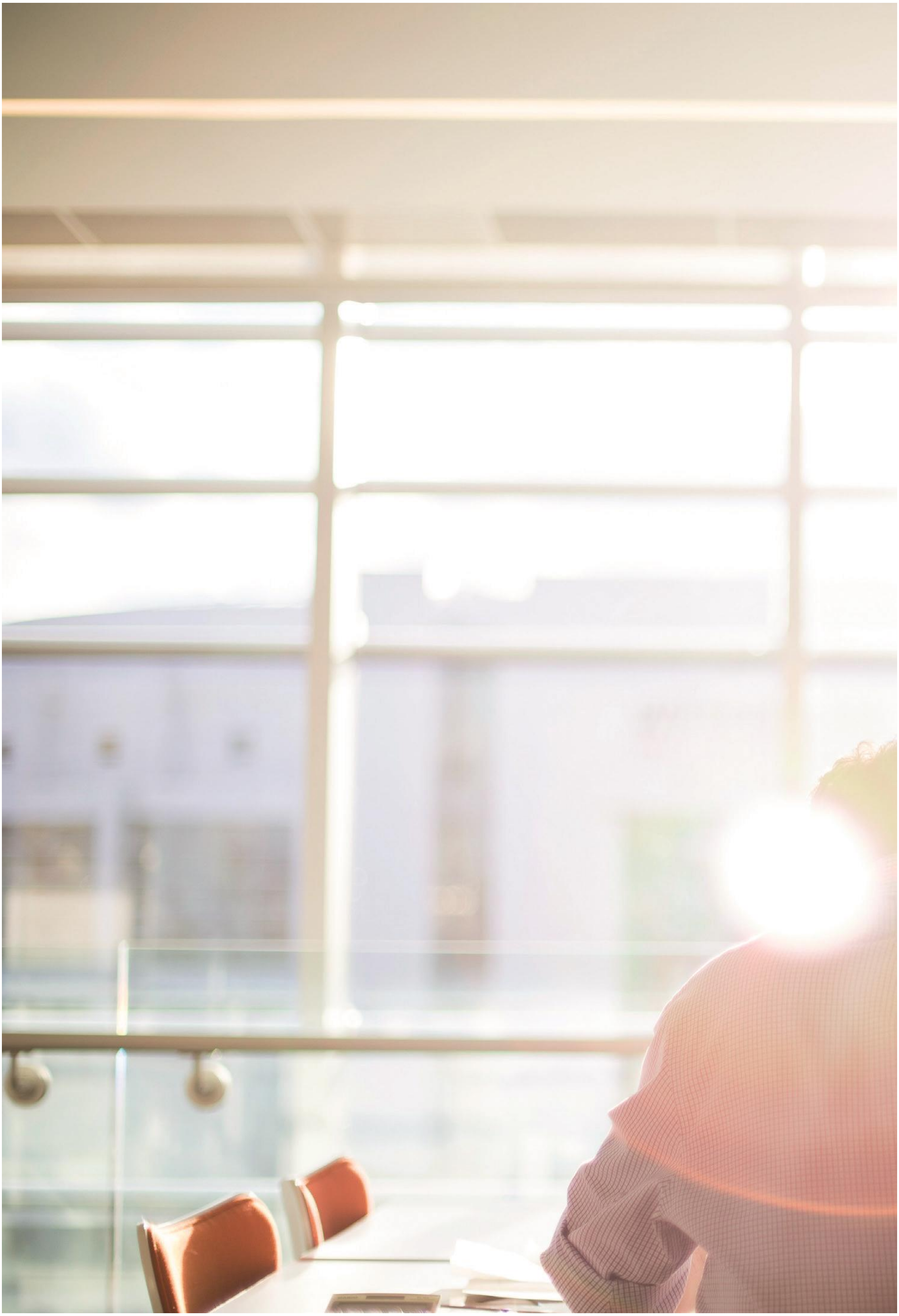
Working Paper

A Policy and System Design Blueprint for Local Power Networks. Local Solar for Reliable, Accessible and Affordable Electricity

June SEKERA

CIRIEC No. 2025/05



A Policy and System Design Blueprint for Local Power Networks. Local Solar for Reliable, Accessible and Affordable Electricity

June Sekera*

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This report was already published in July 2025, in the Series 'Economics in Context Initiative', by the Global Development Policy Center (Boston University, USA).

