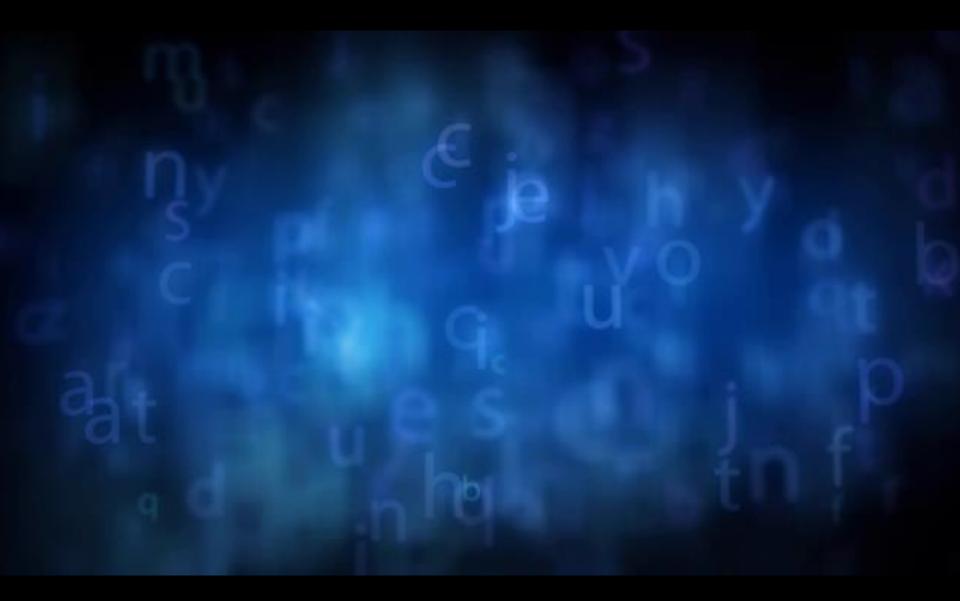
September 2014

TECHNOLOGY INNOVATION IN THE ENERGY SECTOR

Stephen J. Taylor, Director of Technology Transfer, Consorzio per l'Area di Ricerca Scientifica e Tecnologica, Trieste, Friuli Venezia Giulia, Italia With thanks to Strategic Business Insights (SBI)





From idea to market



BUILDING BLOCKS OF THE TECHNOLOGY

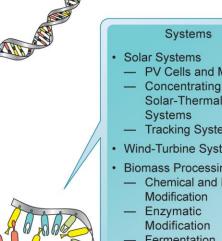


Applications

- Grid-Connected Power
- Transportation Biofuels
- Rural/Off-Grid Power
- · Heating and Cooling

Enabling Components

- PV
 - Silicon (Polysilicon, Ingots, Wafers)
 - Semiconductor Thin _ Films
 - **Organic Semiconductors**
 - Nanomaterials
 - Rigid and Flexible Substrates
- Wind
 - Advanced Composite Materials
 - Rotor Blades
 - Turbines
 - Towers
- Biomass .
 - Short-Rotation Crops
 - Genetically Engineered **Biocatalysts**
 - Photosynthetic Algae
- Geothermal
 - **Reservoir Identification** and Management
 - Drilling
 - Engineered Reservoir Development



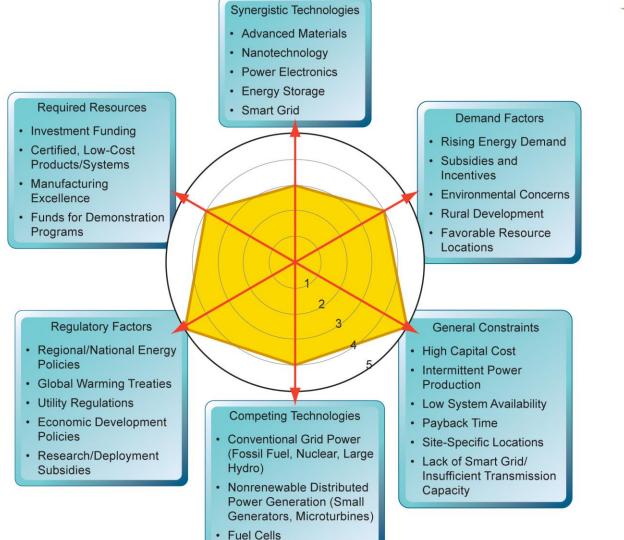
- Solar Systems PV Cells and Modules

 - Solar-Thermal
 - Tracking Systems
- Wind-Turbine Systems
- **Biomass Processing**
 - Chemical and Physical Modification
 - Enzymatic Modification
 - Fermentation
 - **Bio-Separation**
 - Gasification
- Geothermal-Power Plants
 - Steam and Binary Systems
 - Enhanced Geothermal Systems
- · Power Conversion and Control
- Energy-Storage Systems

