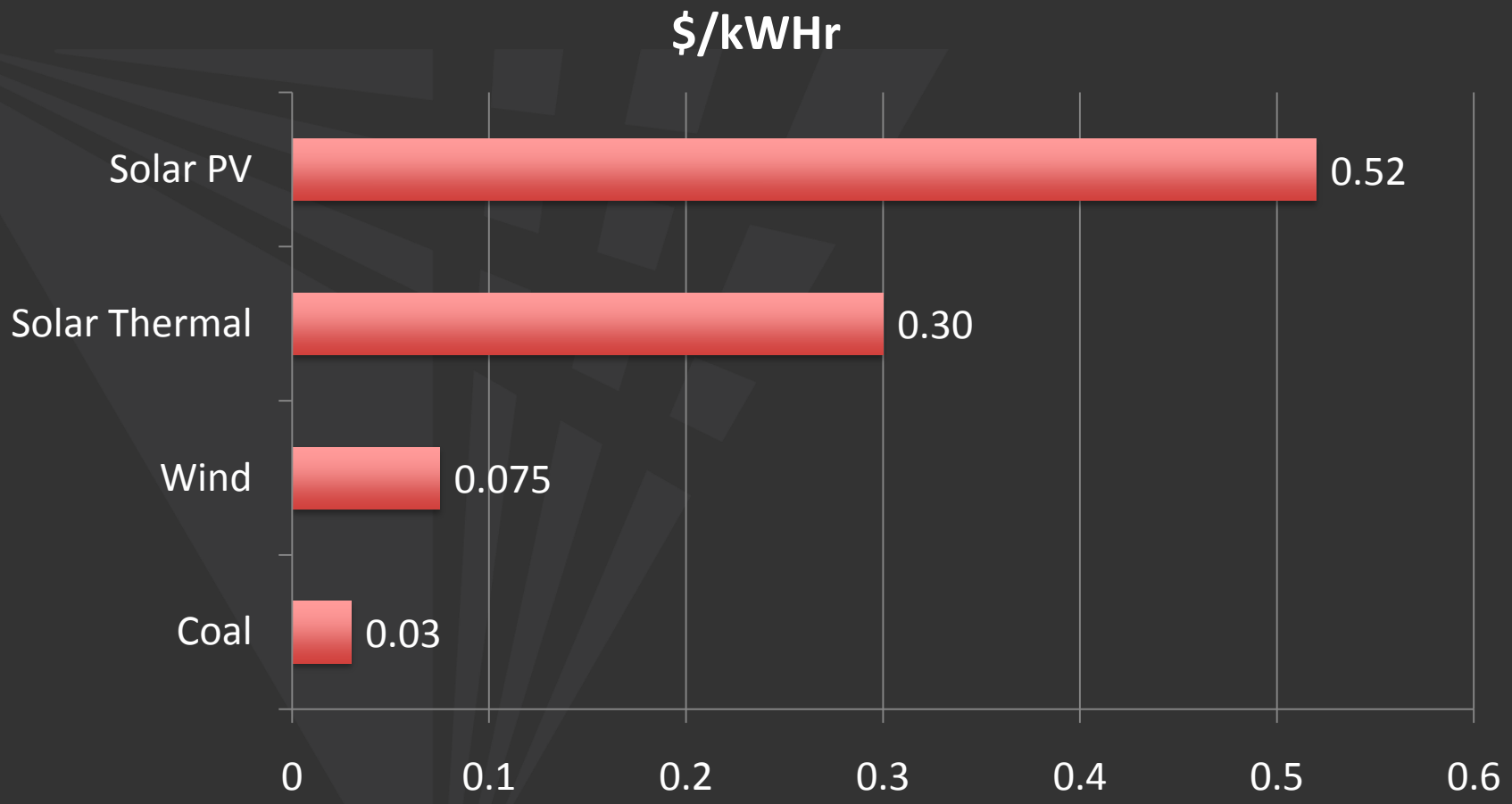
Cost of Energy



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Conclusion: Final System Design

500, 2.5MW Wind Turbines

+

2 Combustion Turbines

=

3143 GWHr/year
(360MW dispatchable)

$2.3B in capital
Internal Return Rate: 8%

$0.075/ kWHr

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Future Work

- Investigate alternative back-up sources
  - CT with Renewable Back-up
- Compare the cost of wind with…
  - carbon sequestration
  - other carbon removal processes

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What we're doing to help IPRO302.F10

- Research Summary Document
  - Explain all assumptions made
  - Explain sources and their importance in industry
- Easy way to pass along research

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QUESTIONS?

