Customization of the T.O.P. Framework

Barriers to Market Adoption of Renewable energy

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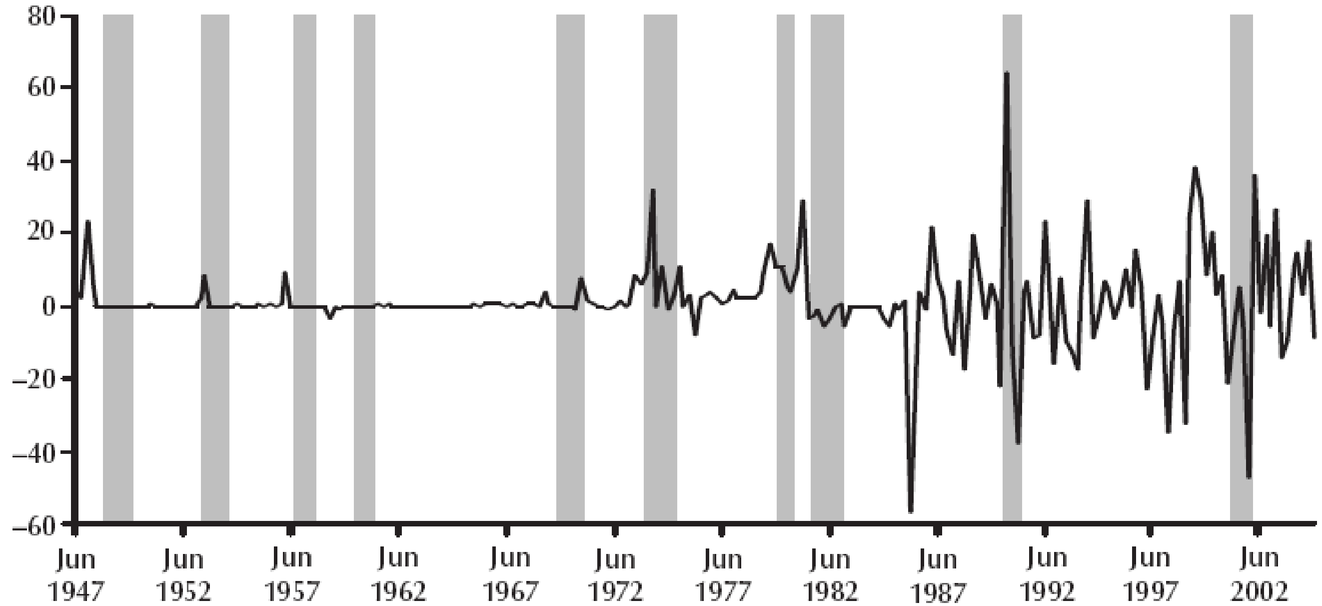
Agenda

- Introduction: Why is there a need?
- Framework Overview
  - *Linstone's Multiple Perspective Framework*
  - *Introduction of C.L.E.G.S. Framework*
- Evaluation of Solar Emerging Markets within Framework
- Evaluation of Wind Emerging Markets within Framework
- Data Analysis
- Conclusions / Recommendations
- References

Why is there a Need?

Volatility

Percentage Change in Quarterly Crude Oil Prices



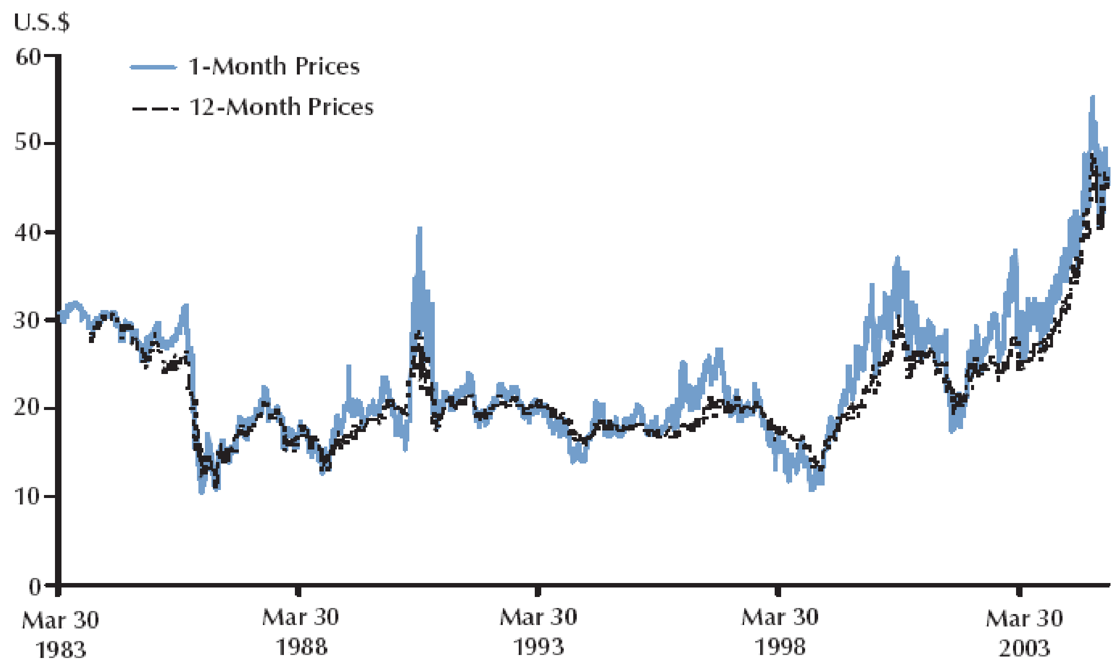
Increasing volatility leads to increased uncertainty in the energy market.

Source: Guo, Hui and Kliesen Kevin (2005)."Oil Price Volatility and U.S. Macroeconomic Activity." *Federal Reserve Bank of St. Louis Review.* 87 :669-83.