Source: SBI

COMMERCIAL DEVELOPMENT PARAMETERS: POWER GENERATION



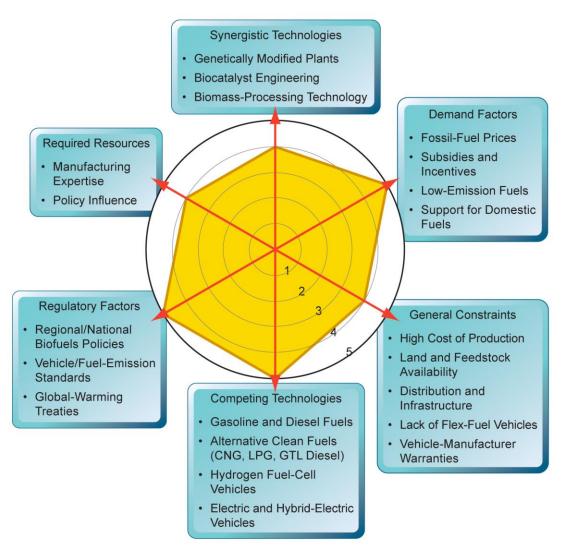


Note: Numbers indicate importance of commercial development parameters relative to each other.

1 = low relative commercial importance; 5 = high relative commercial importance.

COMMERCIAL DEVELOPMENT PARAMETERS: BIOFUELS FOR TRANSPORTATION



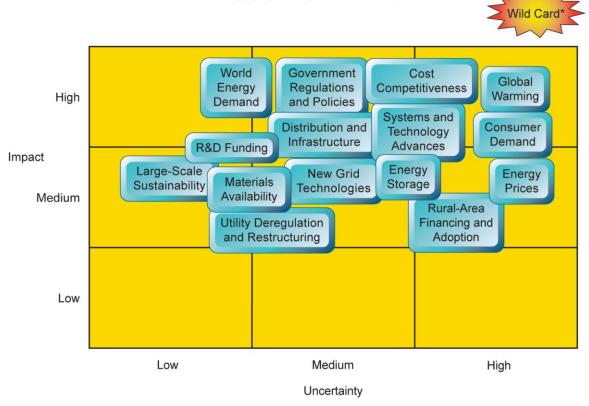


Note: Numbers indicate importance of commercial development parameters relative to each other.

1 = low relative commercial importance; 5 = high relative commercial importance.







ISSUES AND UNCERTAINTIES

* Developments such as very high energy prices or climate-change impacts that precipitate drastic policy changes that favor renewables.

Source: SBI

POTENTIAL IMPLICATIONS OF CHANGE

- Cost-Competitive Renewable Power Systems
- Advances in Renewable Power and Energy-Storage Technology
- · Smarter Grids and Net Metering
- · Subsidies and Other Incentives
- · Renewable Portfolio Standards
- Consumer Demand for Green Power
- Utility Restructuring

A Grid-Integrated Renewable Power Generation

- Widespread Production and Use of Biofuels (Brazil Model)
- Development of Cellulosic Ethanol, Drop-In Biofuels, and Biorefineries
- Biofuels Subsidies and Mandates
- Consumer Demand for Environmentally Friendly Fuels
- · Global Biomass and Biofuels Supply Chain
- Flexible-Fuel Vehicles Available to Consumers

B Sustainable Biofuels for Transportation

Consequences of Change

- A Renewable power technologies become significant component of grid-connected and distributed power systems as costs decline.
- B Biofuels use increases globally to replace a significant portion of conventional gasoline and diesel fuel use
- A+B+C Developing countries become major growth markets for renewable energy technologies. New companies and business models emerge.
- A+B+C+D Renewable energy technologies see use in a broad range of applications to help address urgent global energy needs.

C Reliable, Affordable Energy for Developing Countries/Off-Grid Energy

- Rising Energy Demand in Developing Countries
- Low-Cost, Reliable, Flexible, Renewable Energy Systems
- New Financing Options and Business Models
- Support to Developing Countries from International Agencies
- Clean-Energy Incentive and Transfer Policies
- Greater Local Participation

D Large-Scale Transition to Renewable Energy Systems

- Greater Search for Cleaner, Safer Energy Solutions
- Emphasis on Energy Diversity and Security
- Increasing Urgency to Reduce
 Greenhouse-Gas Emissions
- Spread of Carbon Trading Systems and Carbon Taxes
- Rising Fossil-Fuel Costs
- Large Public and Private Investment in Renewables Sector

Areas to Monitor identifies significant factors and events of change that will affect the roadmap for technology commercialization. This **POTENTIAL IMPLICATIONS OF CHANGE** chart identifies possible ways in which particular combinations of such factors might unfold and combine (the bullets), resulting opportunities or threats (**[**]), and some further downstream consequences.



Source: SBI





Thanks for listening!

Sind Som Root

Stephen Taylor, Director of Technology Transfer AREA Science Park