Products, Services, and Regulations Moving Up and Down the "Energy Ladder"

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Microgrids: Policy Pathways for Progress
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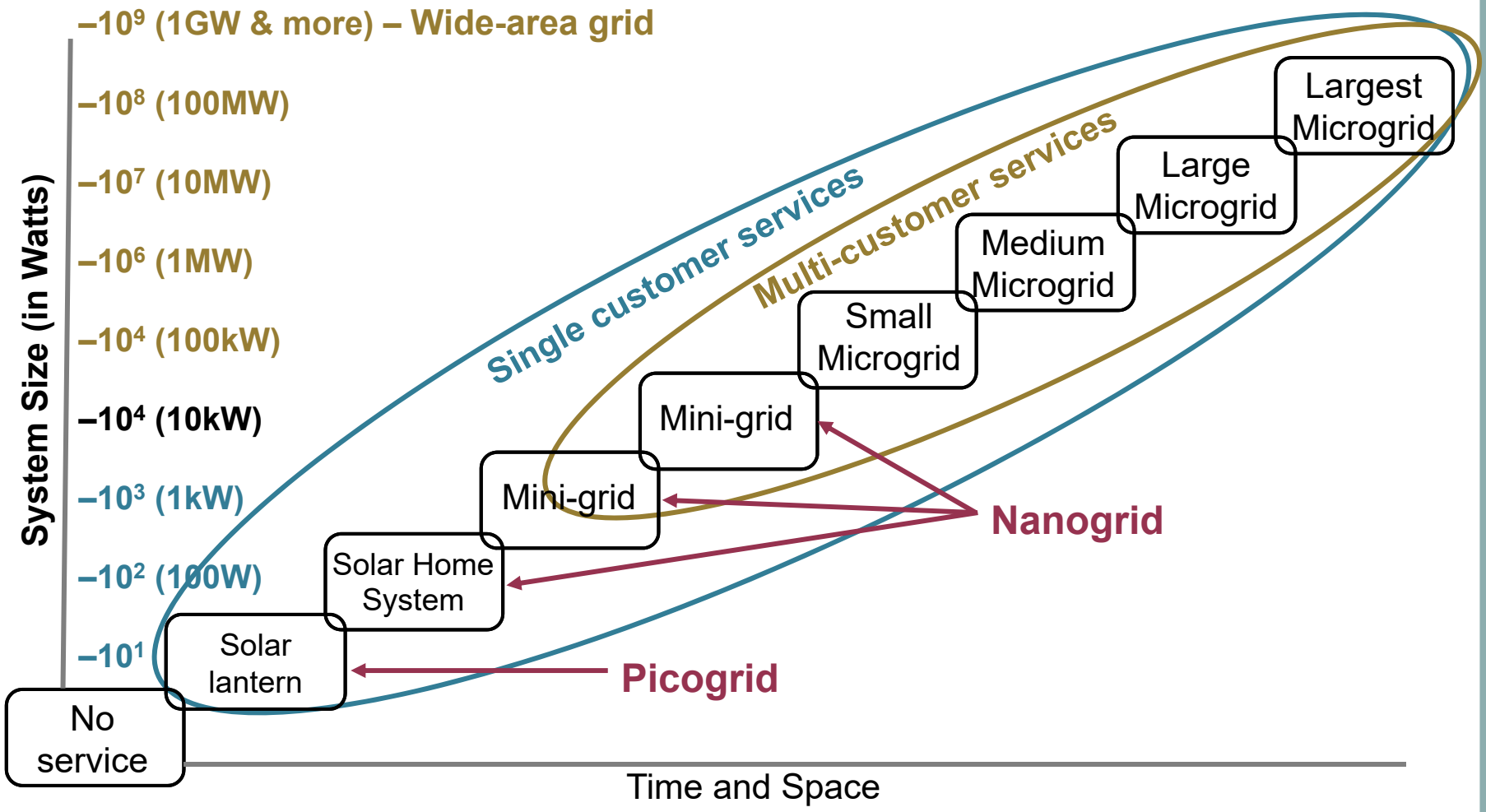
NRRI work in progress…
Regulating Energy Ladder Products and Services

