Small scale renewable energy systems:
Lessons from the last 20 years

Hugh Outhred
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Key points

- Sustainable energy services are important to urban & rural communities in all countries
- Small RES may succeed or fail to provide sustainable energy services:
  - Both general principles and specific context matter
- Success requires:
  - Decision-making that integrates economic, societal , environmental & technical aspects of sustainability
  - Managed innovation in HSO dimensions of technology
  - Well-designed acculturation processes for target communities, RES designers, installers, operators, financiers, policy makers & politicians

Note: RES = Renewable Energy Systems
HSO = Hardware, Software & Orgware

Energy & the environment:
A community in the Philippines after Typhoon Haiyan

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Energy & the environment:
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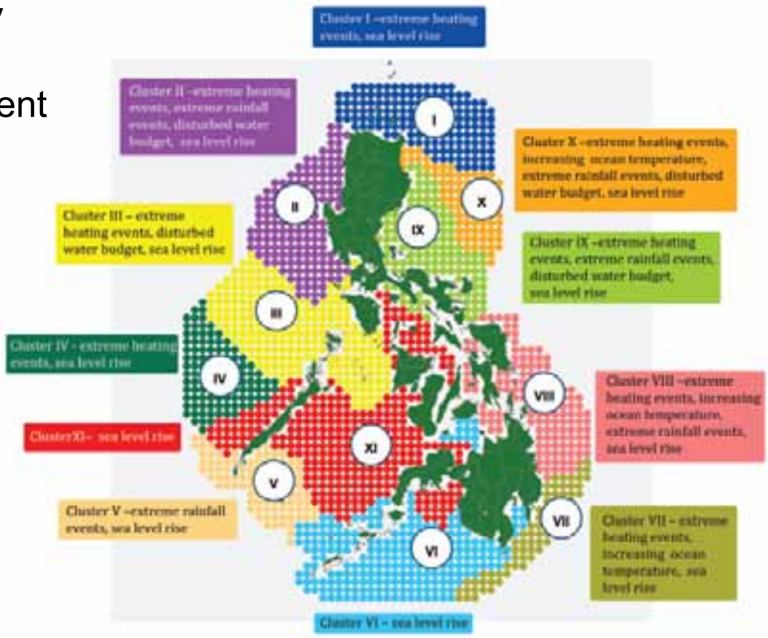
PHILIPPINE EXPOSURE MAP ON CLIMATE CHANGE

http://www.washingtonpost.com/blogs/wonkblog/wp/2013/11/12/what-the-deadly-typhoon-in-the-philippines-tells-us-about-climate-adaptation/

Energy & the environment



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Energy & the environment: the evolving policy context

- *"Continued growth in global emissions creates real risks for all countries, including Australia. It is in Australia's interests to contribute to global action to limit the increase in global average temperature compared with pre-industrial levels to below 2 degrees… Electricity is the most important sector for potential emissions reductions. It has the largest share of Australia's emissions, and the modelling undertaken for the Authority suggests it could contribute the largest share of emissions reductions if policy drivers are effective." (Reducing Australia's Greenhouse Gas Emissions – Targets & Progress Review Draft Report, October 2013,* http://www.climatechangeauthority.gov.au)
- *"Ofgem's principal objective is to protect the interests of existing & future consumers. This includes their interests in the reduction of greenhouse gases and in the security of the supply of electricity and gas."* https://www.ofgem.gov.uk/ofgem-publications/84728/electricitycapacityassessment2014-consultation.pdf

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Alma Cota and Robert Foster (2010). Photovoltaics for Rural Development in Latin America: A Quarter Century of Lessons Learned
http://cdn.intechopen.com/pdfs/12219/InTech-Photovoltaics_for_rural_development_in_latin_america_a_quarter_century_of_lessons_learned.pdf

- *"When developing solar projects in Latin America, there is a tendency for some organizations to focus on the technology, while other focus largely on institutional issues. The happy medium takes into account both and promotes partnerships, local capacity building, quality technical design, and monitoring and evaluation."*
- *"Some key considerations for any solar project include: Develop solid partnerships, conduct strategic planning, use grass-roots development approach, foster reasonable end-user expectations, create sustainable markets, promote capacity building, size appropriately, obtain user input, develop a professional design, insist on quality, conduct preventive and regular maintenance, anticipate future growth, maintain parts supply inventory, consider safety and security, demand guarantees and warranties, conduct follow-up and evaluate results and think sustainability."*

