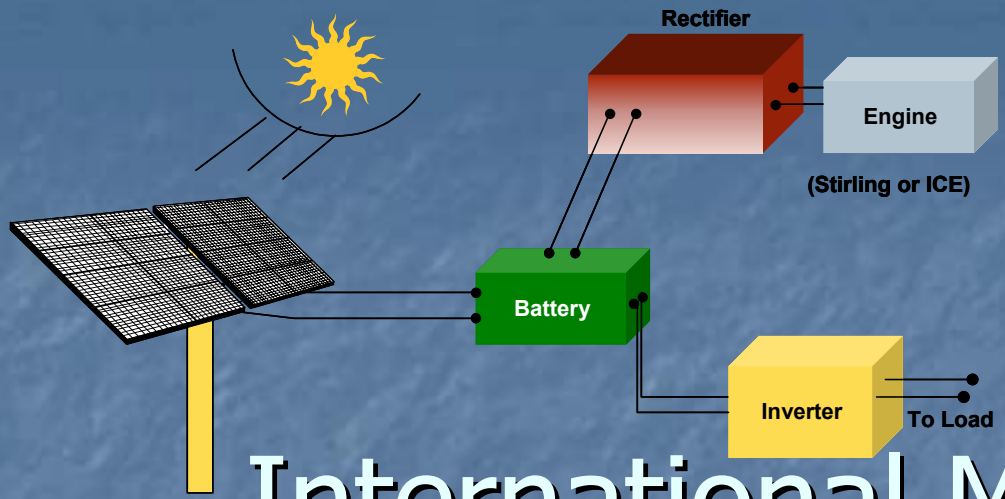

International Market Issues for Hybrid Systems

Mark Williams, US DOE-NETL

Byron Washom, Spencer Management Associates

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A simple overview

- The market is undeniably large
- The incumbent recip technology is inexpensive, inefficient and environmentally inferior
  - Hybrids are the inverse
- Reliability through redundancy and fuel diversity are just two of the numerous drivers that favor hybrids in the long term
- Strong analytical tools validate the advantages of hybrid systems over centralized generation and conventional T&D infrastructures

Good News, Bad News for DG A US perspective

- IEEE DG Interconnection Standard receives 92% approval on ballot in '02
- FERC Open Access Policy has a strong DG position
- State Net Metering and equitable rate tariffs emerging as Pro-DG
  - 36 states have net metering, 14 for FC
  - 14 states have Portfolio Standards or Set Asides
- DG continues as a solution for Power Quality and Reliability in a post 9/11 world with a deteriorating T&D infrastructure
- Strongest growth in global market with World Bank and other multi-lateral support