- What is the 'Energy Ladder' and how does it apply, both to areas with and without any existing grid?
- Why now? What's new and different today – for utilities, for customers, and for the technologies themselves – that makes this discussion relevant?
- Possible utility and regulatory roles for stand-alone (off-grid), on-grid, and dual use products and services
- Identifying regulatory and institutional barriers & breakthroughs, and if necessary opening up energy ladder development pathways

Heading up or down the energy ladder…
Possible steps to an energizing future



The same 'energy ladder' steps, with or without a pre-existing grid

- Individual loads served by stand-alone (off-grid) or dual-use (on- or off-grid) equipment, for high reliability and portability
- Remote facilities – long-distant wires and small loads
- Mini-grids with redundant supplies and back-up service, for critical power needs
- Public-purpose microgrids for emergency response functions and services
- Campus-wide microgrids for high reliability and resilience

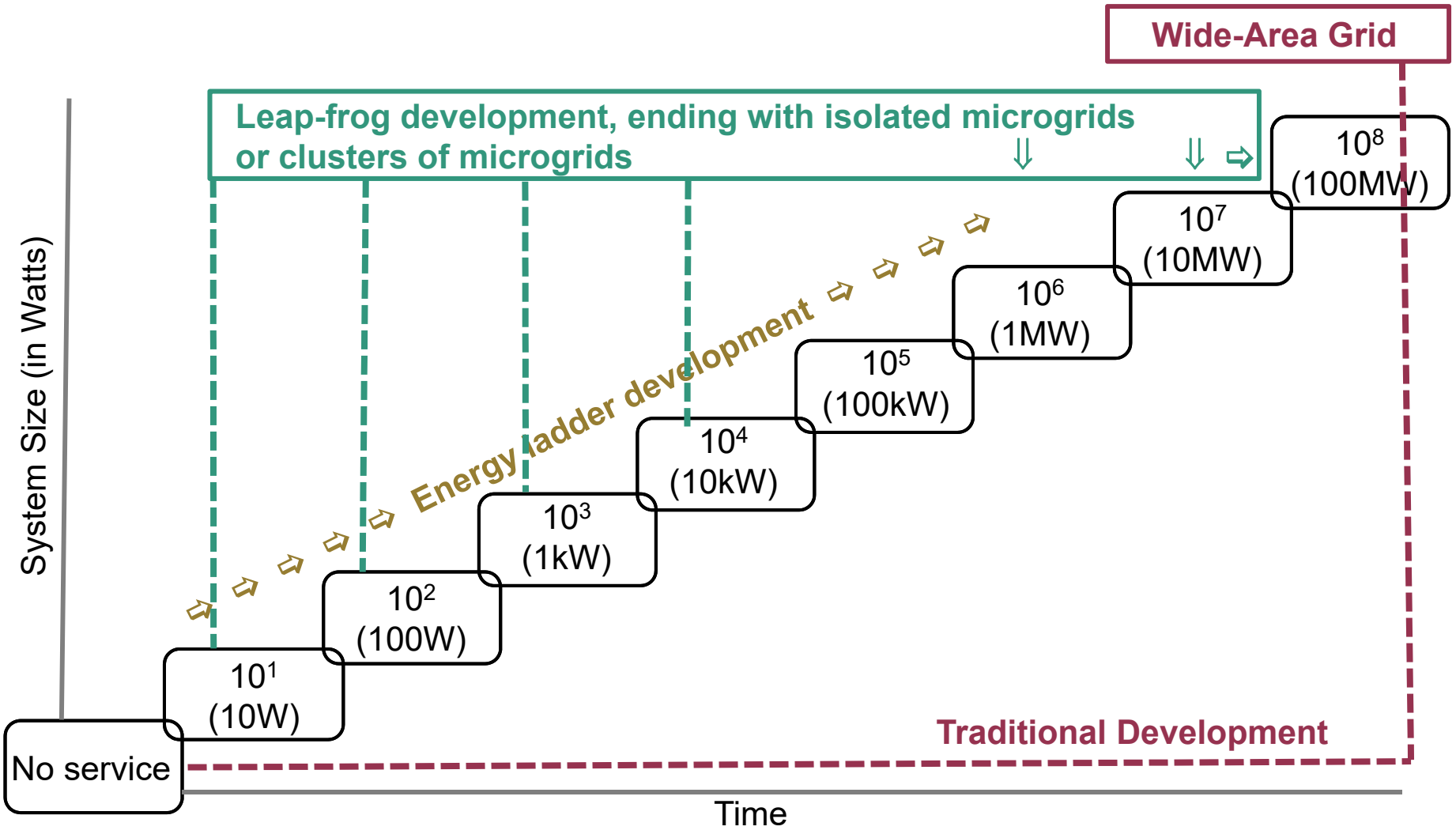
Defining the 'energy ladder'
for places with no pre-existing wide-area grid