Why is there a need?[2]

Pricing Escalation

Daily 1-Month and 12-Month Crude Oil Prices

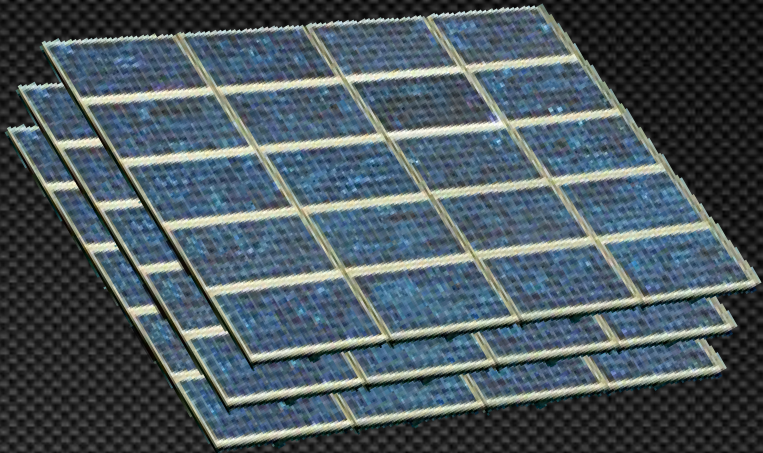


Pricing Escalation leads margin erosion and inflationary pressures in market.

Source: Guo, Hui and Kliesen Kevin (2005)."Oil Price Volatility and U.S. Macroeconomic Activity." *Federal Reserve Bank of St. Louis Review.* 87 :669-83.

Why is there a Need?[3]

The entrance of alternative and renewable energy offers the potential to minimize the impact of both volatility and pricing escalation.



But is there a strategy for new product entry for Renewable and Alternative energies?

Overview of Framework

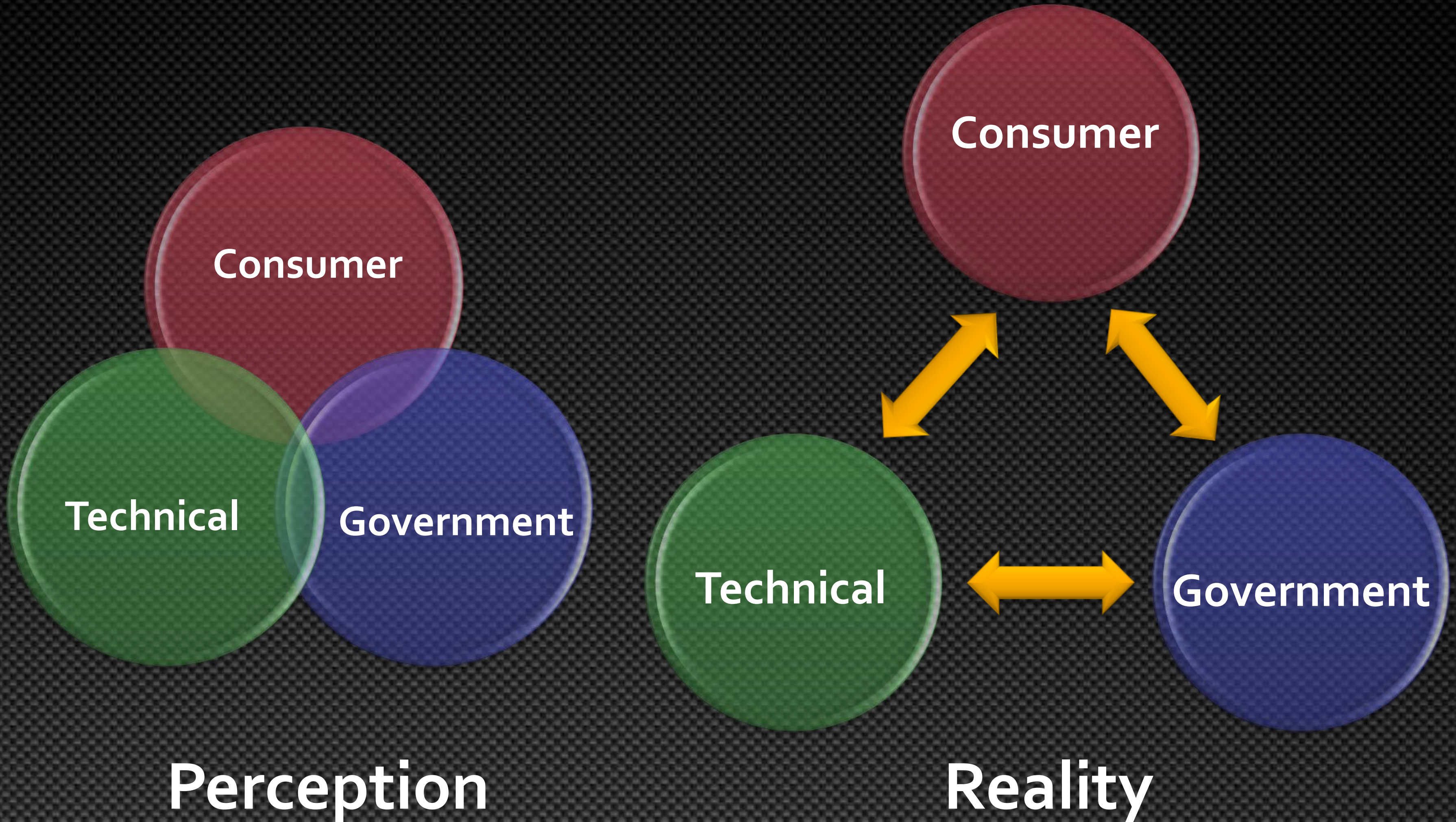
Linstone's Multiple Perspectives Framework

(Offers the viewpoints of those impacted)

Newly Developed Issues (or C.L.E.G.S.) Framework

(Illustrates the key issues new market entrants face)

Multiple Perspectives Framework



Applied From : H. Linstone, "Multiple perspectives: overcoming the weaknesses of MS/OR", Interfaces 15 (4) (July-August 1985) 77-85.
Applied From: Vachon, Stephan and Menz, Fredric (2006) "The Role of social, political, and economic interests in promoting state green electricity policies." Environmental Science and Policy: 9 : 652-662.