Chicago Energy Assumption

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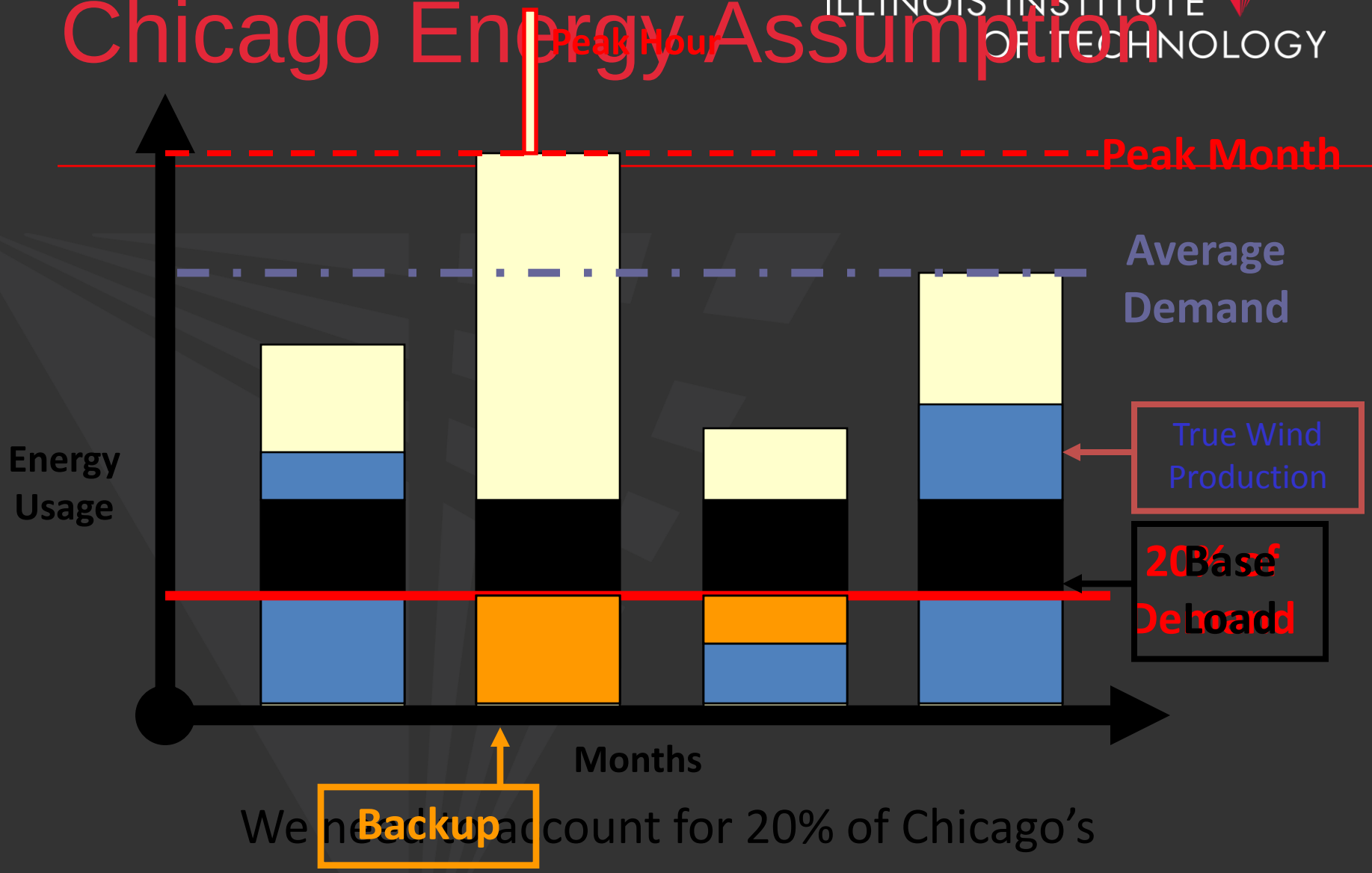