- The 'energy ladder' describes a **progression,** starting with consumers having no or minimal access to modern energy services, through **discrete steps designed so that each one helps to reduce energy poverty, improve the consumer's standard of living, and provide increased economic opportunities**.
- The 'energy ladder' is "... **a sequence of products and services** moving up several rungs, eventually reaching either a wide-area-grid, or a 'leapfrog' over 20th century energy-service delivery to a new paradigm using either single or multiple, nested micro-grids" (Levin and Thomas, 2016).

Defining 'energy poverty'

- Energy poverty is broadly defined as a lack of or minimal access to modern household energy services for meeting basic human needs, such as for lighting and cooking.
- Relieving energy poverty is often defined as having access to at least some electricity and clean, safe cooking.
- Where wide-area grids already exist, households are considered to be living in energy poverty if they spend a high percentage of income on energy and struggle to keep up with rising energy prices.

Possible energy ladder progress via leap-frog advancement



Big picture ideas for 'energy ladder' conditions and considerations

- World Bank (2017b, p. xii) states: "Both grid and off-grid approaches will be critical, but they will have to be supported by a conducive **enabling environment of the right institutions, policies, strategic planning, regulations, and incentives**." The two approaches [grid and off-grid] can and should be complementary, including long-term plans for transforming off-grid and mini-grid systems, when the time comes, by absorbing and consolidating them into larger distribution grid systems.
- Energy ladder products and services should be fully **compatible with one another, and scalable, so that they integrate seamlessly** with either single or multiple microgrids or with a wide-area grid (Stanton, in press)

The changing U.S. utility landscape

- Aging, brittle infrastructures (energy & water), prone to breakdown, expensive repairs, massive replacement costs
- More natural disasters resulting in long-term outages and billion-dollar damages
- Large grid-modernization expenditures
- Environmental pressures, both pushes from regulators and pulls from customers
- Flat or declining utility load & revenues
- Proliferating, cost-effective utility and customer DER options that can produce and deliver multiple benefits
- Growing importance of the food/energy/water nexus
- Changing consumer needs and choices for clean energy, power quality, reliability, and resiliency

What's new and different for customers?

- Major world-wide efforts to bring basic energy services to everyone – "Sustainable Energy for All"
- Changing consumer choices and customer needs for 21st Century power sources, quality, reliability, resilience
- Consumers evolving into prosumers
- Increasing numbers of wide-scale weather-related outages
- Increasing electrification and the use of electricity for mission-critical applications
- A granular view of reliability and resilience, all the way to individual facilities, circuits, and even devices
- Increasing choices for portable power

What's new and different for energy ladder technologies?

- Growth in practical, cost-effective technologies at any scale, including solar plus batteries, plus a dozen other DER options
- Emerging DC equipment standards at every scale, from USB-3 to 12Volts, 24V, 48V, and on up to 384V for commercial buildings
- Innovative financing, including pay-as-you-go
- Massive, growing experience with off-grid systems and services – large and growing markets in remote and rural areas

