Energy and Environmental Analysis Group

LA-UR-

# Factors Influencing US Market Viability for HTS Applications

Fred Roach

Alan Berscheid

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# Mission

**Objective** - Identify, understand, and evaluate key factors and market forces that will influence adoption of HTS technology in power systems.

**Approach** - Develop an analyses framework, required tools, and supporting data to assess the relative viability of HTS applications on both a geographic specific and future time period basis.

# Overall Approach

- **Examine effects of HTS on the bulk power system at a local level (system-level issues)**
  - Losses
  - Voltage Concerns
    - Compensation
    - VAR production
  - Transmission constraints
    - Congestion relief
    - Upstream and downstream impacts
    - Alternative transmission support options

# Overall Approach (cont)

- **Careful review of national, and regional issues and trends**
  - Restructuring
    - Congressional activities
    - FERC
  - Alternative technology developments
    - FACTS
    - EHV DC
  - Environmental pressures
  - Distributed generation & demand-side management
  - Reliability requirements
  - Critical infrastructure surety & protection

# Overall Approach (cont)

- **Careful analysis of regional and local conditions, future projections, and accompanying uncertainties**
  - Identify attractive sites for existing HTS cable replacement
  - Account for probable transmission topologies
  - Include both alternative loading profiles and generation mix options in future evaluations
  - Integrate energy end use considerations

# Overall Approach (cont.)

- **Market forces**
  - Total costs of HTS technology
  - Demand growth
- **HTS system issues**
  - Increased experience with
    - Reliability
    - Maintainability
  - Proper accounting of life-cycle cost issues
- **Deregulation Uncertainties**

# West's Transmission System

"… the estimated cost of bringing the regional transmission system back to a stable system is $10-30 billion, to be spent over the next 10 years on new transmission lines and upgrades of existing facilities."

(EPRI, June 25 White Paper)

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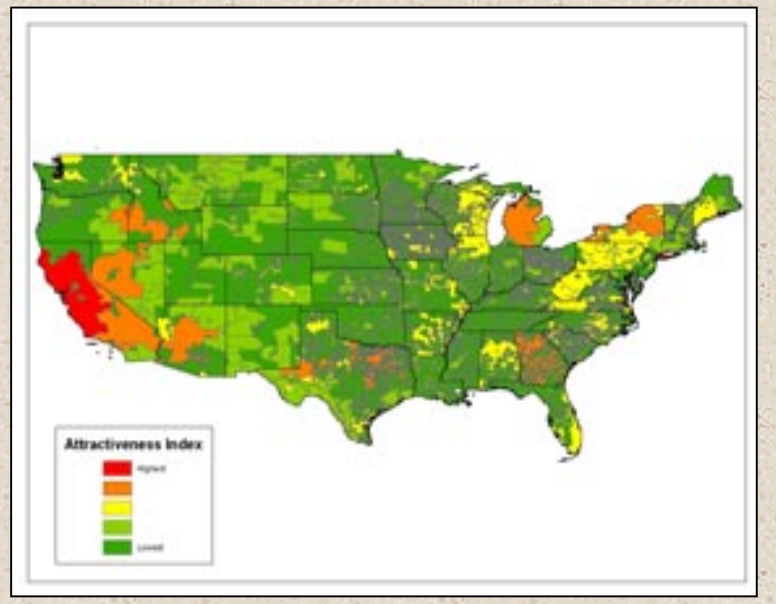
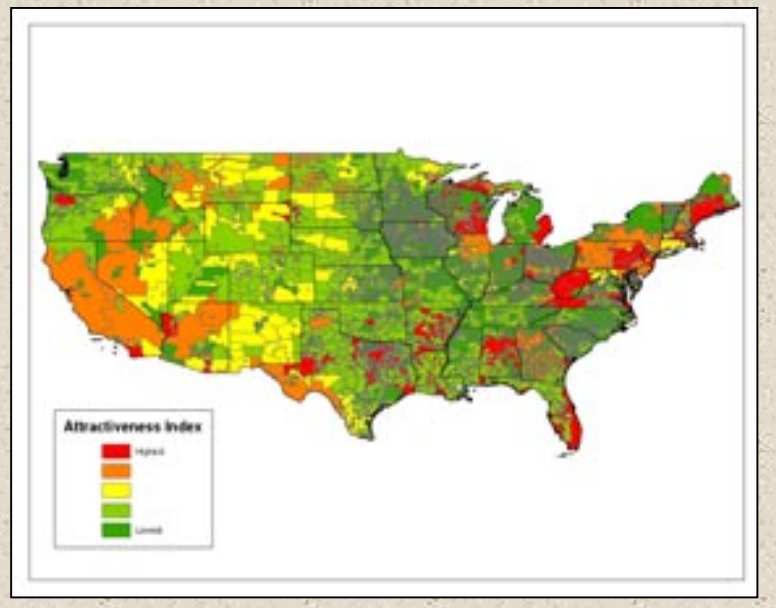
# Market Candidate Rankings

## Cables




- Price/Cost of Generation
- Transmission Losses
- Growth Areas
- Underground Cable Locations
- Line Loading

## Transformers




- Price/Cost of Generation
- Transformer Losses
- Growth Areas
- Number
- Age
- Transformer Loading

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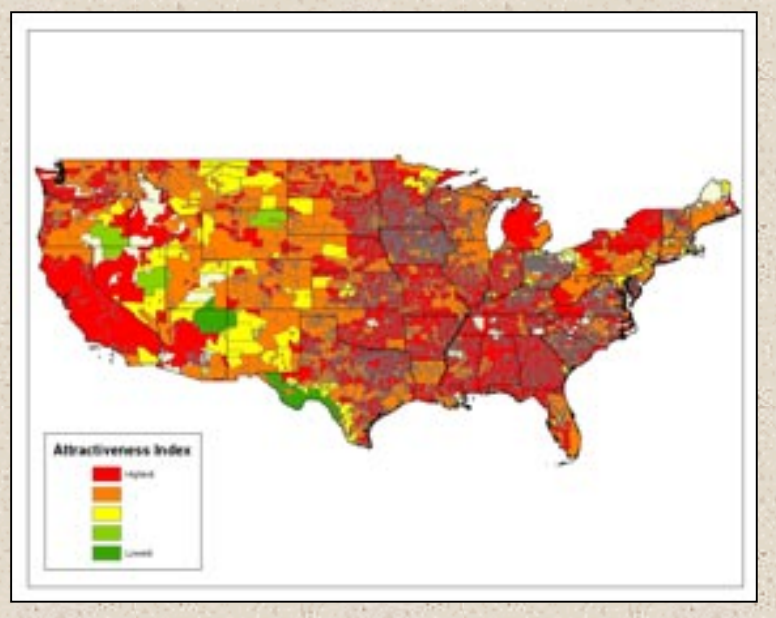
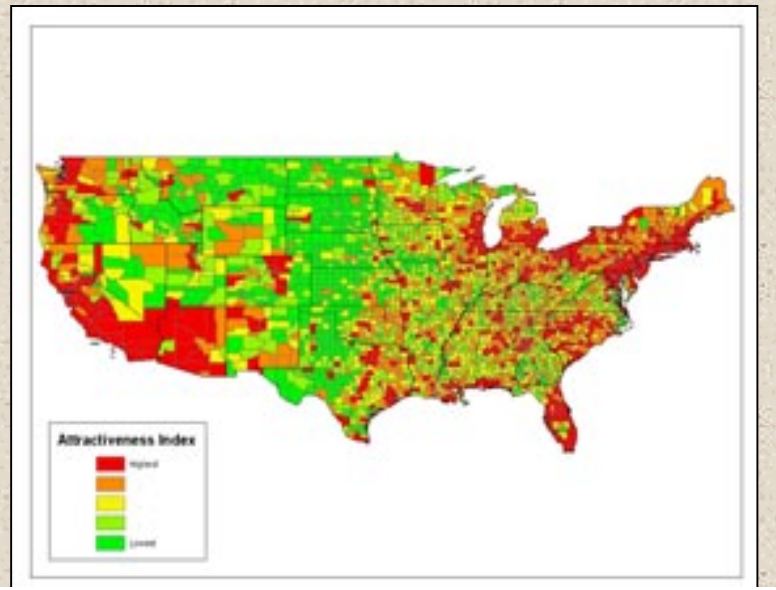
# Market Candidate Rankings

## Storage




- Price/Cost of Generation
- Reserve Margins
- Growth Areas
- Transmission Constraints
- Fluctuations in Daily Loads