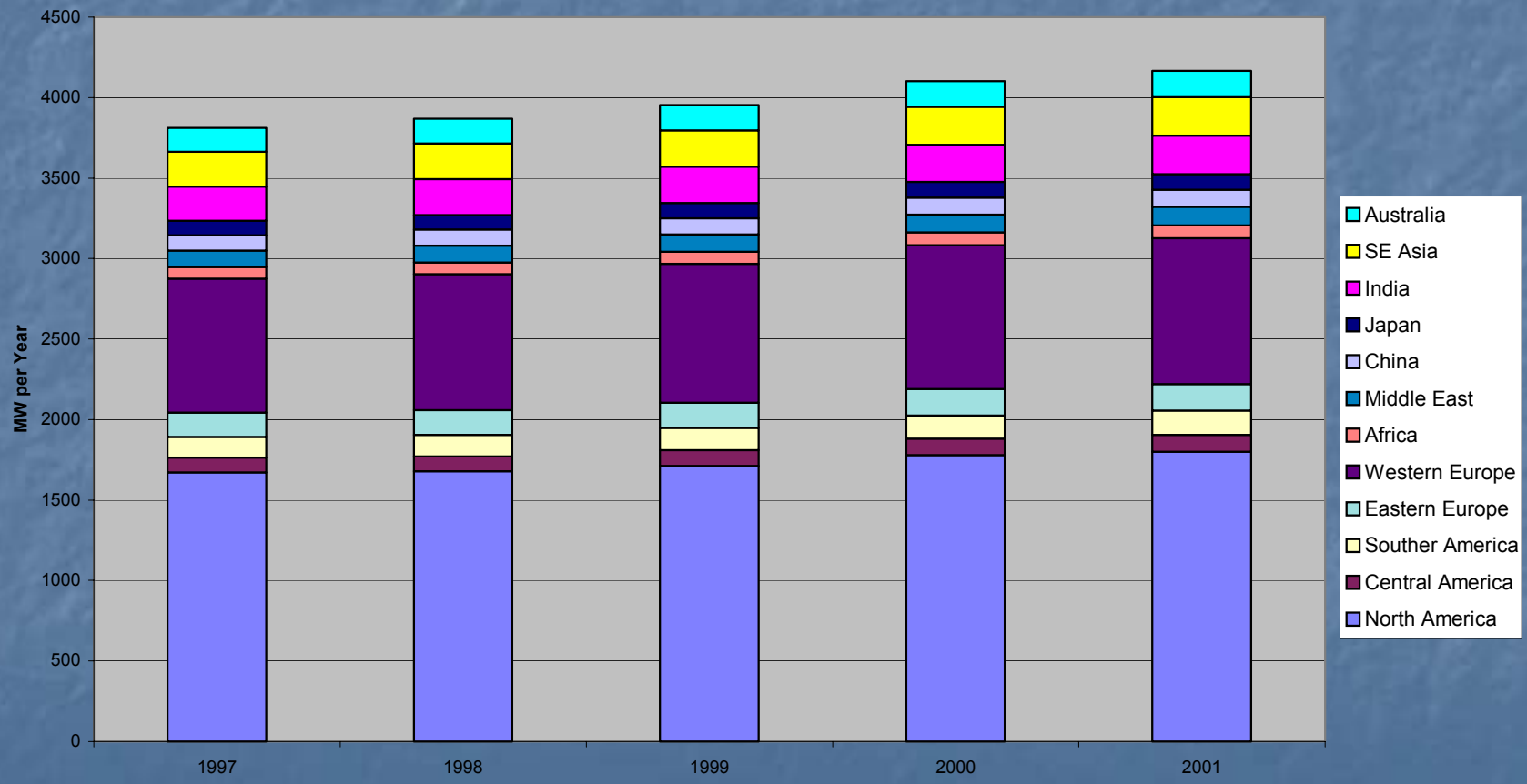
- State deregulation failures have created a reduction in market aggregators and energy service providers that now lack liquidity
- State budget crises have reduced non-tariff capital buydown programs
- "The sizzle is out of the steak" for DG as an energy panacea
  - Industry failed to have cost competitive, reliable products in the market during energy crises
  - Very limited Wall St. analyst coverage of previously over-hyped DG stocks. IPO market now weak
  - Corporate R&D funding reduced to enhance net earnings

Fuel Stocks Trading Off Over the Last 3 Years

Distributed Generation in the Developing Country Markets

- The potential for distributed electricity generation in the developing world is large with the IEA estimating that market growth of decentralized power generation could reach 5-7 GW by 2010.
- In practice, small combustion generators are used extensively in developing countries when central electricity generation and T&D are constrained
- Thus, a market for smaller generators already exists, and when a superior technology (e.g. hybrids) enters these established markets at competitive prices, sustainability risks will be lower