T.O.P. Framework Applied

T

Technical perspective (T) categories	
Basic R&D issues (government)	Applied research issues (industry)
• Develop basic technology	• Product design
• Improve technical performance	• Customer requirements
• Reduce operating costs	• Reducing operating costs
• Reduce capital costs	• Reducing capital costs
• Adequacy of supply for future demand	• Reducing construction costs and time
• Scalability, fit with infrastructure	• Scalability and fit with infrastructure
• Substitution effects	• Address health and safety concerns
• Health and safety regulations	• Research subsidies, grants, contracts

O

Organizational (O) categories	
Government and NGO issues	Industry issues
• Energy independence—economic	• Commercialization, marketing
• Energy security—defense	• Supply chain management, availability
• Energy availability—supply	• Price stabilization
• Regulation—environmental protection, global warming, climate change	• Fit with strategic, regulatory trends
• Regulation—protect health, safety	• Competition, partnerships, clustering
• Economic growth, market competition	• Incentives, subsidies, taxes, quotas
• Reduce energy trade deficit	• Workforce availability, training
• Political dimensions	• Efficiency, carbon footprint
• Incentives, subsidies, tax credits	• Profitability
	• Growth potential
	• Corporate social responsibility
	• Corporate image

P

Personal (P) consumer categories	
Economic issues	Benefit issues
• Energy price levels, stability	• Customer value
• Energy availability	• Health and safety
• Tax policy	• Environmental concern, protection
• Subsidies, tax credits, support programs	• Global warming, climate change
• Financing	• Public opinion, peer pressure
• Lower energy rates from green-energy development	• Conspicuous virtue
• Green-energy jobs	• Sustainability

Source: Harmon, Robert and Cowan, Kelly (2009)."A Multiple Perspectives view of the market case for green energy." *Technological Forecasting and Social Change* 76 :204-213.

Issues / C.L.E.G.S Framework Applied

Cost
- Capital Costs
- Operational Costs
- Environmental Costs

Location
- Geographic Location
- Population Proximity
- Taxation Impact
- Noise / Sound Impact

Efficiency
- Technology Efficiency
- Payback Analysis
- Reliability

Grid Impact
- Grid Modifications
- Grid Upgrades
- Grid Expansion

Scalability
- Ease of Expansion

What is the Key Issues Framework?
- **Overview of key topics to be addressed**
- **Point of Cross Reference for Perspectives**

C.L.E.G.S Expanded

Factors Considered under COST Framework	
Main Factor	*Includes*
Capital Costs	Upfront Costs for Equipment Purchase
	Installation and Construction Costs
	Engineering and Research Costs for the Technology
Operational Costs	Annual Costs for Operating Technology
	Maintenance Costs
	Labor and Operating Costs
Environmental Costs	Costs for Environmental Site Impact
	Costs for Environmental Clean-Up

Factors Considered under LOCATION Framework	
Main Factor	*Includes*
Geographic Location	What site is chosen for the alternative energy
Population Proximity	Location with reference to major population centers
	Potential for Construction and Operations Careers
Noise	Sound Impact/Pollution
Taxation	Taxation Impact on the Renewable Energy

Applied From: Owen, Anthony (2006). "Renewable energy: Externality costs as market barriers." Energy Policy 34: 632 -642.
Applied From: Ediger, Volkan and Kentel Elcin (1999) "Renewable energy potential as an alternative to fossil fuels in Turkey." Energy Conversion and Management 40: 743-755.
Applied From: Kahn, Robert (2000) "Siting Struggles: The Unique Challenge of Permitting Renewable Energy Power Plants." The Electricity Journal. March 1040-6190.

C.L.E.G.S Expanded

Factors Considered under EFFICIENCY Framework	
Main Factor	*Includes*
Technology Efficiency	Cost to create the electricity
Payback Analysis	Cost to create with reference to payback of capital costs
Reliability	Infrastructure reliability and longevity
	Energy reliability

Factors Considered under GRID IMPACT Framework	
Main Factor	*Includes*
Modifications	Changes to existing structure
Upgrades	Technological upgrades to the existing structure
Expansion	Expansion of the existing structure

Factors Considered under SCALABILITY Framework	
Main Factor	*Includes*
Ease of Expansion	Ease which system can be duplicated or expanded

Applied From: Pehnt, Martin (2005), "Dynamic life cycle assessment (LCA) of renewable energy technologies." Elsevier. 16:18 pp. 1-17.
Applied From: Begovic, M., Pregelj, A., and Rohatigi, A..(2001) "Impact of Renewable Distributed Generation on Power Systems." IEEE 0-7695-0981-9/01.