We need to account for 20% of Chicago's power use

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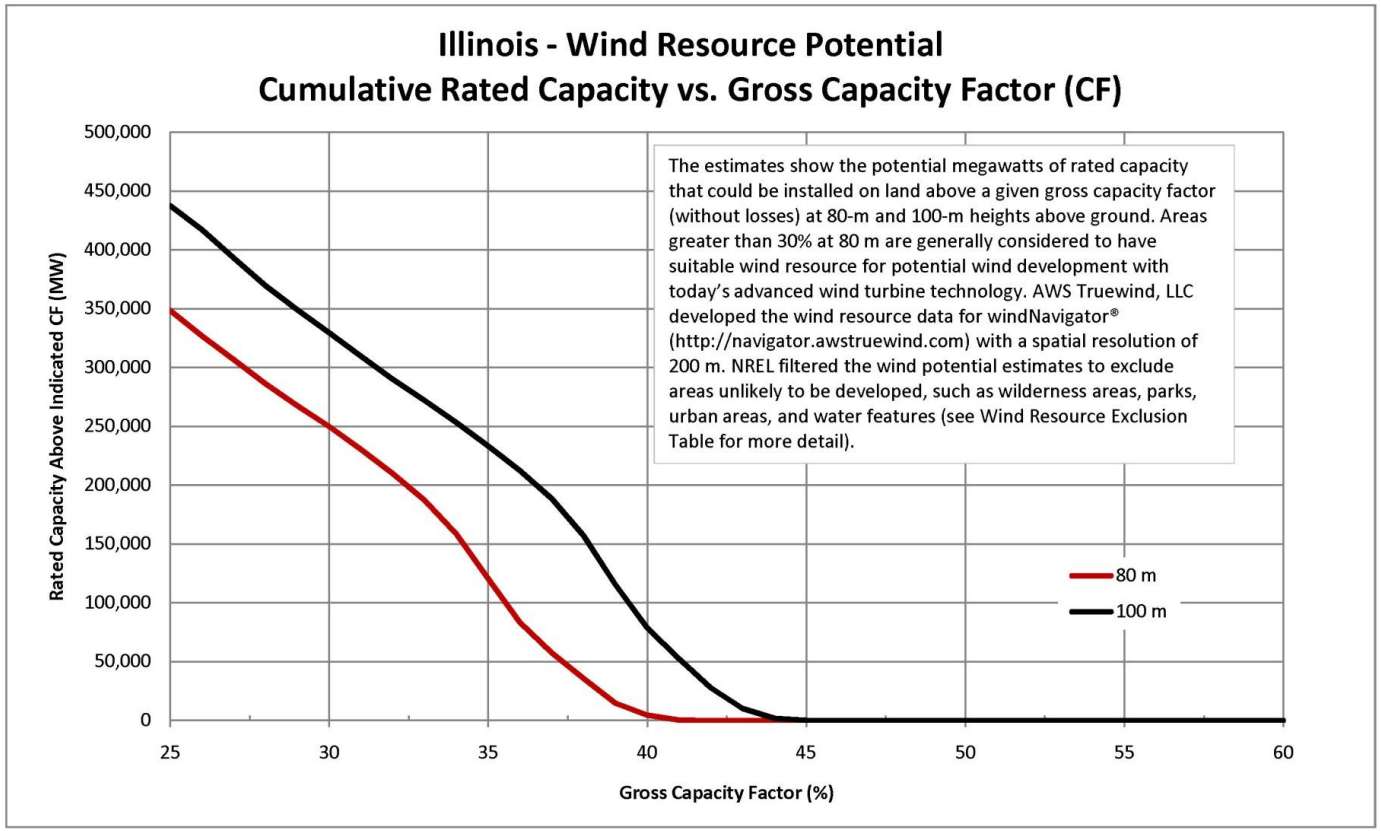
Levelized Energy Cost