## Motors




- Price/Cost of Generation
- Efficiency
- Growth Areas
- Size
- End Use

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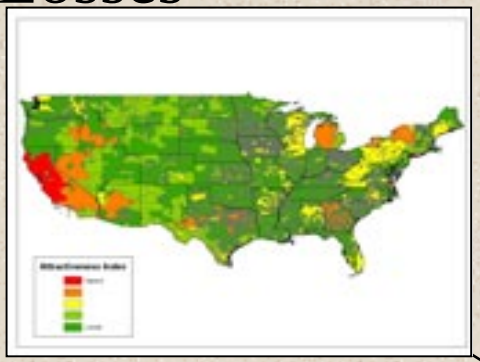
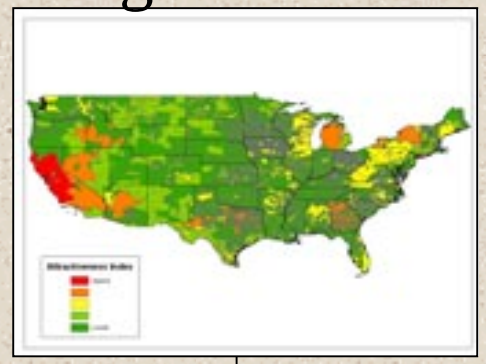
# Influences on Cable Market Potential

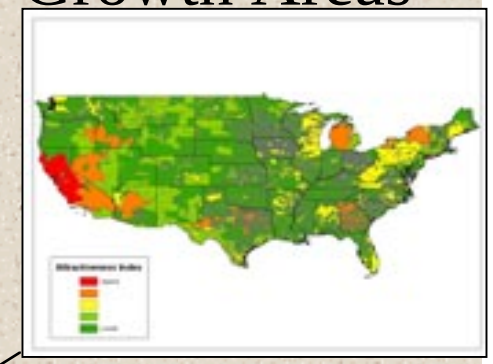
Losses



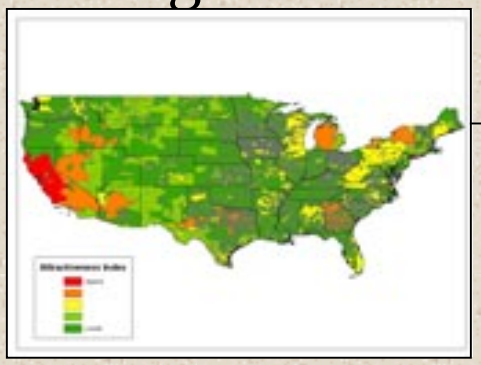
Length



Growth Areas

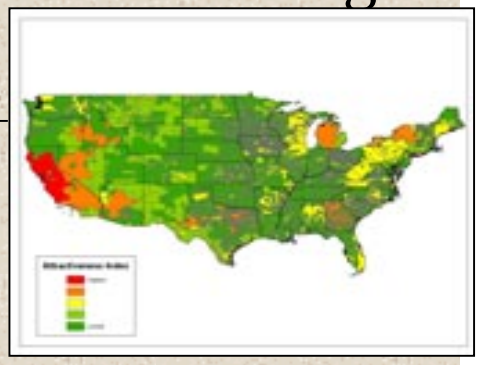


Pricing

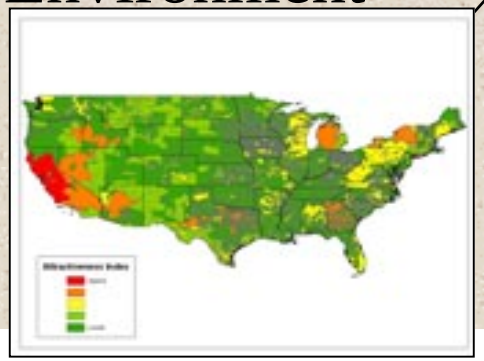


Cables

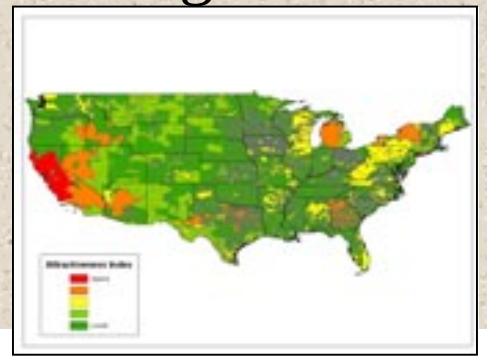
Line Loading



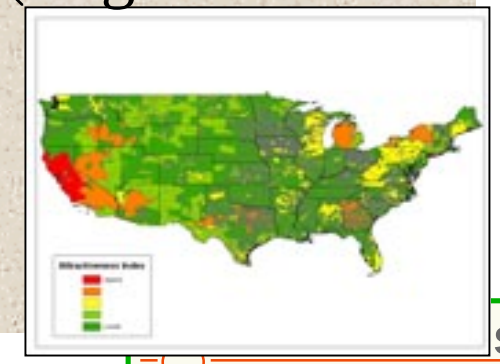
Environment



Underground Cables



Regulation



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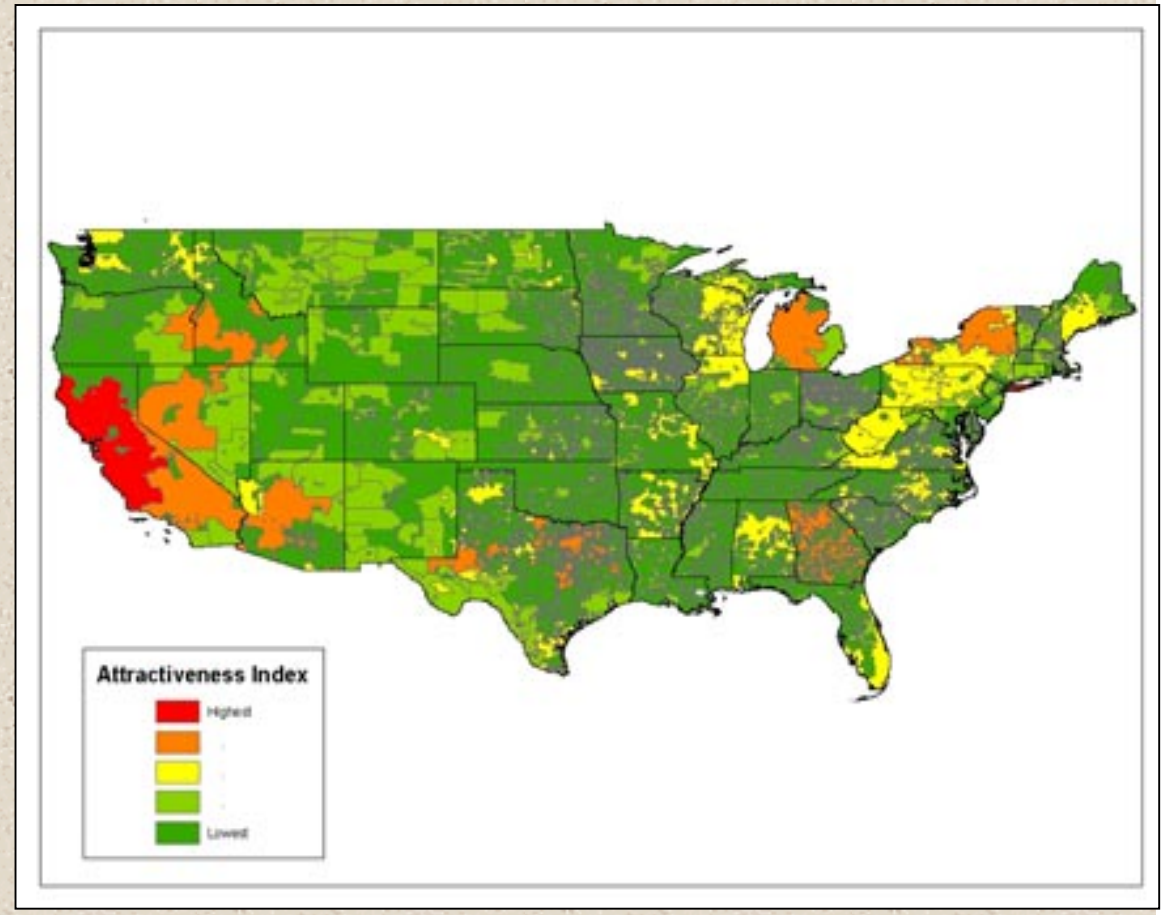
# Price/Cost of Generation

The higher the generation costs, the greater the savings potential from lower line losses and lessened spot market purchases.




Spot prices, unit lamdas, contract specifications, market hubs.