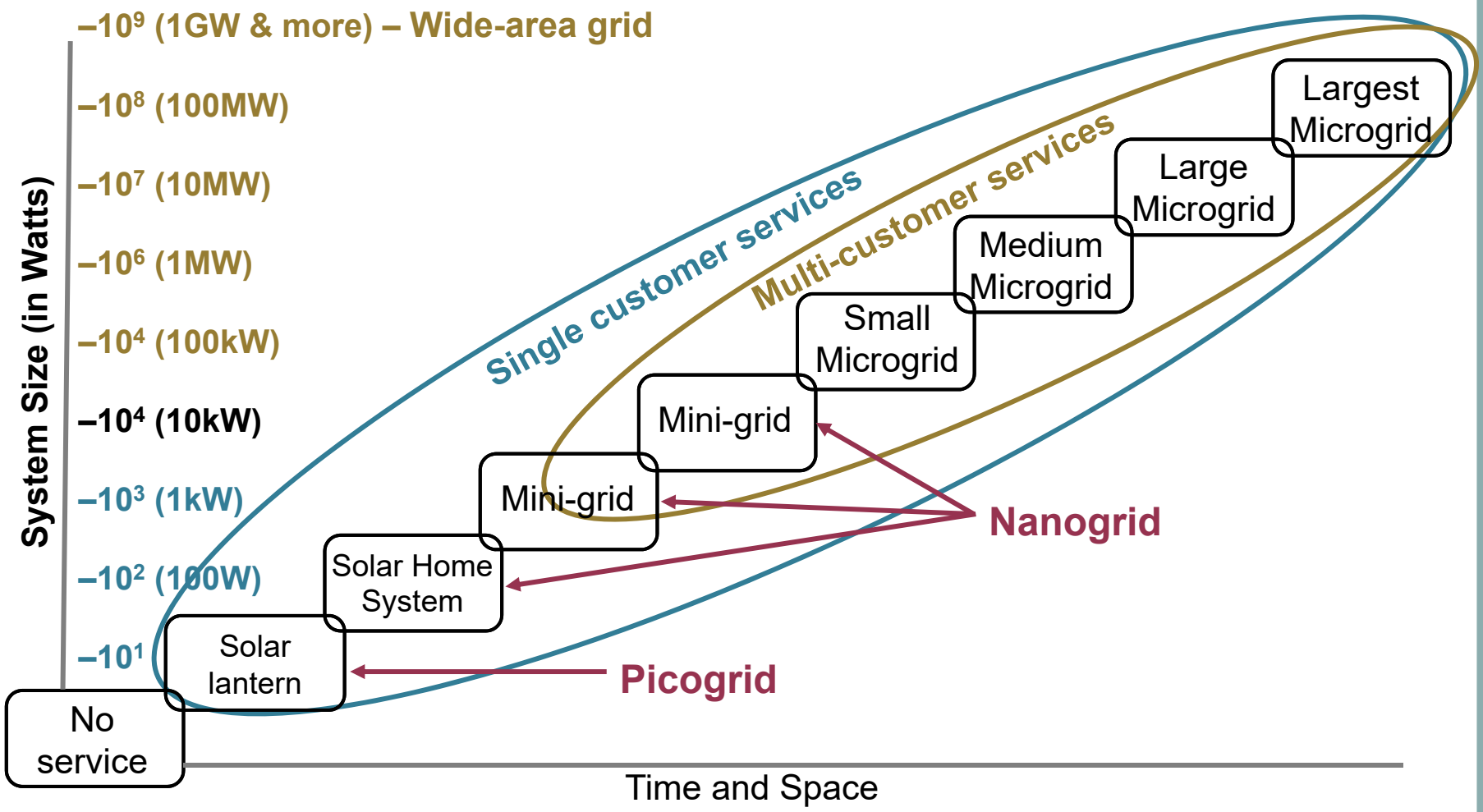
Differentiating markets…

Market Model Name	Seeds	Sprouts	Shoots
Market condition	Non-economic	Pre-economic	Grid-competitive
B/C ratio[1]	B < C, slow if ever ROI	B ≈ C, modest ROI or payback under optimistic scenarios	B > C, patient ROI, reasonable payback under many scenarios
Types of adopters	True believers, Innovators	Early adopters	Early majority
Market share	~1% or less	~1 to 2.5%	>2.5%
DG, NEM growth rates	< 1/3 per year	1/3–2/3 per year	Annual doubling or more
Overall utility sales	Growing	Flat	Declining
Time pressure for regulatory actions	Low	Medium	High
Other	RPS or CEPS goals and growth rates (low, medium, or high)? Supplemental government support policies (low, medium, or high)? Virtual NEM and community-based participation options?		