NREL
National Renewable Energy Laboratory
Innovation for Our Energy Future

AWS Truewind

State	Total (km^2)	Excluded[2] (km^2)	Available (km^2)	Available % of State	% of Total Windy Land Excluded		Installed Capacity[3] (MW)	Annual Generation (GWh)
Illinois	70,763.6	20,787.1	49,976.4	34.25%	29.4%		249,882.1	763,529

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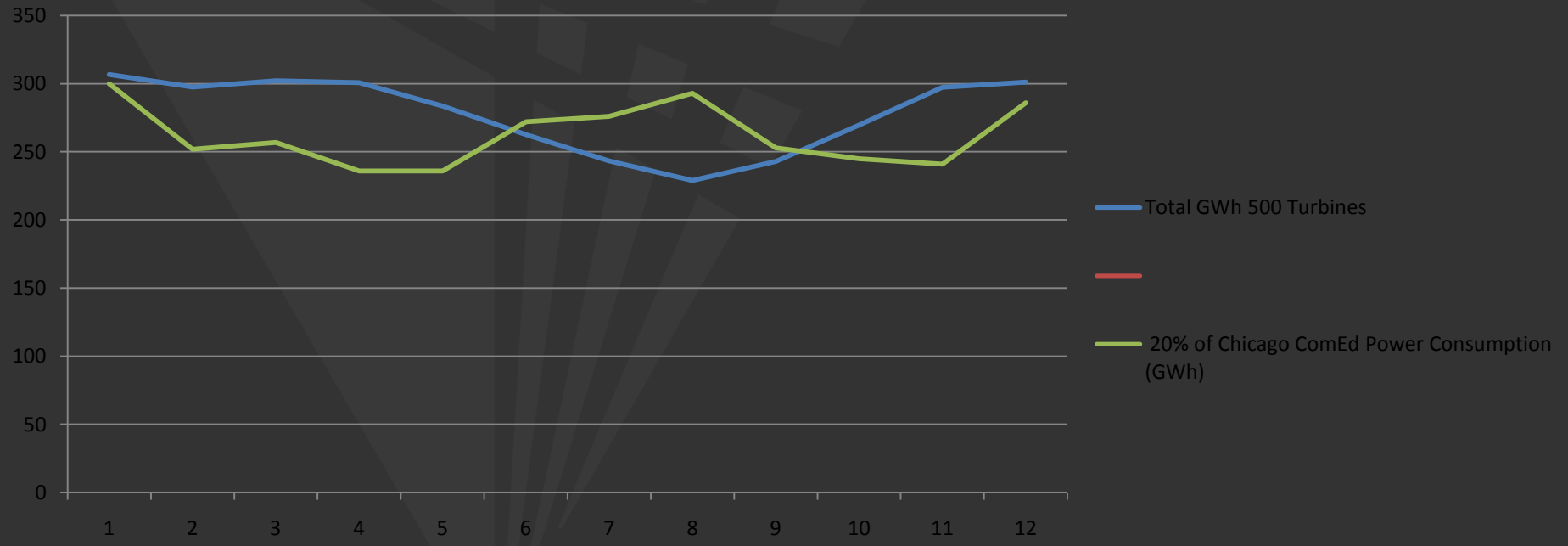
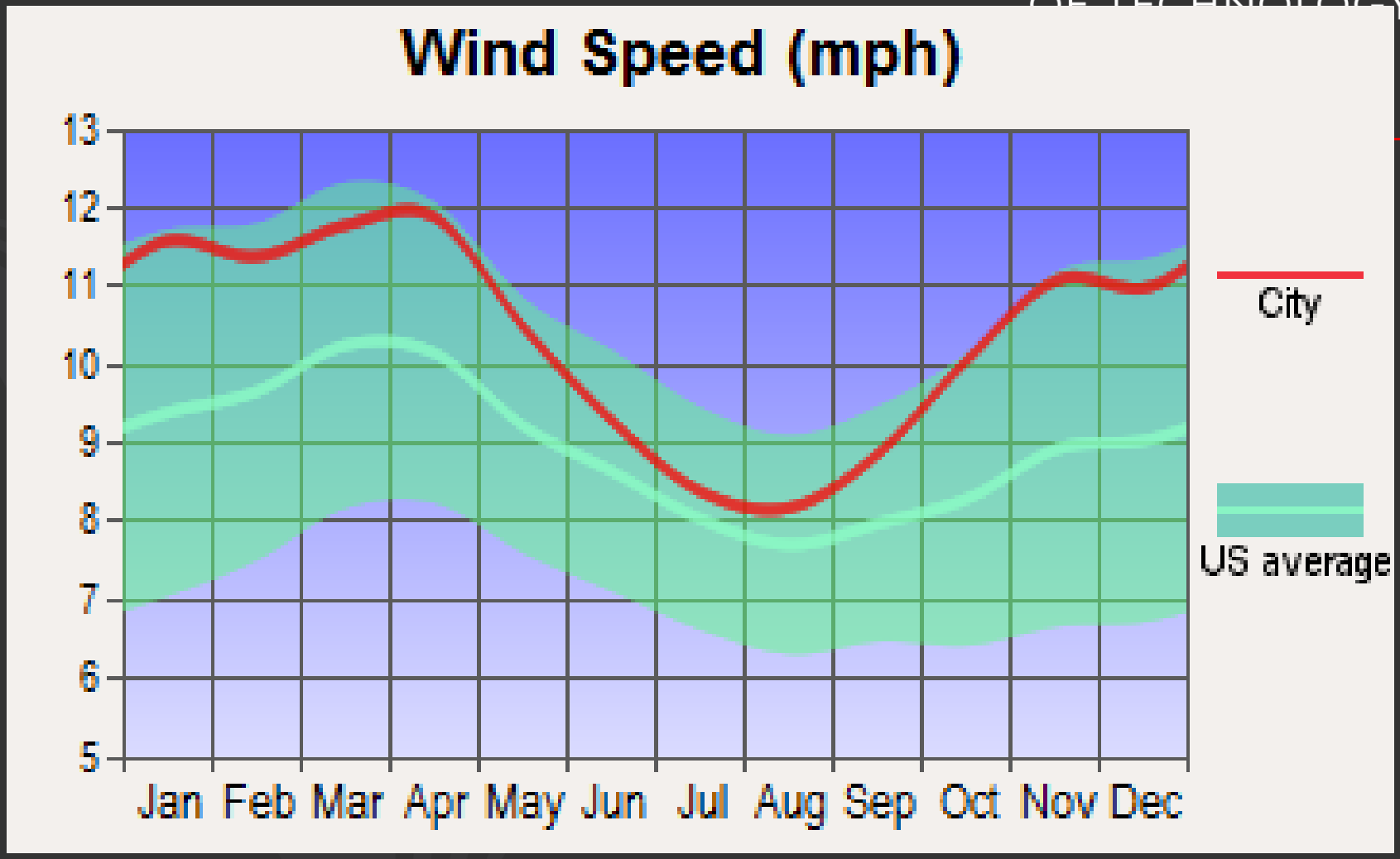
Turbine Analysis

	Turbine Power Output (MW)	Annual Electrical Consumption (MWh)	Avg. Demand (MWh/ hours per year= MW)	Capacity Factor	Adjusted Supply (MW)	Number of Units
Wind Turbines	2.5	3,143,000	358.7899543	0.3	1195.97	**478.39**

479 Turbines adjusted to **500 Total turbines** for Transmission and Transformation losses




Wind Speed (mph)
13
12
11
10
9
8
7
6
5
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
City
US average