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Retnanestri and Outhred (2013), Acculturation of renewable energy technology into remote communities: lessons from Dobrov, Bourdieu, and Rogers and an Indonesian case study. http://www.energsustainsoc.com/content/3/1/9

- *"Renewable energy technology can meet the energy needs of remote communities if local renewable energy resources are available and if it is deployed in a way that meets reasonable community expectations, thus allowing it to diffuse into the local culture in a process that can be called renewable energy technology acculturation. This paper analyzes renewable energy technology acculturation using Dobrov's conceptualization of technology as hardware, software, and orgware; Bourdieu's categories of objectified, embodied, and institutionalized cultural capital; and Rogers' concept of diffusion of innovations."*
- *"The most important lesson from the Oeledo project, when assessed using a combination of concepts developed by Dobrov, Bourdieu, and Rogers, is that off-grid technology transfer requires a sophisticated understanding and deployment strategy"*

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Three-dimensional nature of technological systems
(Dobrov, 1979)

Critical for complex systems

Orgware (institutions, rules, culture):
- *Legislation in all relevant jurisdictions: societal culture*
- *Judiciary, regulation, rule management, mores*
- *Industry structure & self-regulation, eg. ombudsmen, industry codes, industry culture*

Orgware Layer

Software (know-how):
- *Technical regime: knowledge & skills to design, build, connect & operate at component & system levels*
- *Security & commercial regimes: systems for operation monitoring, negotiation & control, including markets*

Software layer

Hardware (tools, machines, equipment):
- *Equipment for energy conversion chain – electricity generation, transmission, distribution, end-use*
- *Equipment for monitoring, analysis & control*
- *Tools & machines for construction & maintenance*

Hardware layer

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RES technology as cultural capital (CC) to be integrated with (possibly basic) pre-existing energy industry cultural capital

HSO-wares	Cultural Capital	Pre-existing industry CC	Integration process
Hardware *Equipment*	**Objectified CC** *Cultural goods/objects such as books, paintings, instruments, machines*	Pre-existing electricity industry equipment	RES equipment is transferred in its materiality (eg through sale or donation)
Software *Know-how*	**Embodied CC** *Long-lasting dispositions of mind and body, possessed by individual or agent*	Information, skill, knowledge to plan, operate & maintain the pre-existing industry	RES information / know-how is integrated through a process of embodiment (requires time & effort)
Orgware *Institution, Rules, Network*	**Institutionalized CC** *Educational qualifications; Institutionalization of embodied cultural capital*	Stationary energy sector organization structure, legislation, rules, etc.	Facilitate transfer of orgware then software then hardware (embodiment process through education & training)

RES Innovator Initial holder of RES CC ⟷ **Industry Innovator** Facilitator of RES CC integration ⟷ **Pre-existing industry CC** Adopter of RES CC

Orgware for facilitating integration of RES into a pre-existing electricity industry

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Decision-making framework for an electricity industry (more formal for larger industries)

Governance regime (O)	▪ Formal institutions, legislation & policies ▪ *Informal social context including politics*
Security regime (H/S/O)	▪ Responsible for core integrity on local or industry-wide basis, with power to override
Technical regime (H/S)	▪ To allow connected industry components to function as industry-wide machine
Commercial regime (S/O)	▪ To coordinate decentralised decision-making according to commercial criteria, including: ▪ *Formally designed electricity & gas markets*

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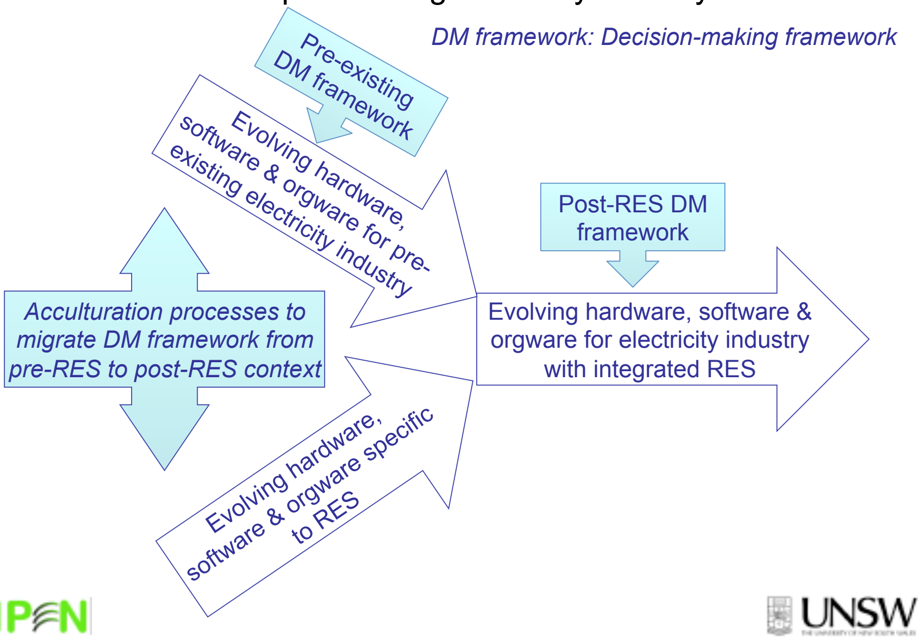
RES integration as a process of acculturation into a pre-existing electricity industry