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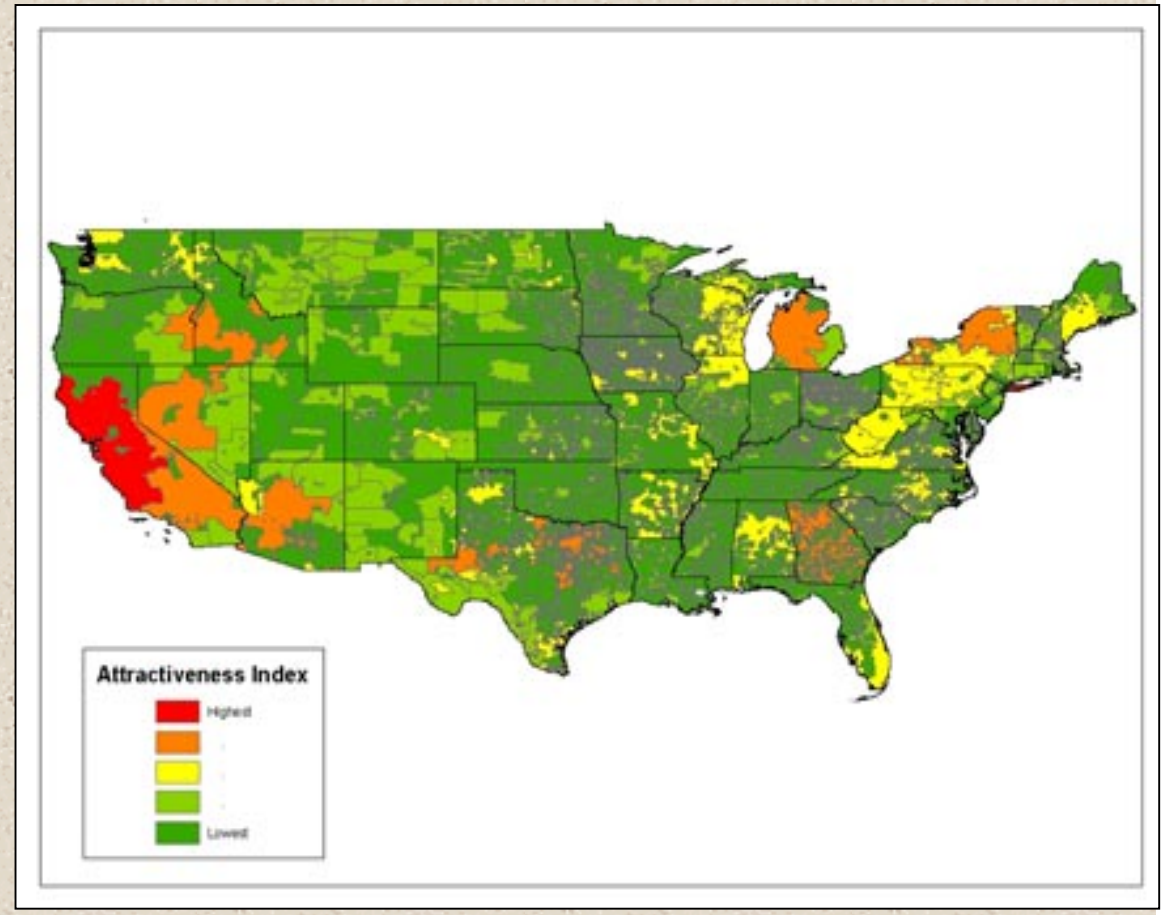
# Underground Cables

- Current miles of underground and marine cables
- Proposed projects
  - International
  - East Coast
  - etc.




Estimates from public, commercial, and proprietary data sources. Proposed projects from planning reports and project announcements.

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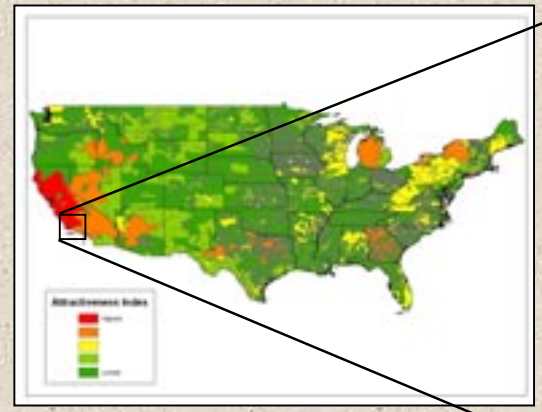
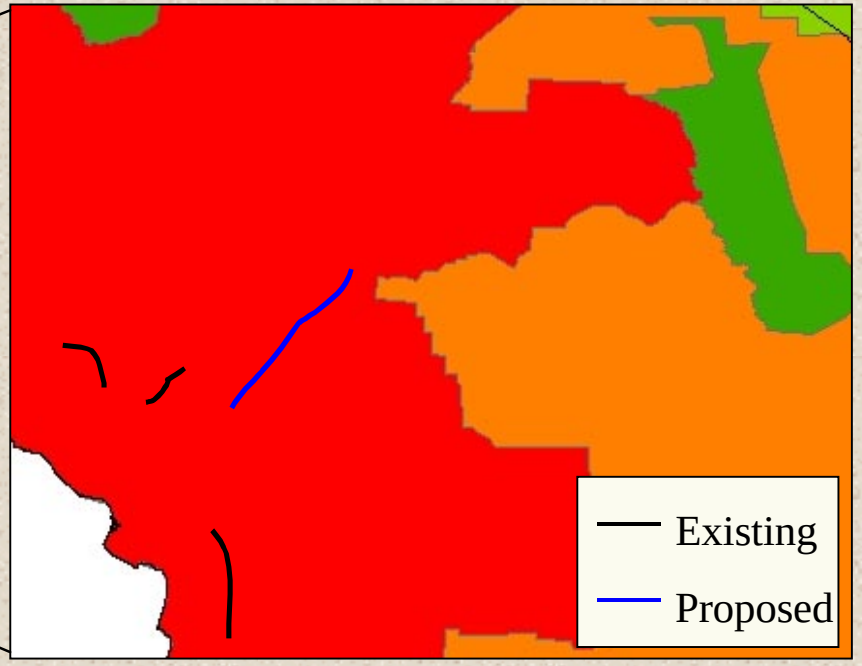
# Underground Cables Locations



Cable locations




Summary:

| kV | Miles |
|---|---|
| 13 | 123 |
| 69 | 95 |
| 115 | 23 |
| 138 | 15 |

65% of cables > 20 years old
many in high demand areas

Potential projects for near-term consideration.

Based on utility maps, one-line diagrams, and utility discussions.

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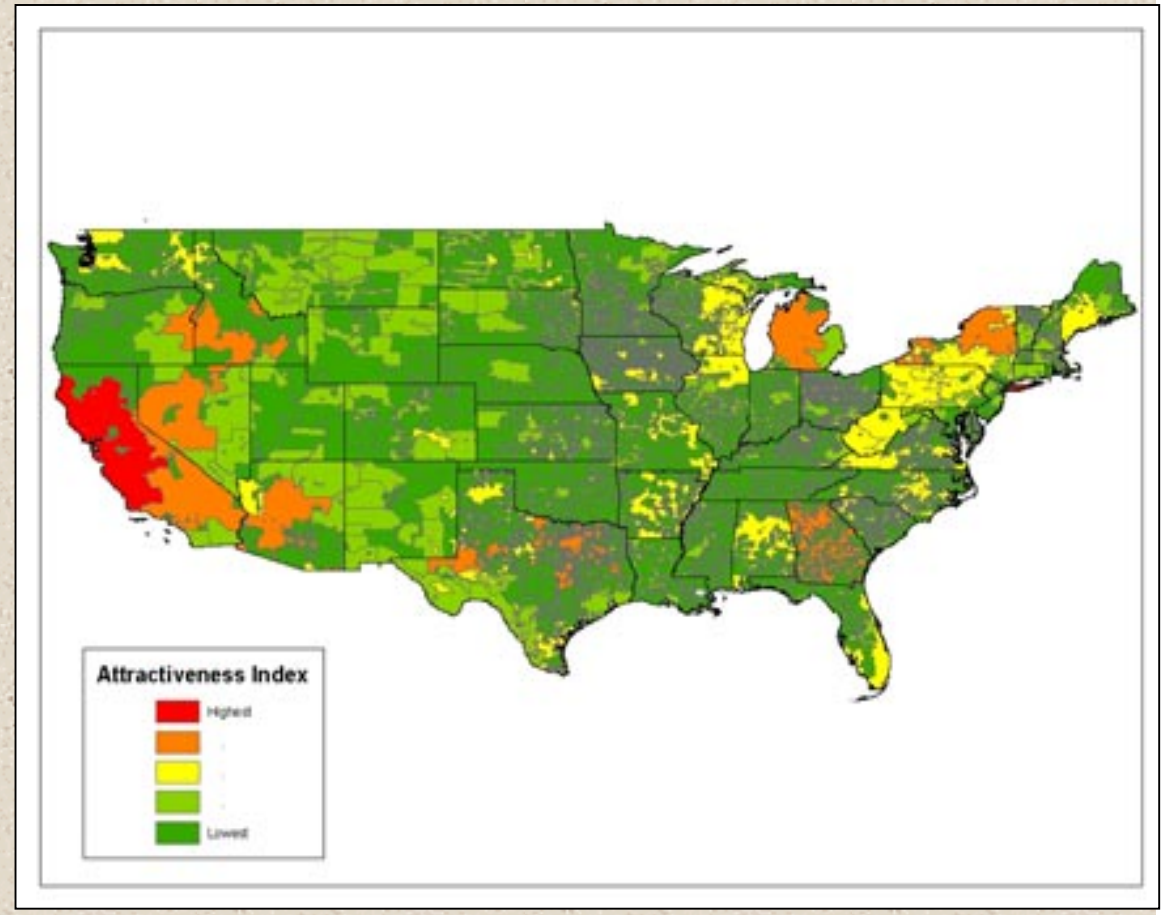
# Length

The shorter the cable run, when coupled with congestion issues, high power prices, and/or high losses should significantly increase the attractiveness of cable replacement.