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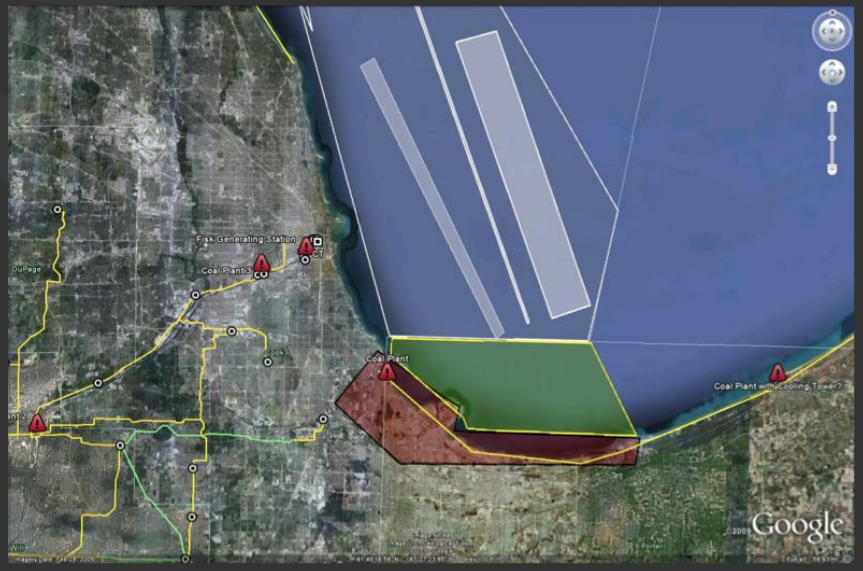
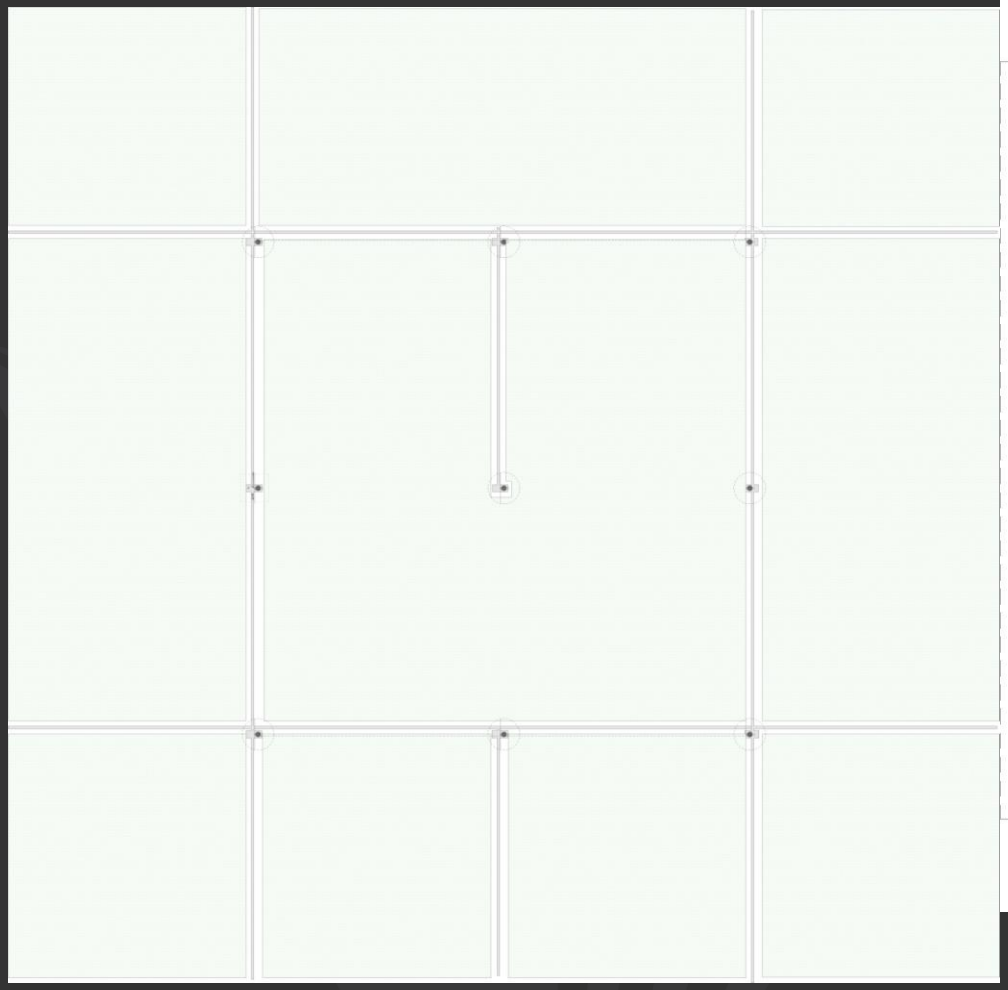
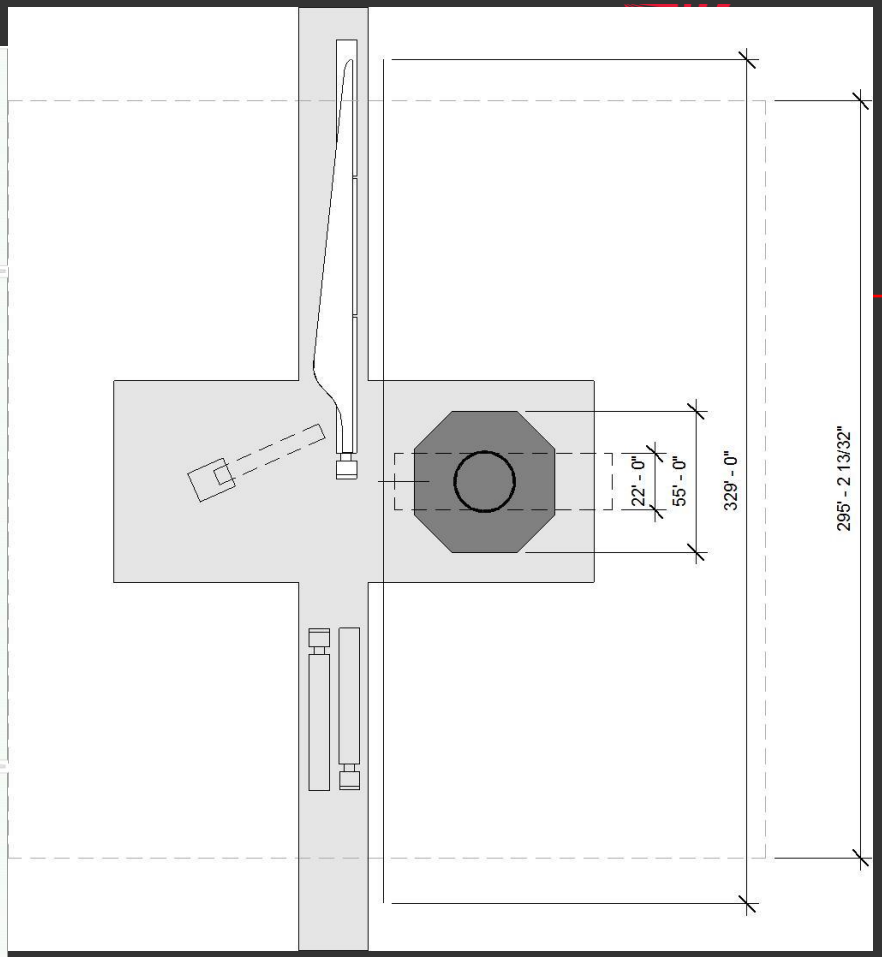
Offshore Wind

- Issues
- - Increased capital cost- Taller Towers, Specialized Foundations, Operations and Maintenance, Weatherproofing.
- - Shipping Lanes
- - It is currently Illegal
- - Aesthetic opposition and Ecological concerns

- Benefits
- Increased Capacity Factor of 5 – 10%
- Increased consistency and direction
- of wind
- Substantial decrease in
- transmission distance






22' - 0"
55' - 0"
329' - 0"
295' - 2 13/32"