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Conclusions

- RES evolves & operates within a societal & environmental context:
  - Hardware, software & orgware must continue to function coherently for RES to become community cultural capital
- Hardware, software & orgware must be designed in with the context in mind:
  - Communities should play a central role in the design, implementation & evolution of their electricity industries:
    - Including issues concerning RES integration
  - All risks to beneficial on-going community outcomes should be considered

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Hugh Outhred Bsc, BE (Hons 1), PhD

Hugh Outhred is the Managing Director of Ipen Pty Ltd, which provides advisory and educational services on energy, society and the environment. He is also a Senior Visiting Fellow at the University of New South Wales, Sydney and Guru Besar Luar Biasa (Visiting Professor) at STTNAS Jogjakarta, Indonesia.

Hugh retired in 2007 after a 35-year career at the University of New South Wales, most recently as Presiding Director, Centre for Energy and Environmental Markets and Head, Electrical Energy Research Group, School of Electrical Engineering and Telecommunications.

Hugh has been a Fulbright Senior Fellow at the University of California Berkeley, a Member of the National Electricity Tribunal, a Member of the New South Wales Licence Compliance Advisory Board, a Board Member of the Australian Cooperative Research Centre for Renewable Energy, an Associate Director of UNSW's Centre for Photovoltaic Devices and Systems, a Member of CSIRO's Energy Flagship Advisory Committee and a Lead Author for the IPCC Special Report on Renewable Energy Sources & Climate Change Mitigation, 2011.

Email: h.outhred@unsw.edu.au; hugh_outhred@ipenconsulting.com,
Web: www.ipenconsulting.com

Ismail et al (2012), Performance Assessment of Installed Solar PV, http://dx.doi.org/10.4236/eng.2012.48059

Table 1. Profiles of solar PV installation in Oke-Agunla Village, Ondo State.

SN	ITEM	REMARK
1	Estimated Population of the Village	1050
2	Average Number of Households in the Village	150
3	Average Number of Persons per Household	7
4	Number of Households Connected	1) 40 off-grid, stand alone 70 W panels per household with battery. 2) 10 off-grid, stand alone 70 W panels for street light poles. 3) 10 off-grid, stand alone 70 W panels for vaccine refrigeration. 4) 3 off-grid, stand alone 70 W panels for a church, a mosque, a school, a palace.
5	Type of Solar PV Installation	Solar Home System (SHS), Solar street Lights (SSL) and Solar Clinic System (SCS)
6	Year of Installation of PV System	June 2006, commissioned by former President Olusegun Obasanjo.
7	Capacity of the PV (Panels) Installed	4.5 kW
8	Major Components of the PV Installation	70 solar panels and accessories, 50 storage batteries, 2 inverters, 2 battery controllers and 8 ELCB breakers, 2 big deep freezer, 15 W bulbs, 200 W bulbs.
9	Objective of the PV Installation	Generate Electricity for the village.
10	Sponsors of the PV Installation	JICA, ECN and Ondo State Government.
11	Status of the Installation	Working well but not enough to meet village demand.
12	Monitoring & Evaluation	ECN, PHCN
13	Sustainability	Continuous training of village technicians who work with experts at ECN for maintenance of the installation.

"[This] study has shown that the installed 4.5 kW solar PV systems at Oke-Agunla village was underutilized as a result of the systems malfunctioning or performance deterioration arising from poor maintenance, lack of technical know-how and inadequate training as well as ill-experience of the project managers."