Framework Case Study

Wind Market Example

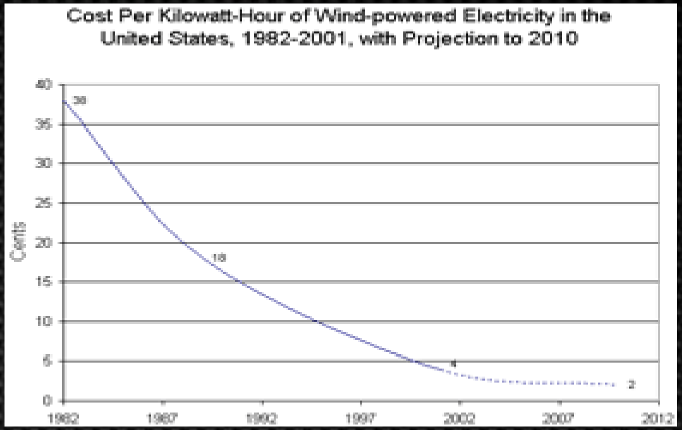
Framework Application

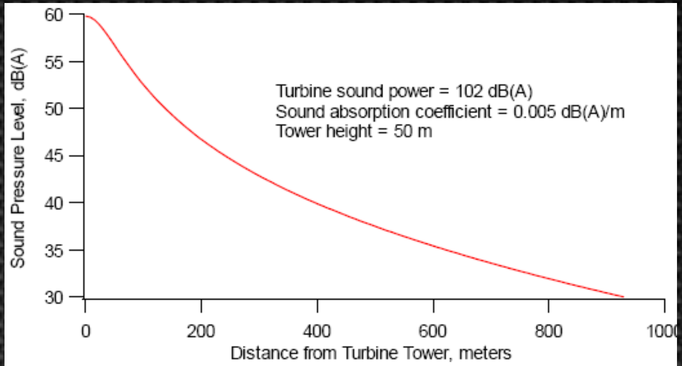
- General perceived issues
  - Capital and operation costs
  - Wind location selection
  - Relies on variable wind gusts
  - Social issues affected by wind farms
  - Transmission infrastructures
  - Low and stable energy price
  - Etc.

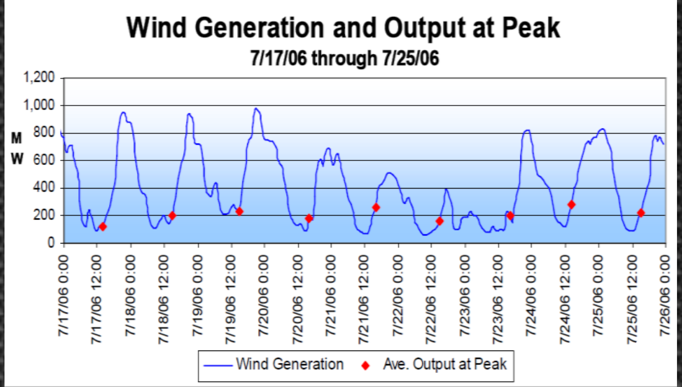
	T	O	P
COST	YES	YES	YES
LOCATION	YES	YES	YES
EFFICIENCY	YES	YES	YES
GRID IMPACT	NO	YES	NO
SCALE ABILITY	YES	YES	NO

Personal – Cost, Location, Efficiency

- **Cost -** *Low & stable price*
  - Technology dev.
  - Subsidization
    - R&D budgets
    - Tax exemptions + rebates
    - Infrastructure
- **Location –** *Noise*
  - Reduce turbine noise
  - Locate away from populous
  - Infrastructure requirements
- **Efficiency -** *Power stability*
  - Capacity, Peak usage stability







Source: Wind Energy — Advantages, Cost, Potential, Statistics, and the Future http://www.grinningplanet.com/2004/12-14/wind-power-wind-energy-article.htm

Source : Rogers, A. L., & Manwell, J. F. (2004). Wind Turbine Noise Issues. *Renewable Energy Research Laboratory, University of Massachusetts*

Source: California ISO. '2007 Summer Loads and Resources Operations Assessment' March 8, 2007

Organization - Cost

A Simple Formula

***Taxpayer* Energy Subsidies**

+

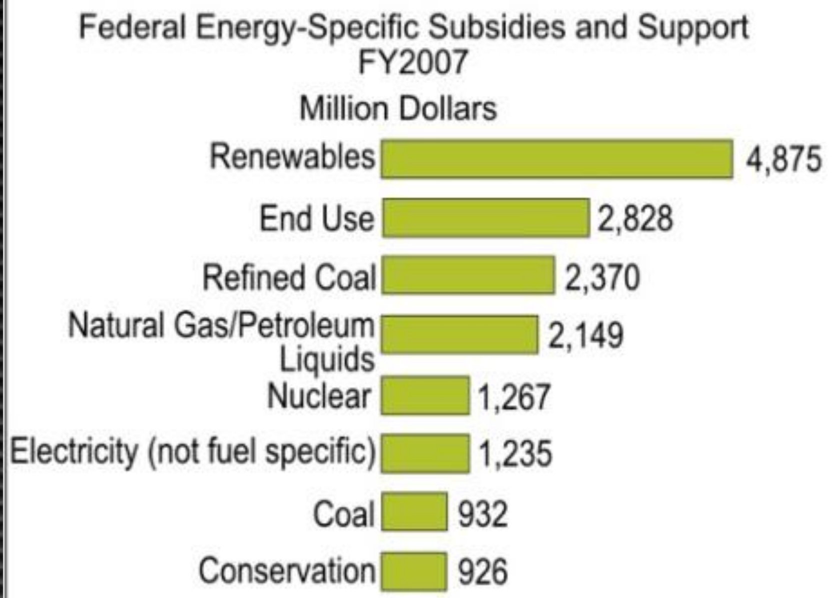
***Consumer* Energy Spending**

=

Total Energy Spending

Source: Texas Comptroller of Public Accounts.

Renewable energy received the greatest share of energy subsidies in FY 2007.



Source: Energy Information Administration, *Federal Financial Interventions and Subsidies in Energy Markets 2007* (April 2008).