Size and Demographics of <10 kW Global Market



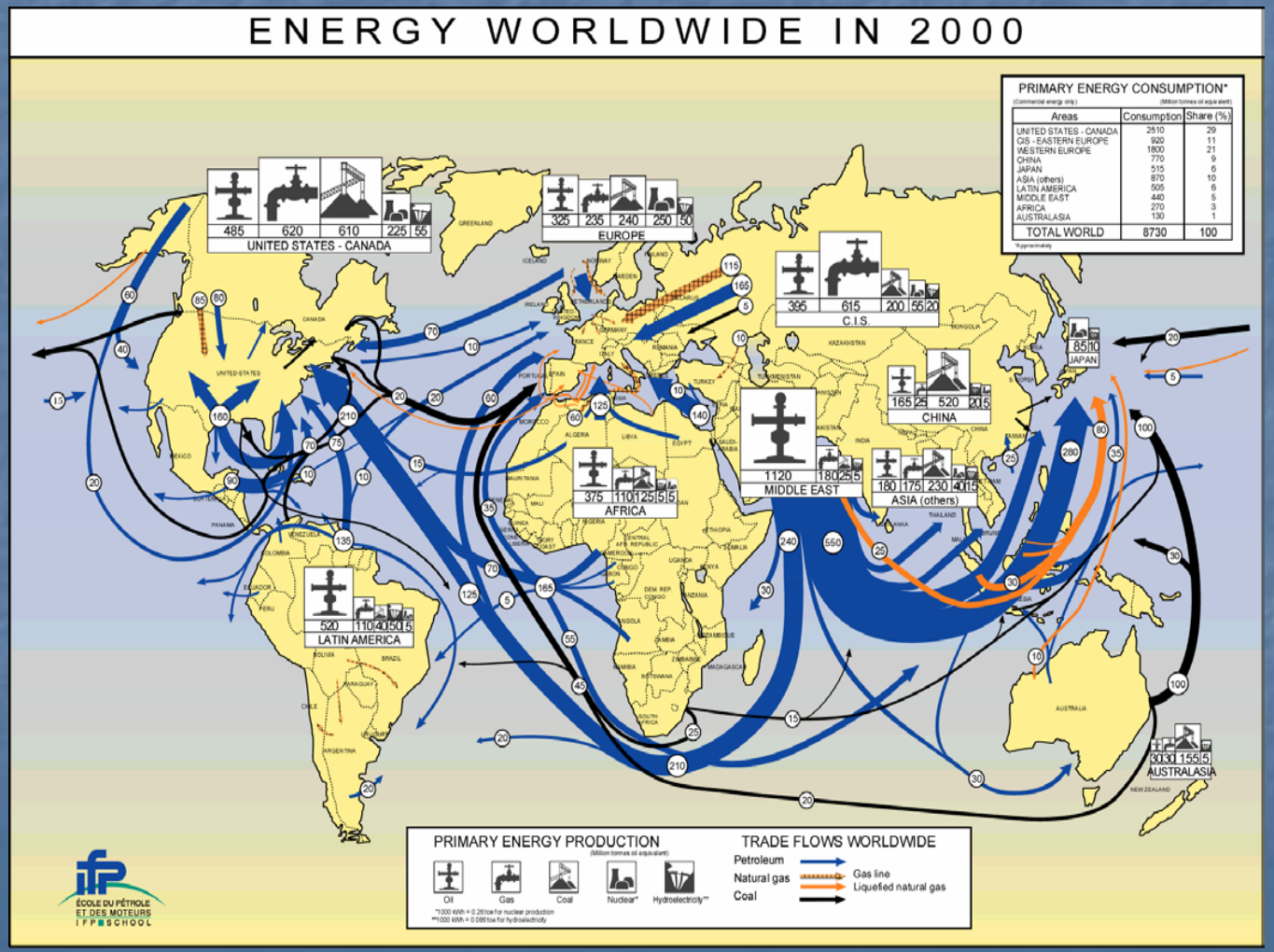
Market Drivers for Hybrid Systems

- Fuel Supply Diversification and Assurance
  - Reliability of supply and hedges against price fluctuations will remain key criteria
- Synergisms for Increased Overall Efficiency
  - Fuel is the single largest cost on a life cycle basis
  - Fuel delivery cost can exceed the wholesale fuel price
- Environmental
  - The reduction in required battery capacity size and the ability to extend the battery life due to the charge-discharge capabilities provides a significant synergistic benefit in both economic and environmental terms
  - Lower local and GHG emissions