Based on utility maps, one-line diagrams, constructions from existing analyses, and utility discussions.

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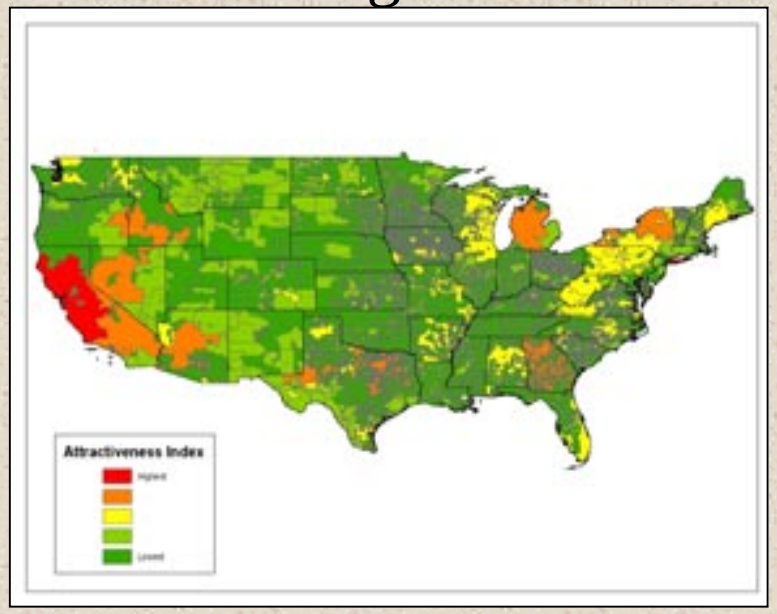
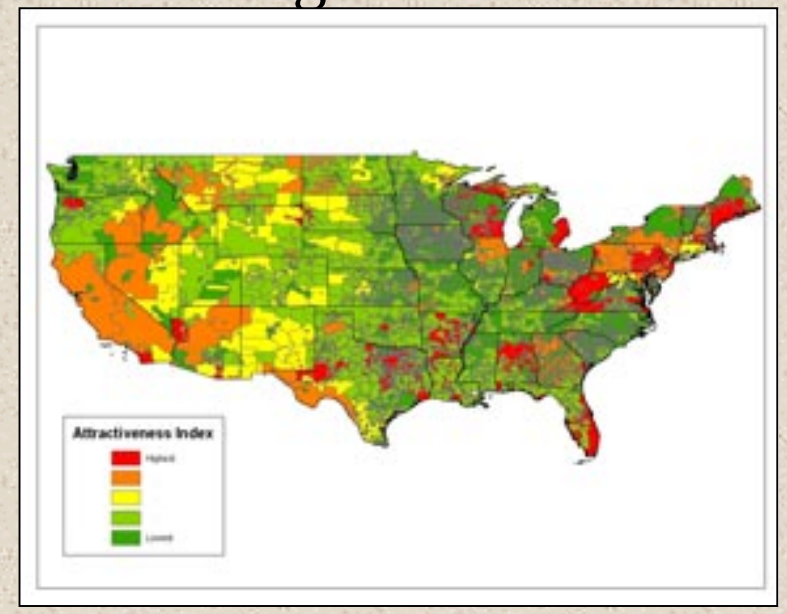
# Growth Areas

Percent load growth




MW load growth




The greater the growth pressures, when coupled with limitations in the current bulk power system, the more significant should be opportunities for HTS consideration and adoption.

Based on utility, public, and commercial energy, demographic, and economic forecasts.

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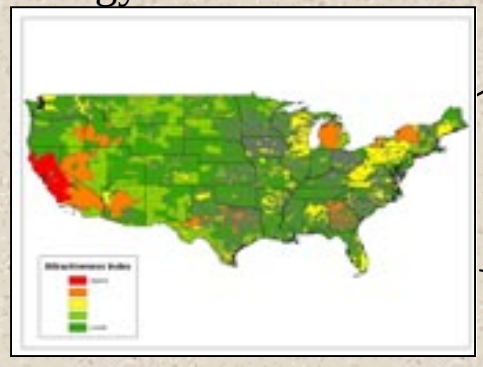
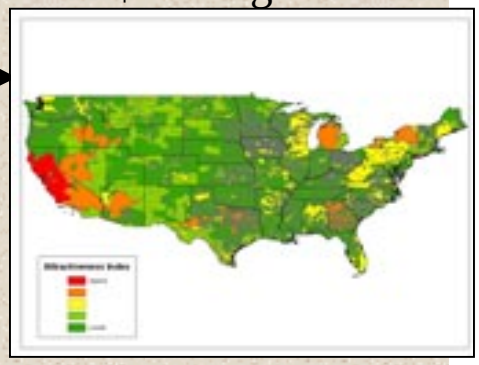
# Transmission Losses

Total MW Loss

Energy Costs

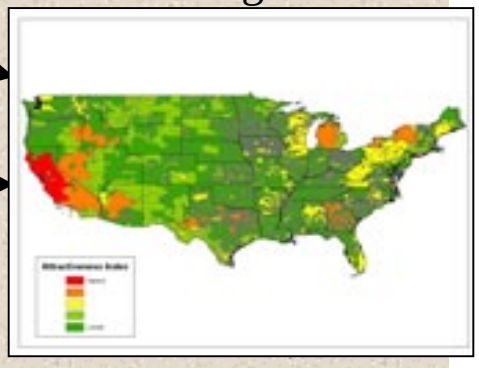


Total $ Savings



MW/Mile Loss

$/Mile Savings



- Areas with high MW losses may need to replace a lot of cable to significantly reduce losses.
- Lines with high MW/Mile losses coupled with high energy costs should be attractive earlier.

Yearly load profiles, and contract and market costs.

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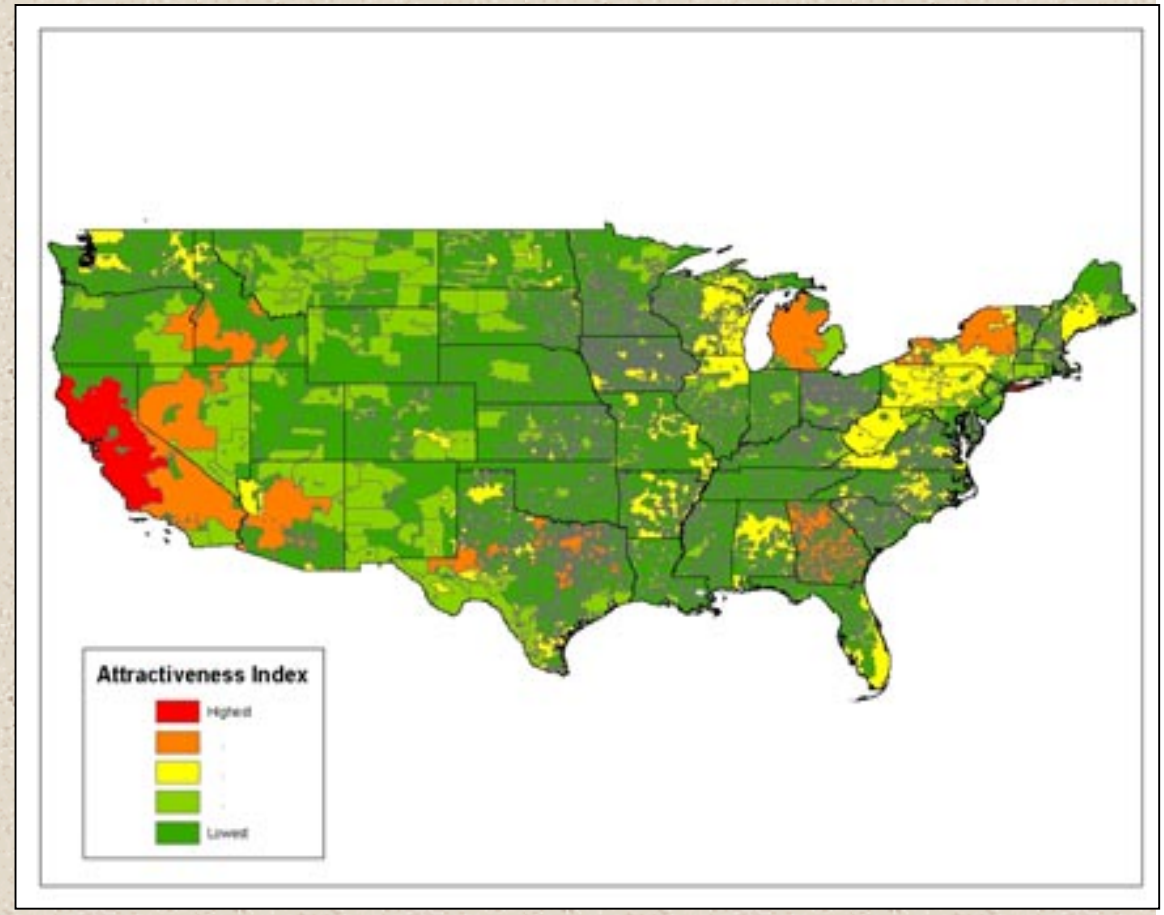
# Line Loading

Reduce transmission constraints

- Critical paths
- Alternative paths
- Upstream and downstream issues

Allow larger bulk transfers




Multiple scenarios for power flow analyses, yearly load profiles, and HTS cable parameters.

