Framework for the Economic Valuation of Decentralised Electricity Supply

Research Proposal

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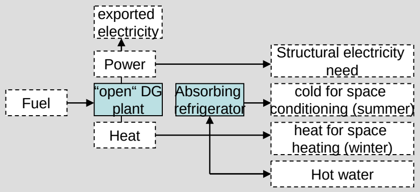
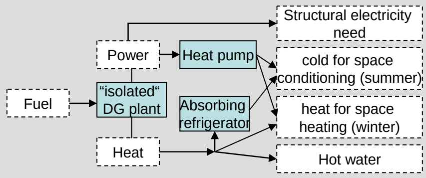
1. Introduction

• Energy industry under multiple requirements in relation to market restructuring, security of supply and systematic reduction of carbon emissions.
• Key element to enable production processes and support economic growth.
• Decentralisation:

- Distributed Generation is an electric power source **connected directly to the distribution network or on the customer site** of the meter. Categories: micro (< 5 kW), small (5 kW - 5 MW), medium (5 - 50 MW) large (50 - 300MW) (Ackermann, 2001).
- Distributed Energy is defined as electricity generation that is **located close to load** and rated at **less than 30MW**. Currently accounts for 4% of installed capacity and 2% of total generation in Australia (CSIRO, 2007).
- It also refers to the **process of transferring power and resources**. This involves political, administrative and market aspects, where local acceptance, ownership, operation & maintenance schemes and fuel storage constraints are major challenges (Alanne, 2006).

Configurations of decentralised supply





(Gulli, 2006)

BENEFITS

Integrated to the existing grid	Stand-alone minigrid
- Reduction of transmission losses	- Prompt access to electricity
- Better load management	- Enhance local economic activities
- Deferral of investments plants, networks	- Avoidance of grid extension

The appropriate diffusion of decentralised technologies can be facilitated through the economic valuation of their full range of benefits, to get a better measure that has not been captured in current commercial arrangements.

2. Literature Review / Current Research

LITERATURE

- isolated systems: project analysis for specific technologies (since the 70's)
- open systems: distributed generation (since late 90's)
- peer-reviewed on system modelling, multi-criteria decision models since 2003

Current energy models use technical analysis&capital flows, not economic valuation.

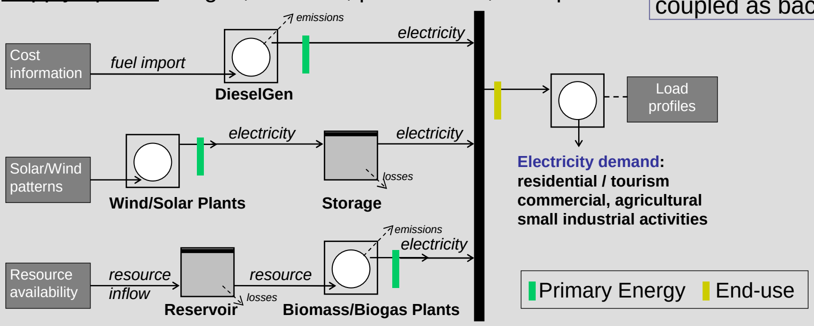
PROGRAMS

- **European FP5 (2003-06)**: ICT (design&monitoring), supply demand matching
- **European FP6 (2005-09):** large-scale deployment (demand management, development of key components and control approaches, business models)
- **USDOE (2005-12)**: key technology areas, demonstration projects.
- **CSIRO**: Intelligent agents (bi-directional flows, management of customer loads and generators, virtual power stations, demand response in minigrids)
- **CSIRO**: Intelligent Grid **value proposition –top-down–** (social, economic, environmental- simulation research based on near-term, high impact scenarios)

3. Framework: overview

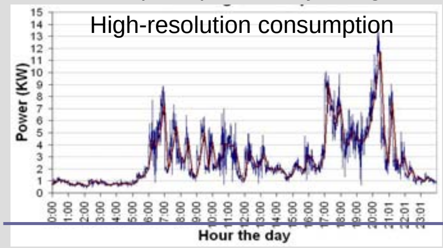
Research Questions: Which schemes of decentralised electricity supply can support better a sustainable economic growth in remote communities? What diffusion path should be followed for their deployment?

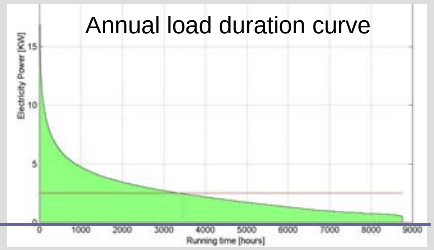
Supply options: biogas, biomass, photovoltaic, wind power + Diesel generator coupled as back-up



3. Framework: demand characterisation

- Demand is **not a steady process** of use of energy: the dynamic load conditions determine **different environmental** and **economic performance**.
- Decentralised generation requires to match very well the demand.
- Energy demand **in Australia**: electricity, hot water and heat (combined heat & power generation as most efficient option if the latter are significant).
- **Load profiles of end-use appliances** of households in NSW are available. Important to observe the **effects of household/user characteristics** on the consumption patterns by using econometric models.





3. Framework: electricity production function

The system is assumed to be owned, maintained and managed by a third-party.

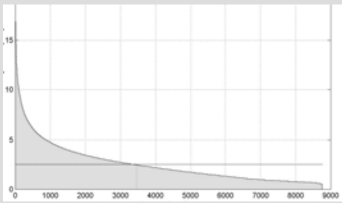
Functional form: $E(L,K,N)=\left(A\cdot L_F^{\alpha}\cdot K_F^{\beta}(t)\cdot N_F^{\varphi}+B\cdot L_{Ren}^{\alpha'}\cdot K_{Ren}^{\beta'}(t)\cdot N_{Ren}(t)^{\varphi'}\right)^{\gamma}$

F = fossil fuel. Ren = renewable fuel

- Input: fuel resources (N), labor (L), capital (K: plant and land use).
- Output: electricity for different applications

- The process is **dynamic and short-run costs are aggregated over one year**. The operation of the diesel generator is conditioned by high power demand conditions or insufficient renewable resources.
- The **minimisation of production costs** allows the greater return of the value-adding activities undertaken by the communities.
- The level emissions of by-products such as greenhouse gases, air pollution, degradation of water resources, impose **additional costs to the community** that **are to be internalised** in the optimisation.

3. Framework: diffusion path



• **Setting tariffs**: according to the load type and overall social costs. The value to the community is given by the area under this demand curve.

• **Minimize the path** of fossil resource use conditioned on the availability of renewable resources and the demand over a 20 year timeframe

• **Trade-off on benefits** between hybrid supply schemes compared to the operation a Diesel Generator (BAU scenario): stochastic analysis according to their operating and societal costs (MonteCarlo simulation).

• Using the **pareto principle**, a path is defined by identifying the supply schemes that are no worst to the BAU scenario in terms of both societal and private costs.

Decentralised systems with lowest additional costs in supporting higher productivity activities are more likely to be deployed sooner.

4. Data and Sources

TECHNOLOGIES

• Current technology costs and performance assumptions.
• Projections of capital costs for DG technologies.
• Full-fuel cycle pollutant emission factors.
• Resource patterns: prices, availability, variability (refer to a case).

DEMAND

• Requesting metered data in households and commerces.
• Load profiles of end-use appliances for households in NSW.
• State and national electricity demand growth projections.
• Price elasticities of demand for electricity

EXTERNAL COSTS

• Environmental costs (using a stochastic approach): range of estimates of the social cost of carbon and air pollutants arising from power generation.

5. Main references

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