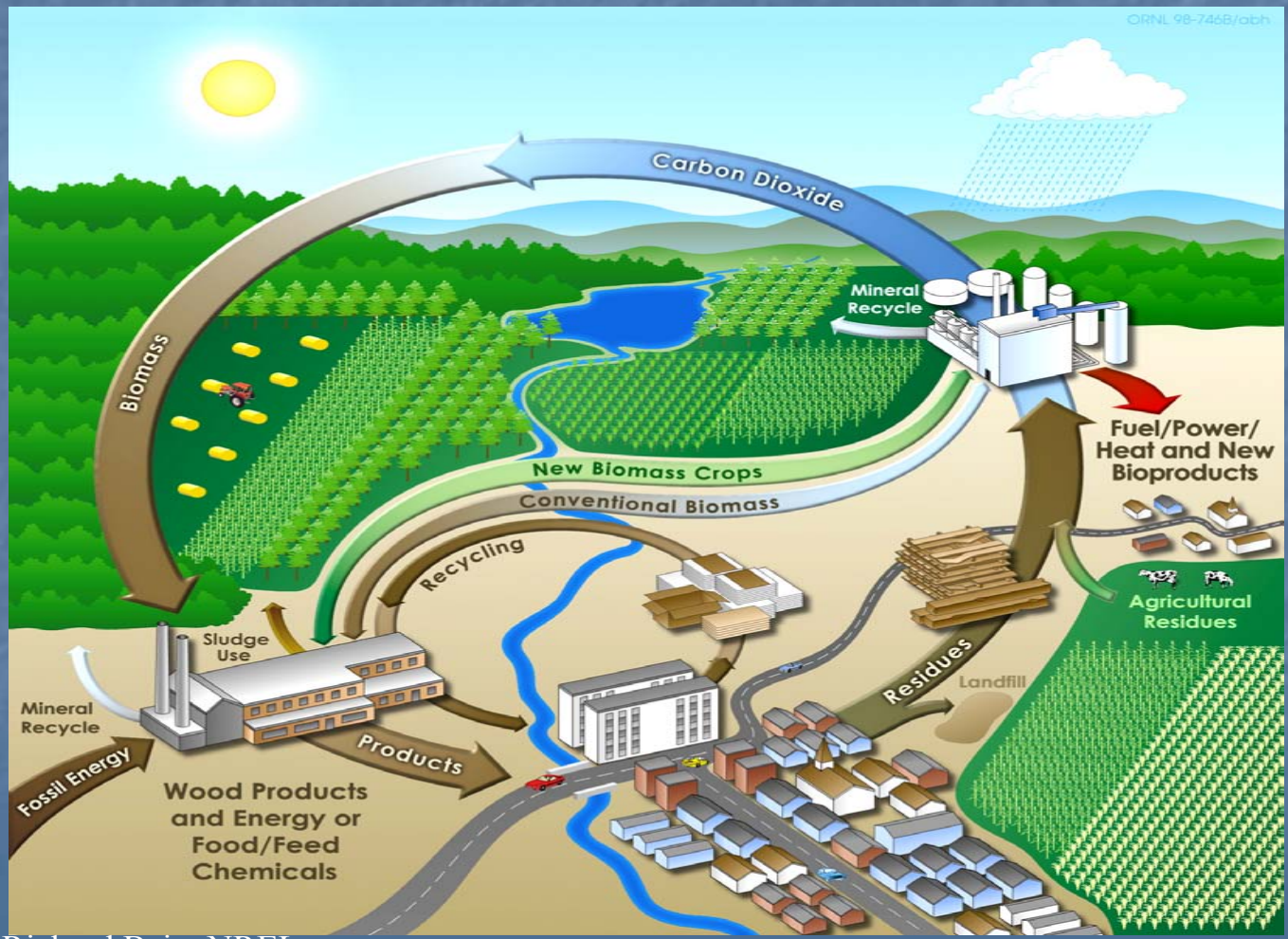
Displacement of Batteries in Hybrid Systems

- The environmental and economic impact of battery disposal from PV is currently a muted controversy
- It is a matter of time before a "cradle to grave" environmental impact assessment is made of the issue due to the inappropriate and unsafe disposal of used batteries in rural applications
- Hybrids reduce required battery capacity by ~50%
- Hybrids increase time between battery replacements by ~2.5:1 which is a substantial environmental benefit that the Multi-Lateral lenders are attuned

Ingenious Supply Anyone?



A long term vision



Graphic: Richard Bain, NREL

Transitioning from 10 kW to 50 MW units

- The unique multi-fuel, high efficiency, low emissions, kW size range and incentives available to hybrids make the required business model and financing modalities dissimilar to reciprocating engine technology
- Higher value markets will require redundancy of smaller units to achieve four to six 9's reliability
- As technology matures, larger units with higher efficiency and lower O&M will dominate markets

International Markets

- Worldwide net electricity consumption is projected to increase at an average annual rate of 2.4%.
- Strong growth in electricity use is expected in the countries of the developing world, particularly developing Asia, as long as SARS does not create a major economic slowdown in the region
  - China's electricity consumption is projected to nearly triple, growing by an average of 4.3 percent/year.
- Slower growth in population, market saturation and efficiency gains are expected to result in a 1.7% growth rate for electricity use in the OECD