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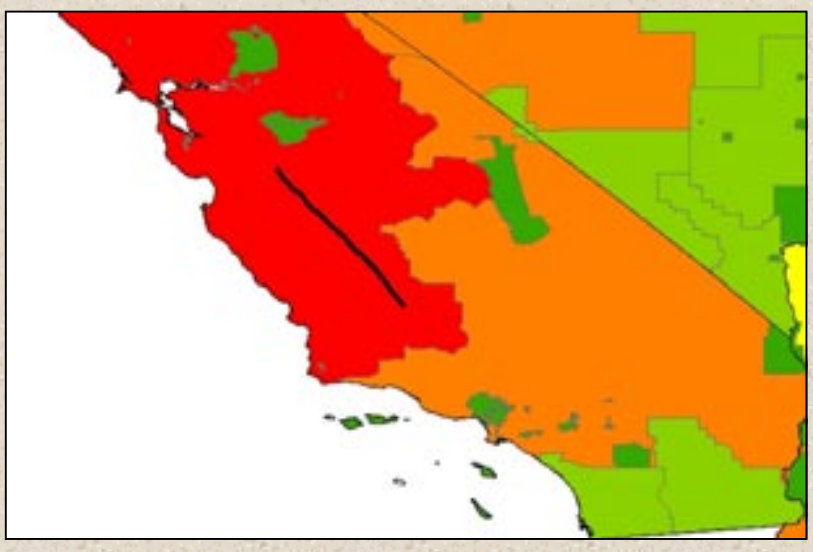
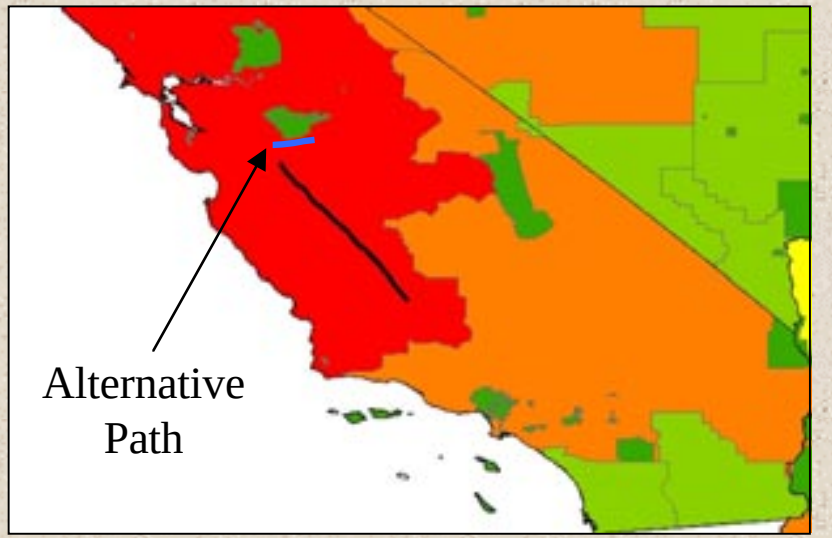
# Path Identification



Replacing a congested path will result in lowered congestion on the desired line, but may increase congestion elsewhere and result in unwanted system affects such as over-voltages.

Replacing an alternative path may also reduce congestion, and be less expensive and result in greater system reliability.




HTS cable parameters and multiple power flow scenarios and analyses.

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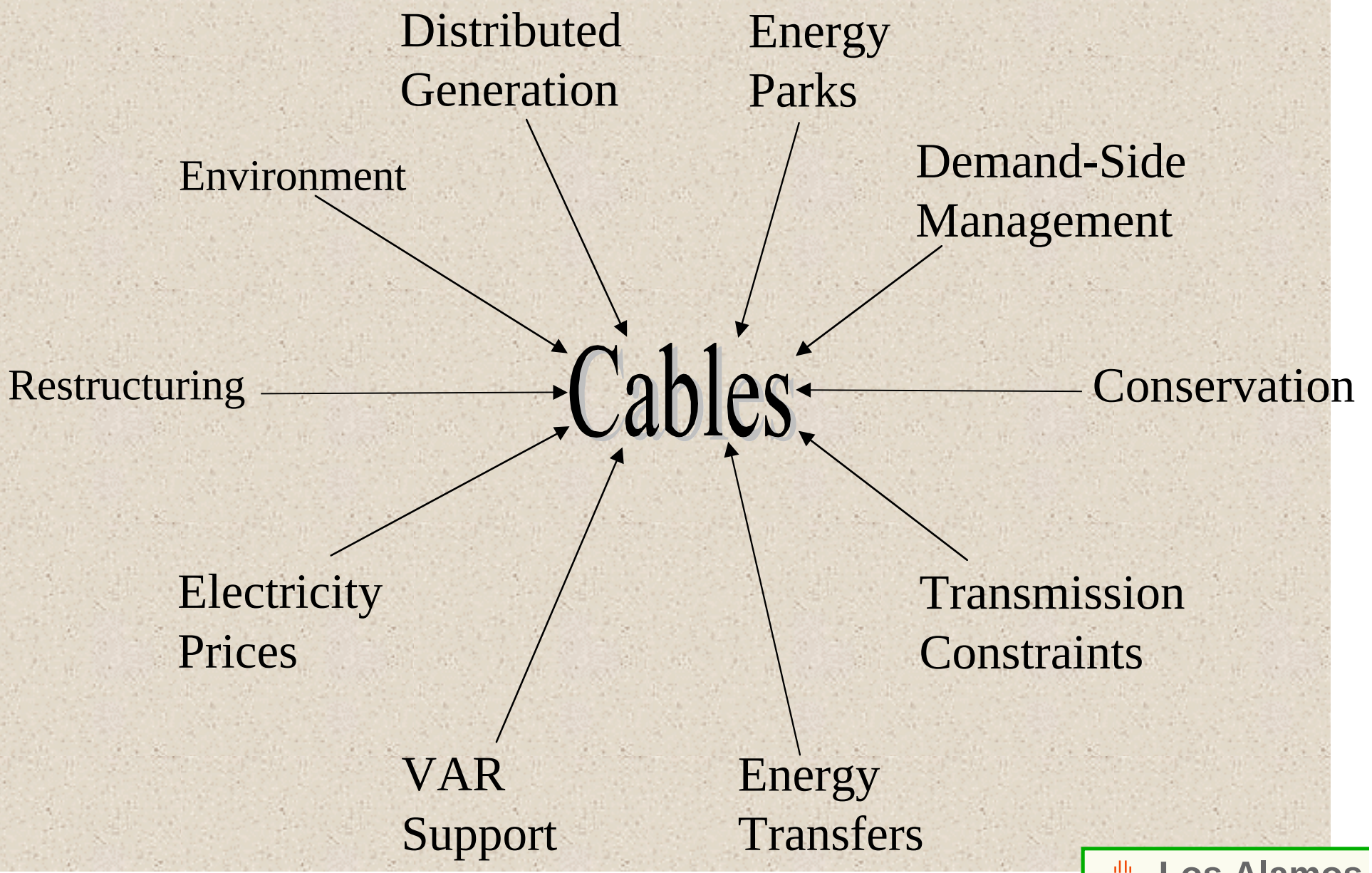
# Influences on Cable Deployment



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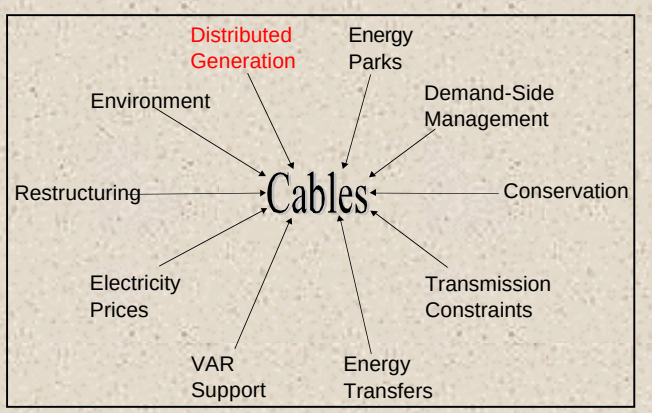
# Distributed Generation




"Distributed Generation" refers to small-scale stationary applications of electric generating technologies.(CEC)

Estimates have been made that 20-25% of generation will be from distributed sources by 2010.