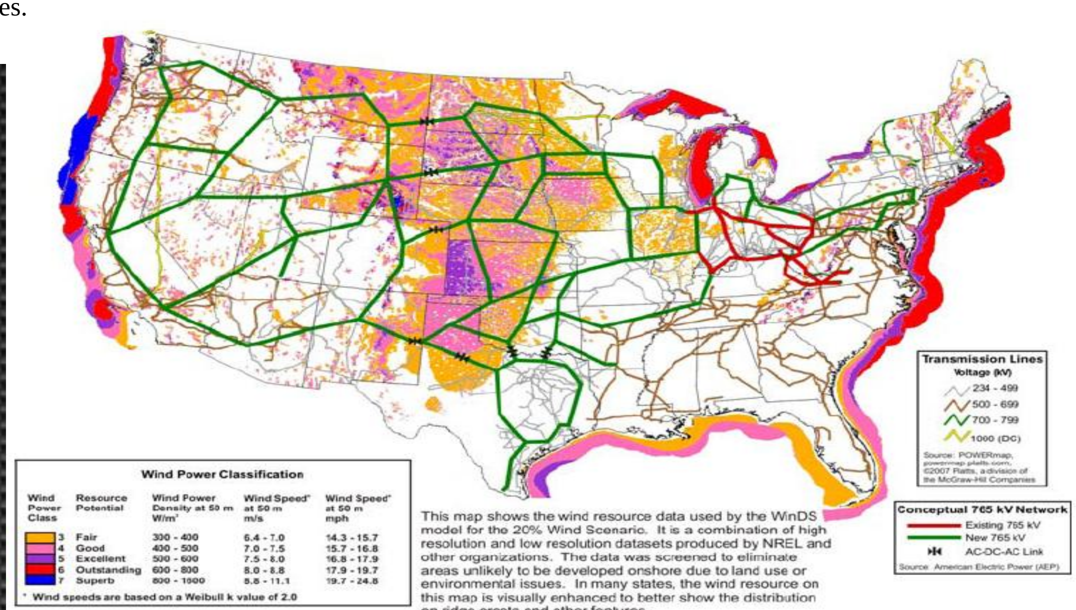
Organization - Location

Country	Commercial	Mixed	Residential	Rural
Denmark			40	45
Germany				
(day)	65	60	55	50
(night)	50	45	40	35
Netherlands				
(day)		50	45	40
(night)		40	35	30

Source : Rogers, A. L., & Manwell, J. F. (2004). Wind Turbine Noise Issues. *Renewable Energy Research Laboratory, University of Massachusetts*

Noise regulations

Source: DOE, U. (2008). 20% wind energy by 2030: Increasing wind energy's contribution to US electricity supply. *Washington, DC*.



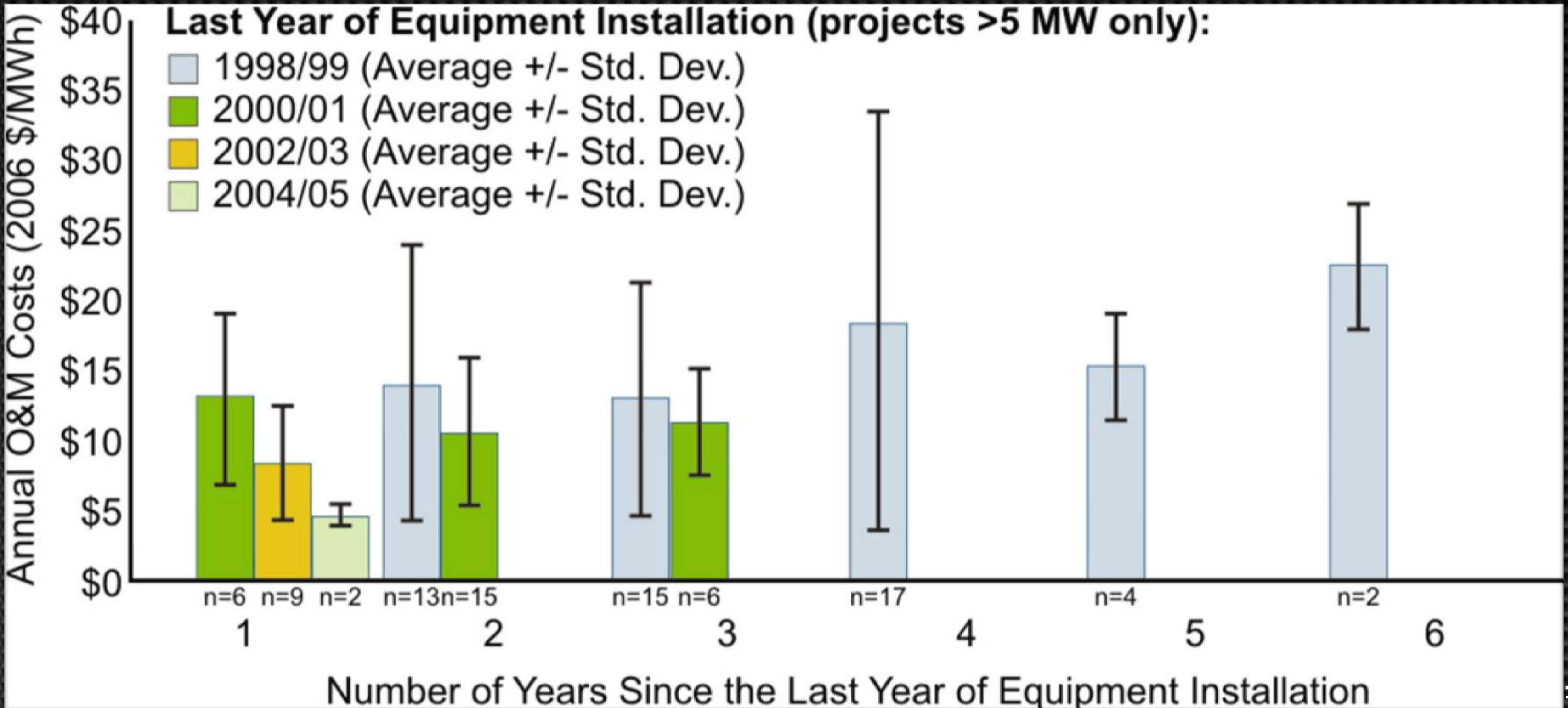
Conceptual transmission plans in U.S.