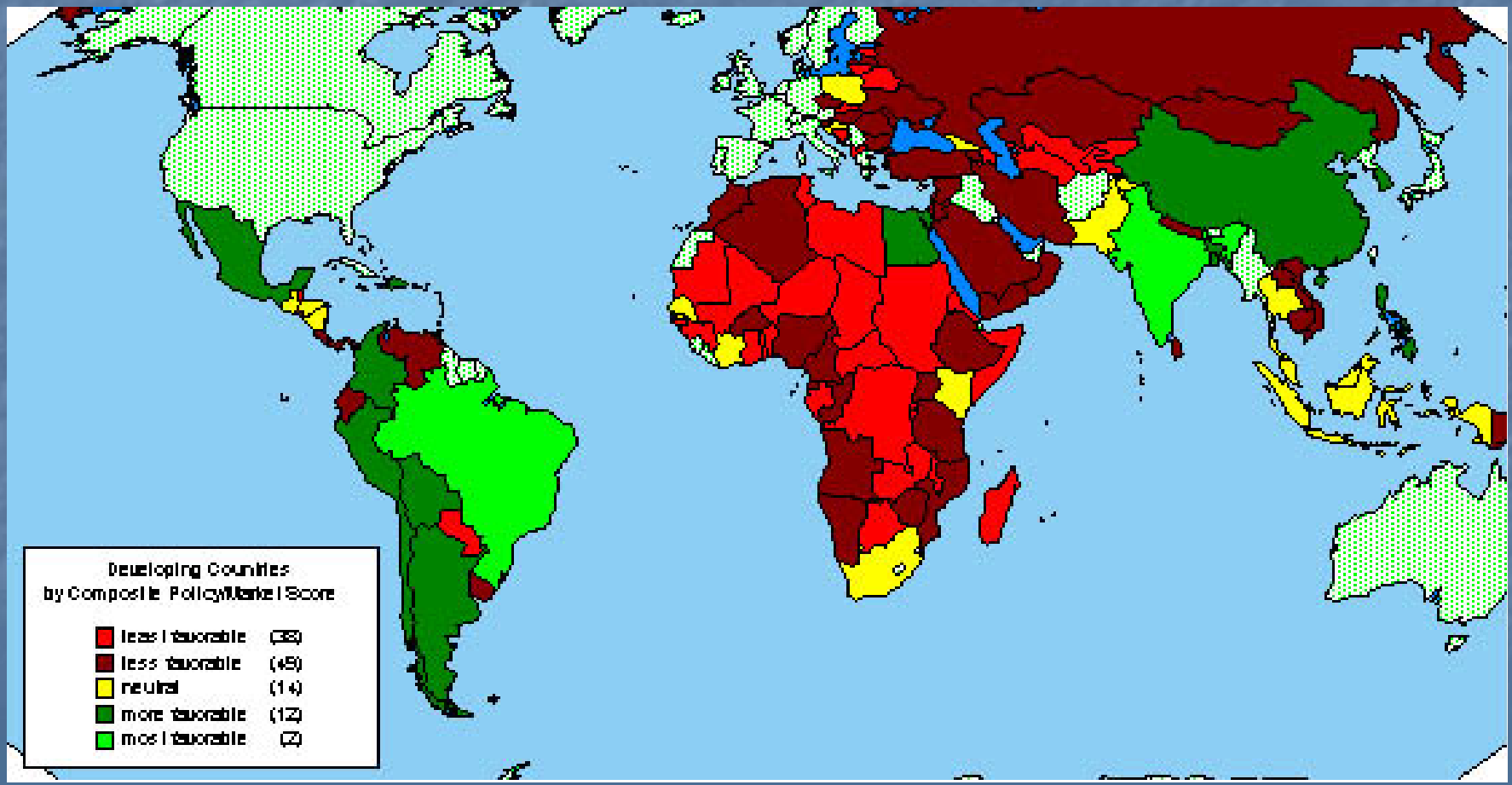
Current Trends

- Foreign direct investment in the developing world slowed in 2001to one-fifth of the 1997 peak.
- Highly publicized deregulation failures have slowed or reversed trends towards restructuring

Future Energy Infrastructure Considerations Favorable to Hybrids

- Current and future need to build a disaster-resistant and disaster-resilient energy system
- A system is not secure because it's American or big, but because it's designed to make large-scale failures impossible and local failures benign
- Consortium for Electric Infrastructure to Support a Digital Society (CEIDS)
  - The architecture will provide a foundation for open, systems-based communications and distributed computing to enable "intelligent" delivery of electric power and connect consumers with energy markets.

Ranking from Eight Point Market and Policy Criteria



Role of Multi-Lateral Lending Institutions

- Except for high value applications (e.g., hotels, office buildings, substations and industry), interviews with the market actors confirmed that there would be minimal developing country market penetration by hybrids prior to 2010 without significant intervention due to inferior price elasticity, infrastructure, and fuel availability.