- Reduces the need for large, centralized energy stations.
- Reduces the need for transmission and distribution upgrades.
- Reduces transmission losses.
- Provides an additional level of system security.
- Potentially reduces transmission bottlenecks (power produced closer to customer load).
- **May <u>lower</u> the need for HTS cable technology!**

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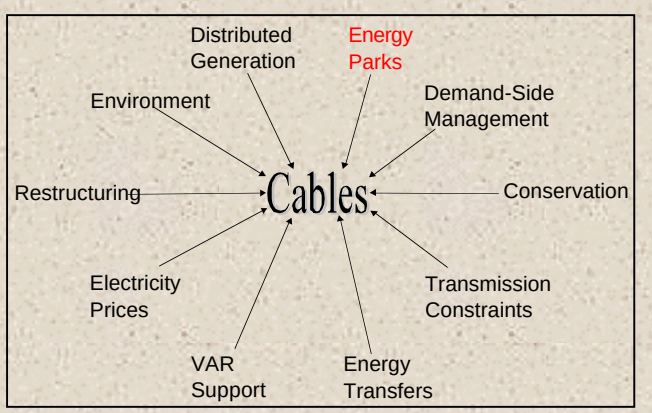
# Energy Parks




Energy parks/campuses are centralized locations of large-scale generator units. (DOE)

Centralized power production will significantly increase transmission requirements and potentially worsen bottlenecks.

- Need to transfer power produced at the energy parks to load centers.
- Expected need to upgrade the transmission system.
- DC transmission may become more attractive.
- **<u>Potential</u> HTS application to transfer large amounts of power!**

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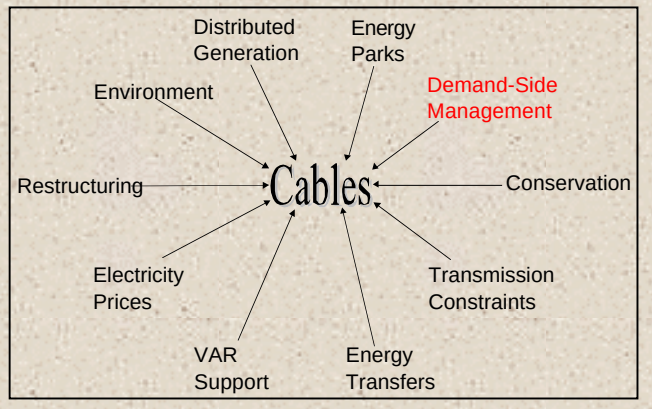
# Demand-Side Management




The planning, implementation, and monitoring of utility activities designed to encourage consumers to modify patterns of electricity usage, including the timing and level of electricity demand.(PMA)

While utilities have shifted away from demand-side management practices, there may be renewed emphasis in the future.

- Lower load during peak hours may delay system upgrades.
- Reduces power costs due to lower purchases of expensive power.
- Potentially reduces transmission bottlenecks (lower peak load).
- **May <u>delay</u> the need for HTS cable technology!**

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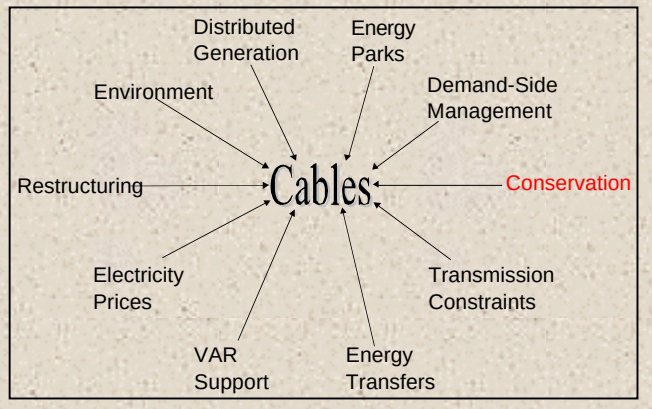
# Conservation




Energy efficiency programs will reduce the energy used by specific end-use devices and systems, typically without affecting the services provided. (PMA)

Such savings are generally achieved by substituting technically more advanced equipment to produce the same level of end-use services (e.g. lighting, heating, motor drive). (PMA)

- Lower loads.
- May delay system upgrades because of lower demands.
- Potentially reduces transmission bottlenecks.
- **May <u>delay</u> the need for HTS cable technology!**

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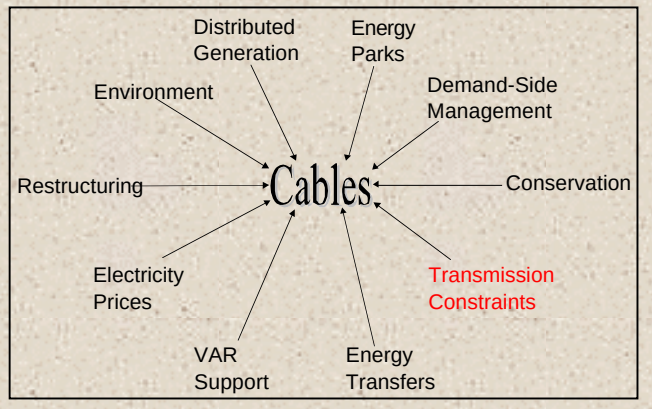
# Transmission Constraints




Transmission constraints occur where lines or transformers impede the desired flow of power due to overloading or security issues.(F&A)

The number and severity of transmission constraints has grown due to the lack of upgrades within the transmission system. This has led to increased congestion costs.

- Thermal overloads prevent the efficient operation of the power grid.
- Expanded N-x contingency conditions have increased transmission constraints.
- Recent evidence of escalating costs due to bottlenecks.
- **May <u>increase</u> the need for HTS cable technology!**

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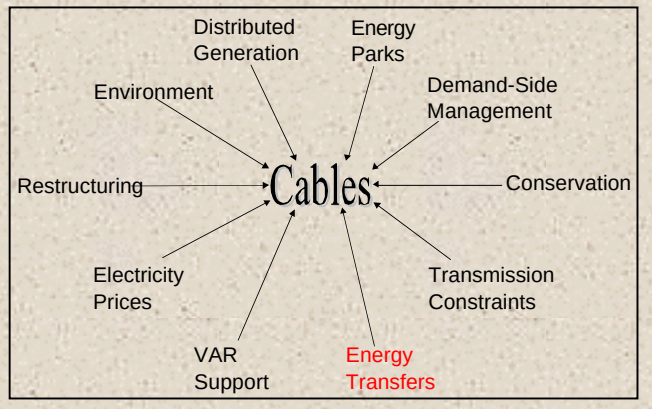
# Energy Transfers

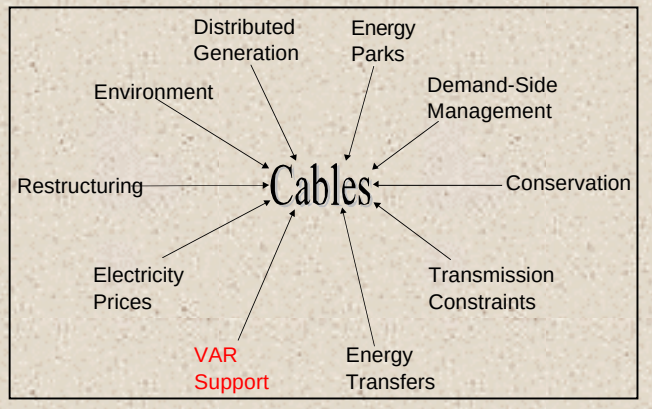



Energy transfers of electric power have increased dramatically, which has led to much higher loading of the bulk power system.(NERC)

A significant number of utilities and regions have, and will continue to experience transfer bottlenecks and associated high congestion costs.

- Increased loading on the transmission system.
- Transmission system not specifically designed to handle large transfers across regions.
- Increased transfers can lead to bottlenecks on the system.
- **May <u>increase</u> the need for HTS cable technology!**

# VAR Support




VAR support is required to maintain system voltages.

Utilities need to compensate their networks by adding capacitor banks (VAR producers) and reactor banks (VAR consumers).