Source: Author's construct based on Taylor, McLaren, et al. 2015 (NREL/TP-6A20-62361) and adapted from Rogers, 2003.

[1] B/C Ratio takes into account utility rates, other costs DER can avoid, and available support policies, like financial incentives.

Energy ladder pathways…



Pico- and Nan0-Solar Market

Market estimates:

- $20 billion (USD) cumulative market 2017-2022
- 25% compound annual growth rate

Source: small excerpt from Global Off-Grid Lighting Association (GOGLA), *Off-grid Solar Market Trends Report 2018.* www.gogla.org

Top energy ladder opportunities where wide-area-grids already exist

- Customers want ultra-high reliability and resilience for some end uses or facilities, including public purpose microgrids for critical needs facilities (e.g., transportation, medical care)
- Sometimes and for some uses, customers value portability and remote, off-grid usage
- Non-wire alternatives can be fully cost-effective
- Electric vehicles will present multiple opportunities, including vehicle-to-grid and second-life batteries
- Increased self-reliance and resilience for different kinds of campuses, and commercial or industrial parks
- Bonuses from special government support policies for selected technologies

Top energy ladder barriers where wide-area-grids already exist

- Rules for monopolies versus third-party providers
- Rules and regulations for private wires and self-generation, including added utility charges for B.Y.O. distributed generation
- Incomplete understanding of the full benefits and costs of DER
- Poorly designed standby and backup rates
- Poorly designed compensation for energy outflow
- Few if any pathways for monetizing ancillary services
- Anti-islanding interconnection rules
- Outmoded centralized-power models for IRP and DSP
- Obstacles in financing, insurance, building and fire codes, tax rules
- Lack of consumer awareness of choices and opportunities

Top energy ladder opportunities where there is no wide area grid

- Solar lanterns with batteries – a "killer app" with a cell-phone charger
- Solar Home Systems (SHS) with batteries – runs a few lamps and one or more low-voltage appliances (like a fan, computer, or TV, or larger systems can add one or more higher-voltage appliances, like a refrigerator)
- Neighborhood or village systems:
  - Solar charging systems, like kiosks, as a service
  - Solar streetlights, solar water pumping
  - Critical needs services, like remote medical facilities
  - Mini- or micro-grids, with an agricultural or industrial facility as a host or anchor tenant, plus neighboring homes

Top energy ladder barriers where there is no wide-area-grid

- Lacking economic viability for many possible steps
  - Starting points with no or very low demand, because consumers have few if any immediate uses for electricity
  - Lack of consumer awareness of choices and opportunities
  - Widespread unfamiliarity with electricity
- Consumer distrust – Consumers might have already experienced poor performance, durability, and reliability of some devices
- Financing obstacles – Subsistence-markets are often largely non-cash economies
- Need to build business capabilities in remote locations – There are often institutional voids, and long-distances make it harder to provide service, maintenance, and spare parts
- Few empirical studies, learning from early experiences

NRRI energy ladder research next steps

- Continue describing sound regulatory approaches and incentives for each step in the ladder, in multiple development scenarios, e.g.:
  - led by regulated utilities or provided by competitive suppliers and markets
  - in areas both with and without pre-existing wide-area grids
  - for multiple scales of technologies that operate in one or more of three modes, stand-alone (off-grid), grid-connected, or dual-use
- Case study reports of multiple development scenarios, documenting experiences with several steps up and down the energy ladder

Energy ladder regulatory challenges for areas with a pre-existing grid

- Roles for regulated utilities versus competitive service providers
- Interconnection technical standards, rules and procedures that enable any practical and safe operations, including intentional islanding
- Product and service quality assurance and quality control
- Full compatibility for products and services up and down the energy ladder
- Rates and tariffs for partial requirements service accounting for both benefits and costs
- Considering rules enabling mini- and micro-grids:
  - for single customer facilities and campuses;
  - for public-purposes; and,
  - for multi-customer facilities and campuses