Enabling the International Market

- There is a need for bringing together various stakeholders and using appropriate financing modalities to facilitate sustainable, decentralized markets for those technologies that have the attributes of fuel flexibility and hybridization, particularly with renewable technologies
- Primary challenges for organizing and delivering hybrid project financing, not unlike other supply-side distributed generation, will stem from the large number of small projects which characterize most of these rural, peri-urban and urban markets

Near Term Objectives for the Developing Countries' Hybrid Markets

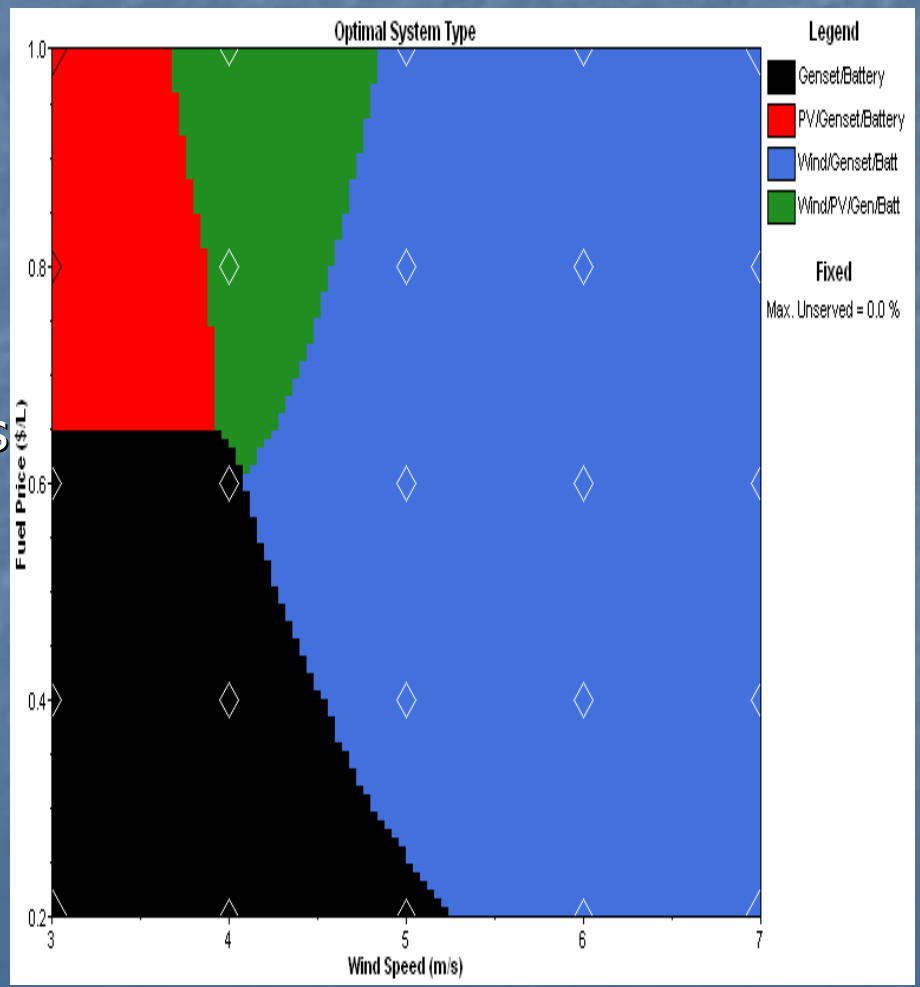
- Create and utilize near-term capital and targeted subsidies, reflecting the fact that hybrid systems are currently pre-commercial and uneconomic;
- Develop concessional co-financing which uses commercial methods tied to commercial capacity building and conducting strategic programs ("market launching orders") of hybrid systems
- Direct assist a range of capacity building, policy and market organizing activities for sustainable markets

In-Country Needs

- Policy and utility barriers, standards, permitting & siting, and end-user awareness;
- Capacity building and training of market actors in all phases of the project cycle including application engineering, installation, O&M, after sales servicing, fuel supply, financing and other infrastructure capacities; and
- In-country project identification, site selection criteria and economic feasibility analysis of specific applications and markets, including distributed generation cost/benefit, interconnection and load management analysis for utilities.