- Charging capacitance for HTS cable is high than that of standard overhead lines.
- May need to add or subtract compensating devices based upon the specific scenario.
- **Uncertain impact for HTS cable technology!**

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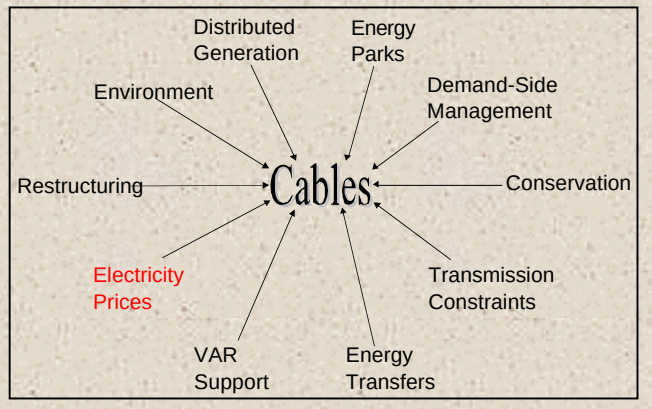
# Energy Prices




Energy prices have dramatically increased of late in many parts of the US, with further increases probable -- both in selected regions and nationwide. (DOE/EIA)

Higher energy prices, when coupled with inefficiencies in the power grid, have a strong adverse impact on local, regional and national economies.

- Higher congestion costs during many hours.
- Cost of business for most have significantly increased.
- Reduces power costs to customers due to less need for purchase of expensive power.
- **HTS application has potential for dramatic reductions in energy costs!**

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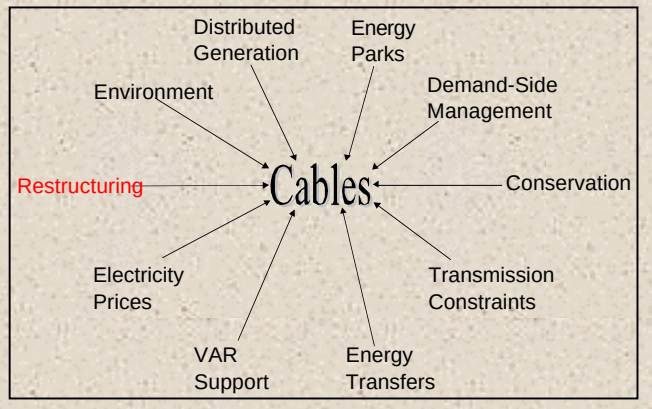
# Restructuring Changes




Restructuring occurs when utilities change their business practices. Regulatory policies continue to mandate significant changes in the industry.

Restructuring has led to utilities selling off generation assets and to delay or cancel transmission projects.

- Causing significant uncertainty in the electric utility industry.
- Increasing congestion due to lack of needed system improvements.
- Greatly expanding the number of players in the market (generation and potentially transmission).
- **Uncertain impact for HTS cable technology!**

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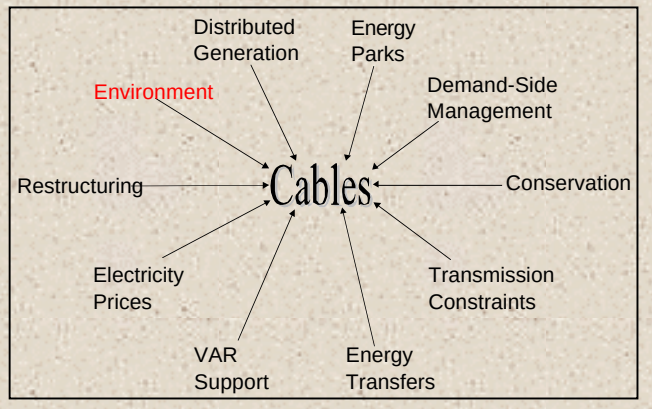
# Environmental Pressures




Environmental topics such as air quality, hazardous materials, right-of-ways, and EMF are placing increasing demands on current technologies.

Environmental pressures are placed on utilities to operate the power system in a safe and "more environmentally friendly" manner.

- HTS cable uses liquid nitrogen for cooling (not a pollutant).
- HTS cable transfers more power, and thus, utilities may need fewer transmission paths.
- HTS cables would generally be underground.
- Lower losses resulting in reduced generation levels.
- **May <u>increase</u> the need for HTS cable technology!**

# Wrap-up

- Cost
- System integration
  - Maintenance
  - Reliability
  - Operating issues
  - Utility acceptance
- Better understanding of trends and issues
  - Restructuring
  - Distributed generation
  - Demand-side management and conservation
  - Environmental concerns

# Factors Influencing Cable Deployment

- **Distributed Generation** - Leads to power production closer to customer load, and therefore, there is less of a need to upgrade the transmission system.
- **Energy Parks** - Centralized locations to produce electricity will likely result in the need for upgrades and additions to the transmission system.
- **Demand-Side Management** - Lowers the total electrical demand, and thus, could lead to postponement of system upgrades.
- **Conservation** - Lowers the total electrical demand, and thus, could lead to postponement of system upgrades.
- **Transmission Constraints** - Present constraints on the bulk transmission system have led to higher prices.
- **Energy Transfers** - Deregulation has led to increased transfers of power over longer distances, which has in turn leads to higher loading on the bulk power system.

# Factors Influencing Cable Deployment

- **VAR Support** - Utilities need to compensate their networks by adding capacitor banks and reactor banks to maintain system voltages.
- **Electricity Prices** - If wholesale electricity prices continue to increase, there will be pressure to find more economical ways of transferring power.
  **Restructuring** - Restructuring has led to utilities selling off generation assets and to delay or cancel transmission projects. It has also led to significant uncertainties about the future.
- **Environment** - Environmental pressures are placed on utilities to operate the power system in a safe and "more environmentally friendly" manner. This includes reducing emissions and hazardous materials.

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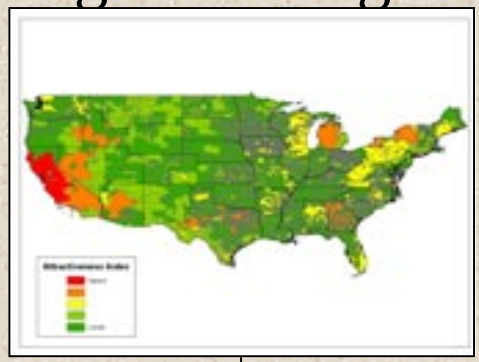
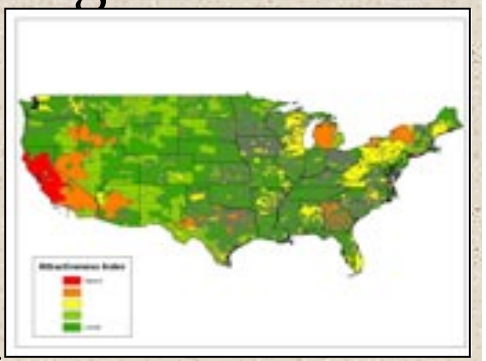
# Transformers