Organization – Efficiency, Grid Impact, Scalability

- Efficiency
  - Industry support
  - Development programs
- Grid impact
  - Alternative energy cost sharing
  - Federal and state incentives supporting renewable energy technological developments.
  - Peak usage capacity
  - Codified some codes to install renewable generation of up to 1 MW at one location .
- Scale ability
  - Ability to integrate in grid.

Technology - Cost

- **Direct Impacts**
  - Installation cost
  - O&M cost
- **Indirect Impacts**
  - Increased cost of insurance and financing
  - Slowing or stopping development
- **Environmental**
  - Protected or endangered plants at the location



Technology - Location

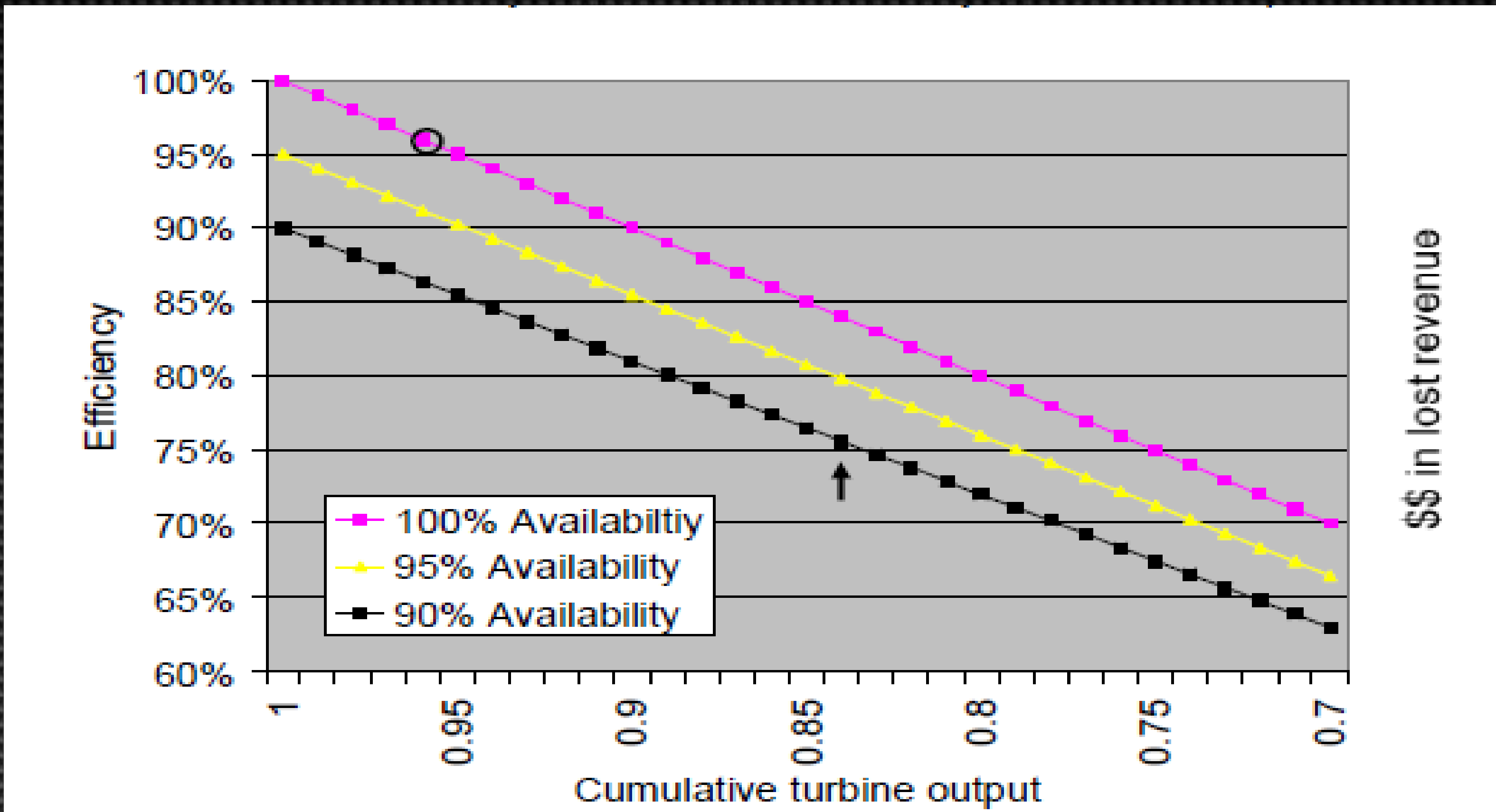
- Location
  - Location is key to the development of wind product because the location itself delivers the primary resource for the energy, wind.

  - Geographic
    - Terrain, accessibility, and complexity
    - Orientation to prevailing wind
    - Cost of land
    - On-site vegetation
    - Soil conditions
    - Exposure to extreme wind speeds
      - Storms, hurricanes

  - Taxation
    - Wind turbines for producing electricity are exempt from regular taxation.
    - Taxation of a wind turbine facility commences six months after the facility has been commissioned

Technology Efficiency

If the turbine could convert all the wind's power to mechanical power we would say it was 100% efficient. But that is impossible. There is a loss in energy, which is a loss in ROI.



Roger R. Hill, Valerie A. Peters, Jennifer A. Stinebaugh and Paul S. Veers, "Wind Turbine Reliability Database Update."