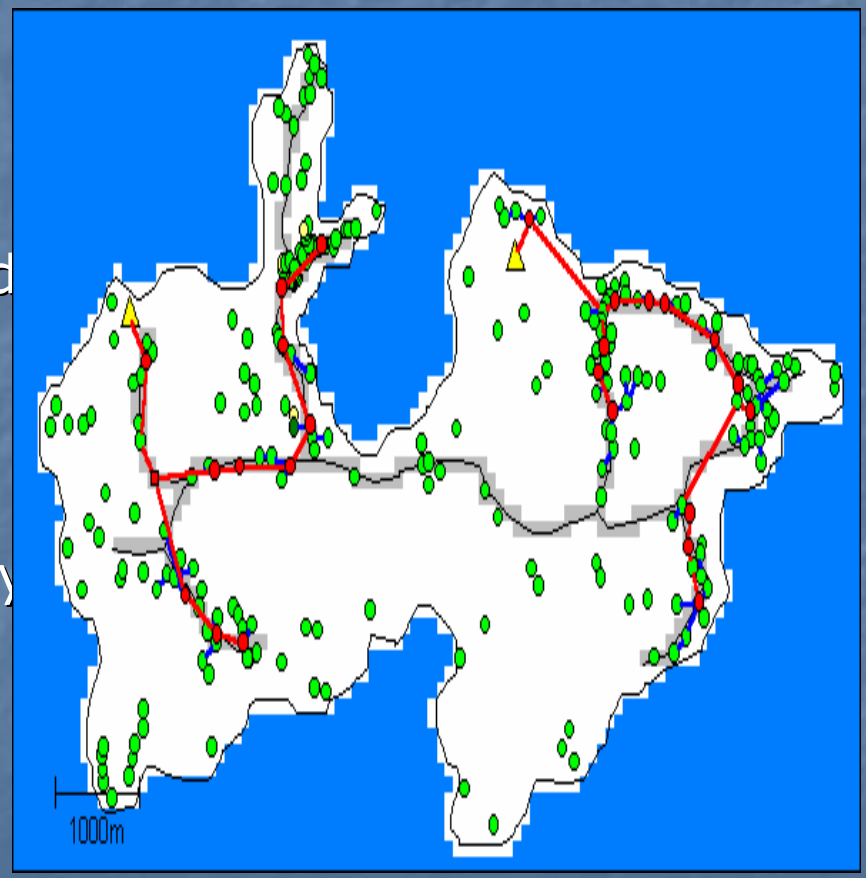
HOMER Software

- A computer model that simplifies the task of evaluating design options for off-grid power systems for remote and stand-alone applications
- Optimization and sensitivity analysis algorithms allow users to evaluate the economic and technical feasibility of a conventional and renewable/hybrid options and to account for variation in technology costs and energy resource availability



ViPOR Software

- An optimization model for designing village electrification systems
- With load sizes and equipment costs, ViPOR decides which load should be powered by isolated power systems and which should be included in a centralized distribution grid.
- The distribution grid is optimally designed with consideration of local terrain



Hybrid2 Software

- Models combinations of wind turbines, PV arrays, micro turbines, diesel generators, power converters, and battery storage, both in AC, DC, or two-bus systems.
- Allows for more than 100 dispatch configurations with multiple generators, renewable sources, and battery storage
- Does project cash flow and investment payback.
- Economic analysis that considers new or retrofit systems, O&M costs, equipment overhaul costs, installation costs, taxes, and system salvage value
- Economic module outputs include but are not limited to life cycle costing
- (http://www.ecs.umass.edu/mie/labs/rerl/hy2/intro.htm)

Peri Urban Market for Hybrids

- According to the UNDP, of 1.3 billion poor people, about 40 percent live in peri-urban agglomeration,
  - in Latin America 90 percent of the poor live in peri-urban areas.
- Peri-urban households are easier and cheaper to electrify than unserved rural households
- Generation, transmission, and distribution costs are much lower than in isolated rural villages because lower-cost grid extension is feasible
- "Peri-Urban Electricity Consumers—A Forgotten but Important Group: What Can We Do to Electrify Them?" (October 2001 Report 249/01)