Losses

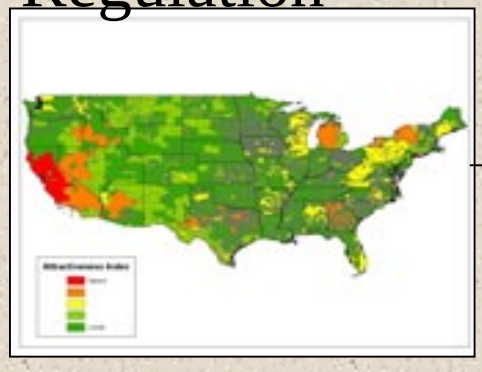
High Loading



High Growth



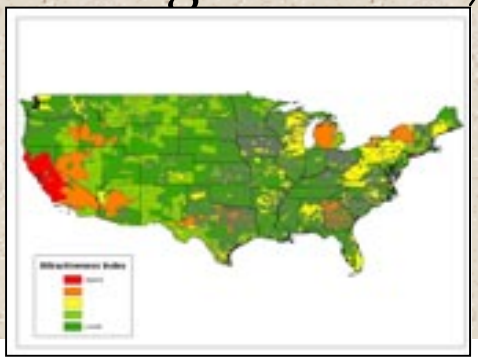
Regulation



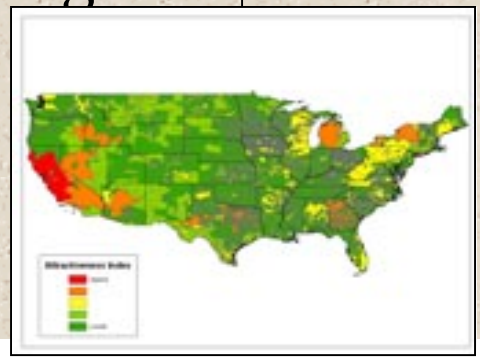
Transformers

Environment

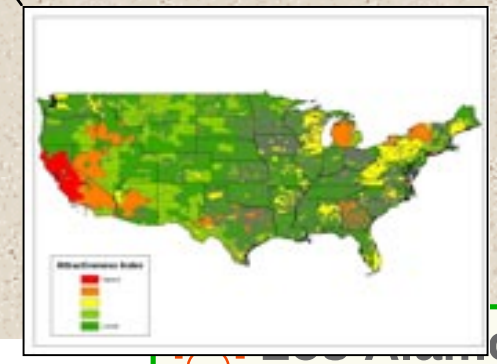
Pricing



Age



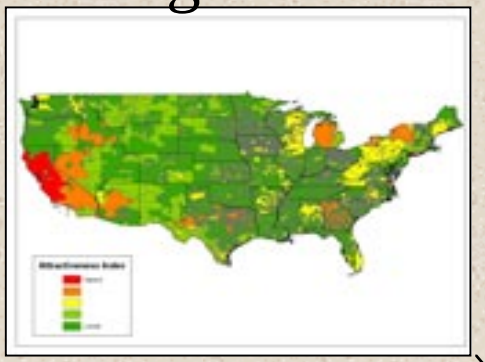
# of Transformers



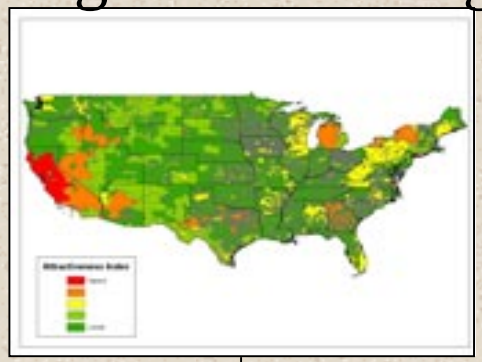
Energy and Environmental Analysis Group

# Storage - Utility

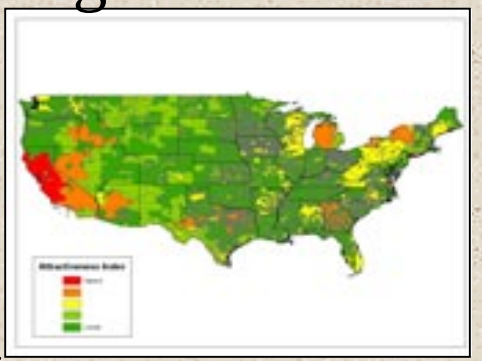
Pricing



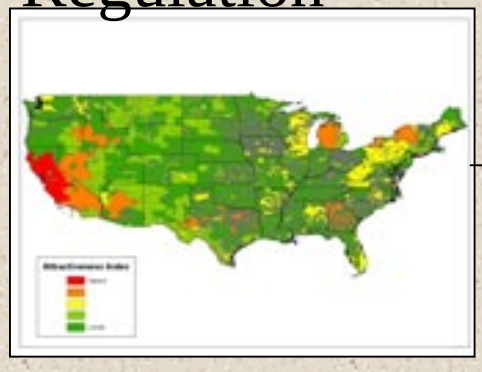
High Load Swings



High Growth



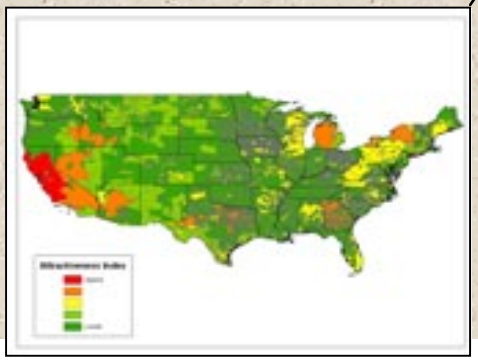
Regulation



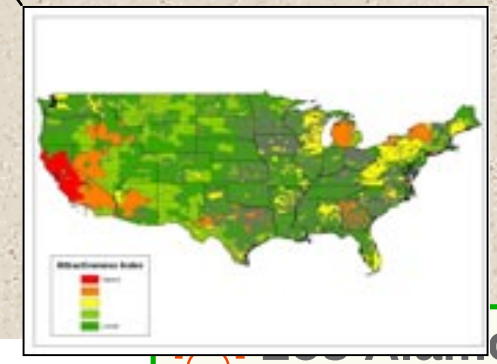
Storage

Environment

Xmission Constraints



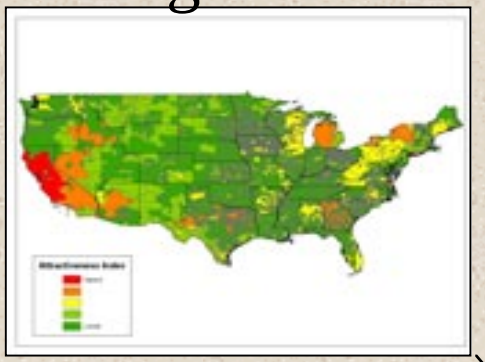
Low Reserves



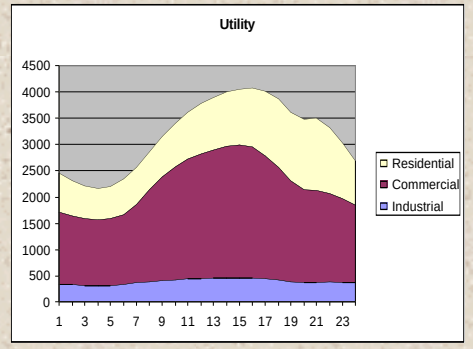
Energy and Environmental Analysis Group

# Storage - Customer

Pricing

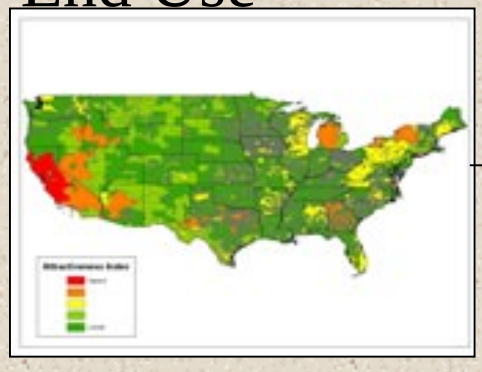


Load Curve




Load Mix

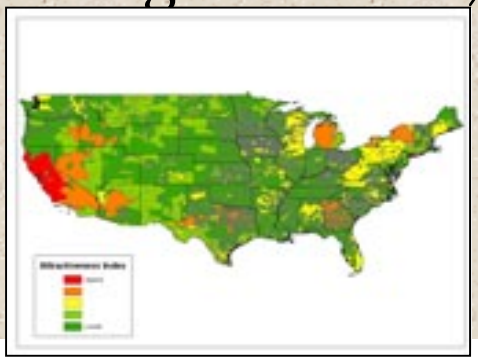
End Use



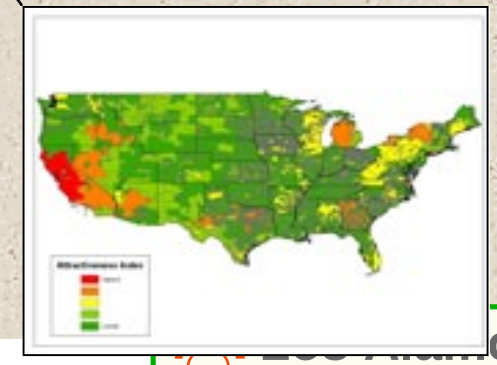
Storage

Environment

"N"egawatt Pricing



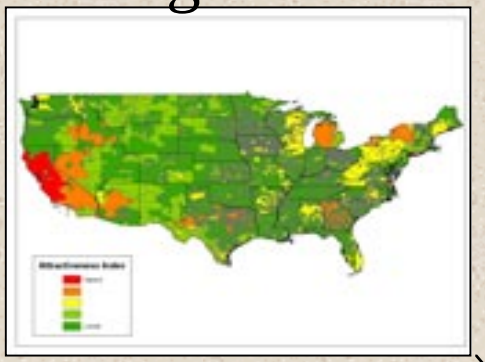
Customer Growth



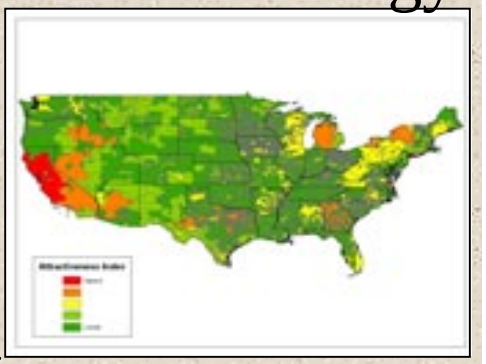
Energy and Environmental Analysis Group

# Motors

Pricing



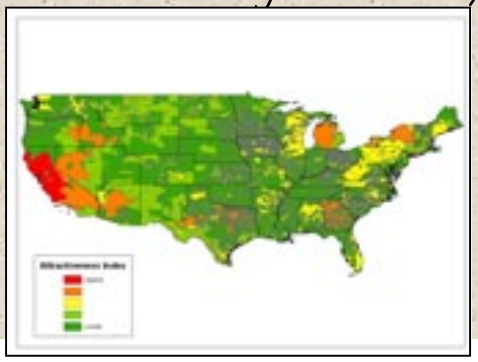
End Use Energy



Size

Motors

Efficiency



Growth