Technology Grid &Scalability

- Grid Impact
  - o Delivered to the purchaser in a cost-effective manner.
  - o Physically interconnect a site to a transmission system
- Scale ability
  - o At present,
    - sufficiently of wind energy.
  - o In future,
    - Possibility of wind energy become significant source of clean electrical production on a scale comparable to or greater than other technologies, such as hydropower

Framework Case Study

Solar Market Example

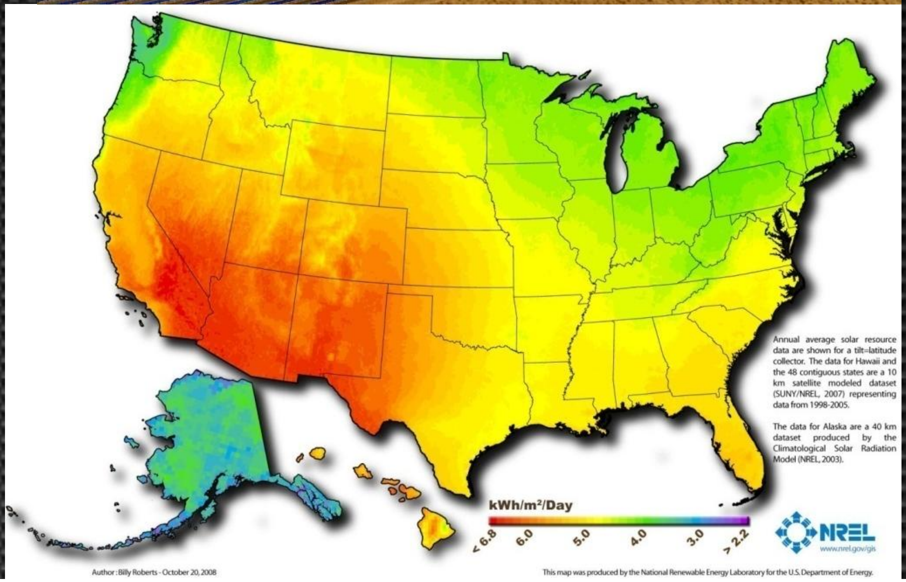
Framework Application

- General perceived issues
  - Capital costs
  - Mainstream but not affordable for consumer
  - Large amount of sun facing space required
  - Relies on "sunny days" for reliable energy
  - Transmission infrastructure
  - Low and stable energy price
  - Etc.

	T	O	P
COST	YES	YES	YES
LOCATION	NO	NO	YES
EFFICIENCY	YES	YES	YES
GRID IMPACT	NO	YES	NO
SCALE ABILITY	NO	YES	NO

Personal

- Cost
  - High capital costs
  - Cost per watt generated still high
  - More costly for large scale implementation
- Location
  - Avg household requires 512 sqft of solar panel
  - Requirement of more "sunny" days then not
- Efficiency
  - Cost /watt generated/stored un-even
  - More space for fewer "sunny" days
  - Directly linked to **Cost** for **Consumer**



National Renewable Energy Laboratory. (2007). National Solar Radiation Database 1991-2005 Update. DOE/NREL. Retrieved from http://www.nrel.gov/docs/fy07osti/41364.pdf

Organization – Cost, Location, Efficiency

- Cost
  - Identical case to the Wind Sector
- Location
  - Government owned property
  - Eminent domain clause(s)
  - Residential / Private
- Efficiency
  - Cost of investment , ROI directly connected
  - Greater subsidization, tax benefits
    - Where greater investment is required due to efficiency

Organization – Grid Impact, Scalability

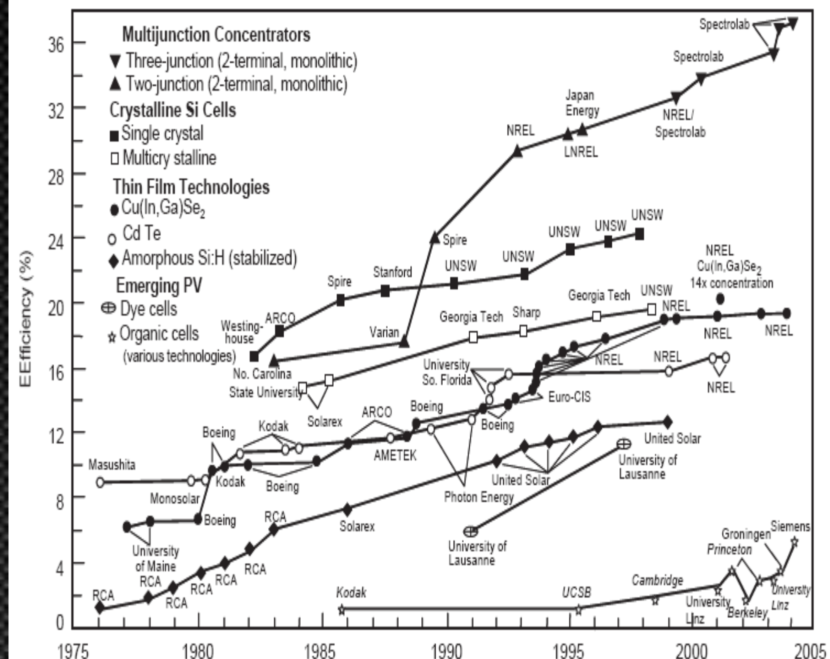
- Grid impact
  - Self sustained rural/remote grids
  - Peak availability ("sunny") during peak usage of A/C
  - Consumer level purchases reduce grid usage
- Scalability
  - Rapidly developing technology means greater R&D towards capacity development
  - Panel efficiency and technology advancement means higher replacement rates

Technology - Cost

- Cost
  - o Globalization of manufacturing panels, etc.
  - o High initial capital costs
    - Mean higher R&D cost to push efficiency
  - o Manufacturing use of toxics
  - o Government / Grant Subsidization available
    - In limited amounts and scenarios
      - o Education, efficiency R&D

Technology – Efficiency, Grid Impact

- Efficiency
  - Significant gap between the best performances and the theoretically predicted values for each solar cell technology
  - Efficiencies of commercial modules are only about 50–65% of the best performances
- Grid impact
  - Same case as organizational
- Scalability
  - Modular nature of solar power technologies enable them to be built as the demand for energy grows and embedded within an existing network



Surek, T. (2005). Crystal growth and materials research in photovoltaics: progress and challenges. Journal of Crystal Growth, 275(1-2), 292-304.