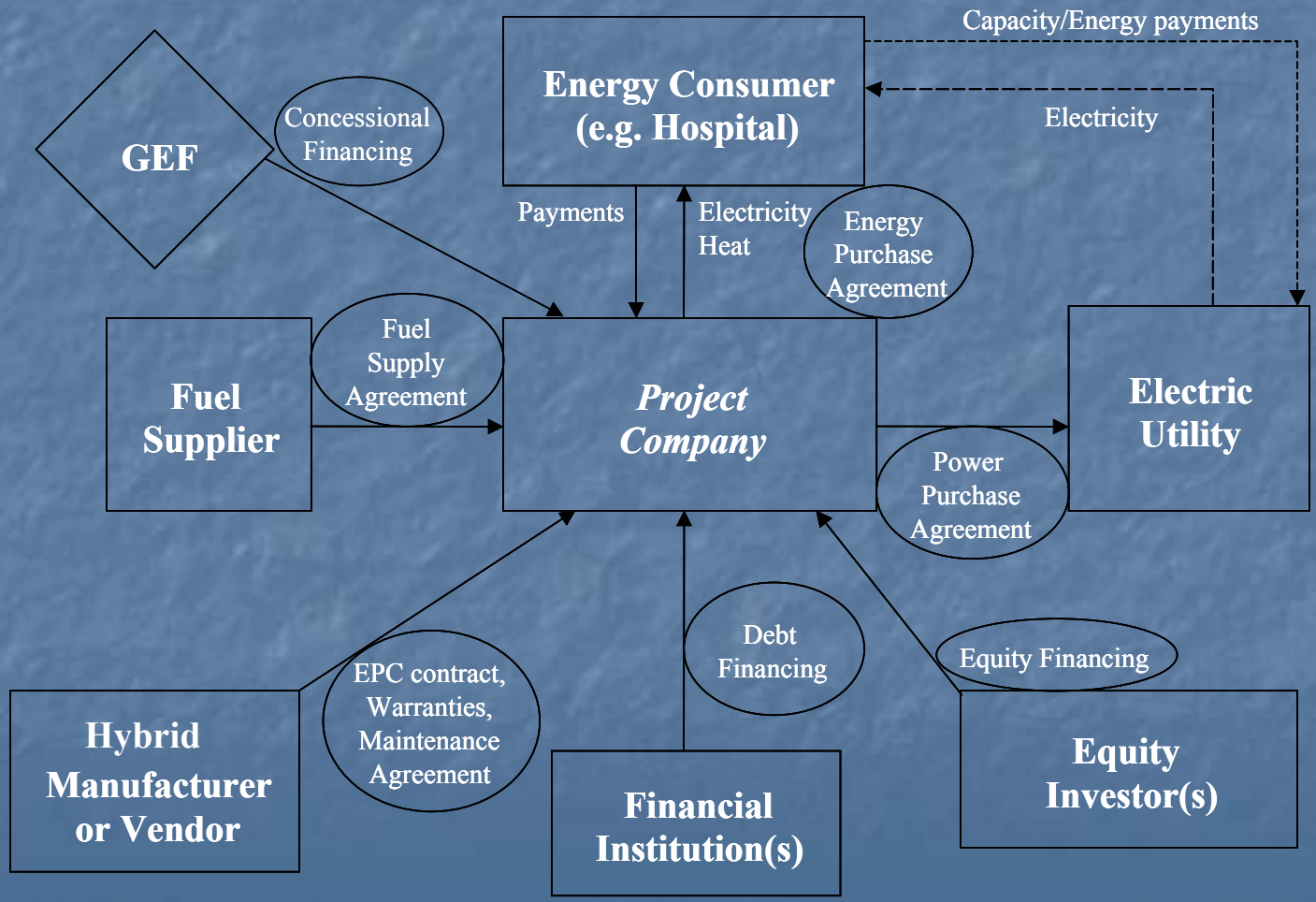
Market Actors for Hybrids

- Three special types of market actors with strong potential relevance for hybrid project development, implementation and financing are (i) electric utilities, (ii) fuel suppliers, (iii) manufacturers
- Each can play a key role in market aggregation strategies, including
  - sponsoring ESCOs and equipment financing
  - A "super-ESCO" program is one where the utility acts as the ESCO from the customer's perspective, but, to deliver the hybrid projects and services, qualifies and organizes a network of hybrid project partners to co-market and deliver the projects,

Developing, Financing and Implementation Actors for Hybrids

- Hybrid manufacturers and related component suppliers;
- Equipment distributors/ vendors, who can include ESCOS and any party who directly markets hybrids to the end-user
- ESCOS which provide after-sale O&M services for installed equipment
- Electric utilities
- Fuel suppliers, which can include natural gas utilities, LPG vendors, and biomass producers
- Financial institutions, and
- End-users which may include organizations which aggregate end-users for the purpose of project development and implementation.

Likely Project Structuring



UN And World Bank Publications

- Best Practices for Distributed Electrification (ESMAP ‘01)
- Options for decentralized energy charging systems, installation of renewable energy systems (World Bank ’96)
- Connection to medium-tension transmission lines (ESMAP 2000)
- Specific solutions for peri-urban areas (World Bank ‘99),
- Project-specific documents (based on country interventions) already implemented for commercial electricity services (World Bank 1998) and mini-grids (World Bank 1999)