Energy ladder regulatory challenges for areas without a pre-existing grid

- Comprehensive stakeholder consultation and participation in setting institutional, social, and technical roles
- Roles for regulated utilities versus competitive service providers
- Product and service quality assurance and quality control
- Interconnection technical standards, rules and procedures that enable any practical and safe operations, including intentional islanding
- Rates, tariffs, and collection methods enabling consumer progress up the earliest energy ladder steps
- Full compatibility for products and services up and down the energy ladder
- Continuity and long-term plans for each community: service from mini- or micro-grids or extending a wide-area grid

Learn more here…

- Meister Consultants Group, Inc. (2017). *Practical Guide to the Regulatory Treatment of Mini-Grids*. Report for National Association of Regulatory Utility Commissioners. https://pubs.naruc.org/pub/E1A6363A-A51D-0046-C341-DADE9EBAA6E3
- North Carolina State University, Clean Energy Technology Center, *50 States of Grid Modernization*, *https://nccleantech.ncsu.edu/the-50-states-reports/*
- Patterson, 2007, *Keeping the Lights On*, and, 1999, *Transforming Electricity: The Coming Generation of Change*. www.earthscan.co.uk
- Levin, T., and V. M. Thomas. 2016. "Can developing countries leapfrog the centralized electrification paradigm?" *Energy Sustainable Development* ***31***:97–107.
- Lovins and Rocky Mountain Institute, 2002, *Small is Profitable*.
- Rocky Mountain Institute, 2015, *The Economics of Load Defection*. http://www.rmi.org/electricity_load_defection
- Sandia National Labs, 2017, *Microgrid Design Tool Kit*. *goo.gl/m7ccZw*
- Smart Electric Power Alliance (SEPA, www.smartpower.org):
  - *51st State Ideas: 'Role of the Utility' Summary of Submissions*
  - Beyond the Meter reports and Planning the Distributed Energy Future
  - Microgrid Business Models

Related NRRI & Stanton Reports

- Stanton and Nordman, 2017,"Regulating 'Energy Ladder' Products and Services: Delivering Vital Energy Services Using Off-Grid, Mini-Grid, and Micro-Grid Power Systems," *ICER Chronicle* ***7***(August 2017), 37-45.
- Barua, Costello, Kline, Phelan, Stanton, 2016, "Future Drivers and Trends Affecting Energy Development in Ontario: Lessons Learned from the U.S." (Mowat Energy Research Report #137). https://mowatcentre.ca/emerging-energy-trends/
- Stanton, 2012, *Are Smart Microgrids in Your Future? Exploring Challenges and Opportunities for State Public Utility Regulators, NRRI 12-15.*
- Stanton, 2012, *Consultant Report for Maine PUC Docket 2010-267: Smart Grid Coordinator, NRRI 12-02.*
- Stanton, 2015, *Distributed Energy Resources: Status Report on Evaluating Proposals and Practices for Electric Utility Rate Design, NRRI 15-08.*
- Stanton, 2015, *Getting the Signals Straight: Modeling, Planning, and Implementing Non-Transmission Alternatives, NRRI 15-02.*
- All NRRI Reports available for free download at www.nrri.org

Energy Ladder Resources

- Appropriate Technology Collaborative – www.apptechdesign.org
- *Energypedia* (a wiki platform for collaborative knowledge exchange on renewable energy, energy access, and energy efficiency topics in developing countries) – https://energypedia.info/wiki/Main_Page
- Global Off-Grid Lighting Association (GOGLA) – www.gogla.org
- Johns Hopkins School of Advanced International Studies, Initiative for Sustainable Energy Policy (ISEP) – sais-isep.org
- Sesame Solar: Turnkey, Mobile Nanogrids – www.sesame.solar
- Sun-Connect Off-Grid News – www.sun-connect-news.org
- Sustainable Energy for All – www.seforall.org
- United Nations, Environment, Sustainable Development Goal 7 (SDG7): Affordable and clean energy – https://goo.gl/nSBKEJ
- World Bank, Energy – www.worldbank.org/en/topic/energy