Case Study Analysis

Data analysis and comparison

Initial Results

Wind			
	T	O	P
COST	YES	YES	YES
LOCATION	YES	YES	YES
EFFICIENCY	YES	YES	YES
GRID IMPACT	NO	YES	NO
SCALE ABILITY	YES	YES	NO

Solar			
	T	O	P
COST	YES	YES	YES
LOCATION	NO	NO	NO
EFFICIENCY	YES	YES	YES
GRID IMPACT	NO	YES	NO
SCALE ABILITY	NO	YES	NO

Data Comparison

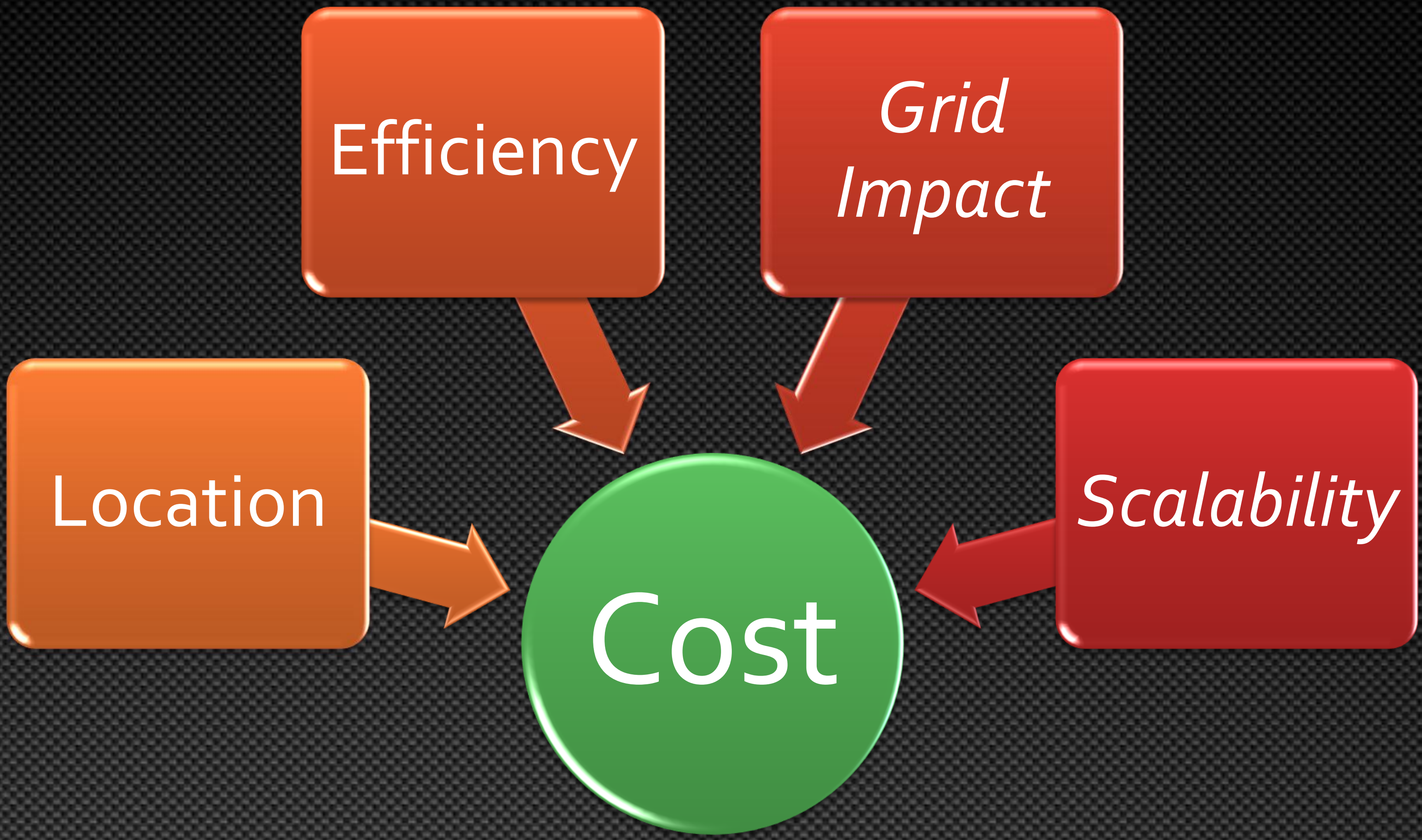
Wind			
	T	O	P
COST	YES	YES	YES
LOCATION	YES	YES	YES
EFFICIENCY	YES	YES	YES
GRID IMPACT	NO	YES	NO
SCALE ABILITY	YES	YES	NO

Solar			
	T	O	P
COST	YES	YES	YES
LOCATION	NO	NO	NO
EFFICIENCY	YES	YES	YES
GRID IMPACT	NO	YES	NO
SCALE ABILITY	NO	YES	NO

Conclusions & Recommendations

What have we learned, and what next?

Common Barriers



Conclusions & Recommendations

- 1-mile overview of the application
- Required improvements:
  - Further application to specific products and companies is required to improve validity of framework structure
  - Renewables is an emerging market therefore the model will change as the market develops
  - Implement as a balance score basis with weighted evaluations rather than yes/no generalizations

References

Begovic, M., Pregelj, A., and Rohatigi, A..(2001) "Impact of Renewable Distributed Generation on Power Systems." IEEE 0-7695-0981-9/01.

California ISO. '2007 Summer Loads and Resources Operations Assessment' March 8, 2007

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Wind Energy — Advantages, Cost, Potential, Statistics, and the Future
http://www.grinningplanet.com/2004/12-14/wind-power-wind-energy-article.htm