The present working paper is thus a reprint.

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Abstract

At this stage in human technological and social development, electricity has arguably become a basic human need. Yet, access to this vital resource is increasingly precarious. Electricity rates charged by private utilities are rising. Outages are increasing due to climate-change impacts and obsolete, decaying infrastructure. Private utilities, with their centralized generation and dependency on inefficient, energy-wasting long-distance transmission, are failing to meet public needs. In the United States, the national political leadership is working to undercut the deployment of solar and wind power, the least expensive forms of generation. In the face of these challenges, this project investigated the feasibility of local solar generation to meet peoples' need for accessible, affordable, reliable electricity. We found that, despite the hurdles, it is still possible to increase the ability of communities and households across the income spectrum to self-generate their electricity. Local solar generation is technologically straightforward and is popular with the public. This policy and practice Blueprint lays out the technological, institutional and financial design features and the policy framework to create solar-based **Local Power Networks (LPNs)**, which can increase access to reliable, affordable electricity in communities across the country. LPNs are mini-grids, locally-owned and operated, comprised of electricity generation and storage at both the individual building level and at the network level. Municipal utilities and electric co-operatives are in a position to take action through a neighborhood- or community-level "solar saturation strategy", which can lower costs, increase energy access and expand the provision of clean, renewable energy through local public power.

Keywords: USA, electricity networks, local grids, mini-grids, solar power, local control, distributed renewable energy, regulation, cost

JEL Codes: D24, H44, H54, L32, L33, L94, O33, O21, O38, P13, P18, Q42, Q48

This report was primarily authored by June Sekera, Director of the Local Power Networks project at the Global Development Policy Center (GDPC), Boston University, USA. Bill Powers, Registered Professional Engineer, provided technical information found throughout this document, and particularly in the System Design section. Dr. Neva Goodwin, Director of the Economics in Context initiative at the GDPC reviewed report drafts and provided crucial contributions, as did Johannah Blackman and Beth Woolfolk of A Climate to Thrive.

The Local Power Networks Project is supported by funding from the Rockefeller Brothers Fund and the Rockefeller Family Fund.

In January 2025, a draft of this Blueprint was circulated among energy system specialists and technical experts on the United States electric power system and on decentralized solar generation. The reviewers provided an abundance of valuable feedback. This is the revised version following that technical review. We are grateful for the very helpful technical feedback from Deb Chachra, Matt Grimley, Bill Julian, Lorenzo Kristov, Simon Pirani and Tyson Slocum.

The original draft of this Blueprint was written in 2024 in a policy environment that was crucially different from the current landscape. The federal government’s policy and financial supports for local solar no longer exist for the most part. However, despite, and even because of, the present stance of the US federal government on energy policy, the Local Power Network model is more urgently needed than ever. It is an approach that can be piloted now and could be implemented nationally later, when the federal government returns to an energy transition, as it surely must, and is seeking models on which to build.

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OVERVIEW

This document presents a policy and system design “blueprint” for solar-based Local Power Networks (LPNs). LPNs are mini-grids, locally-owned and operated, comprised of generation and storage at both the individual building level and at the network level. LPNs can operate in “island” mode most of the time, with the grid serving as the standby power source. This reverses the existing model in which microgrids are standby systems to be used in emergencies.

In a sense, the LPN approach represents a ‘back-to-the-future’ model – a return to decentralized, locally-controlled, non-corporate generation and supply of electricity: self-generation for self-consumption. Early in the era of electricity production, self-generation was common. Tens of thousands of independent, small generator stations produced power for self-consumption. However, in the first decades of the 20th century, this system was replaced by centralized generation by private corporations. Electricity supplied from centralized, privately-owned power plants was deemed to be a “natural monopoly” that required government regulation to attend to consumer interests.

When fossil fuels are the energy source, large scale, centralized generation can be more thermodynamically efficient than many small fossil fuel generators. But with solar as the energy source, this industrial model is upended in two significant ways. The thermodynamic efficiency advantage disappears. Whether arrayed by the thousands in a solar farm or as part of a small rooftop system, the production efficiency of a solar module is the same. And, with the solar fuel source everywhere, the “natural monopoly” argument disappears.

Almost uniquely among United States industries, the electric power industry operates in an environment that is largely shaped by public policy: regulators approve private utilities’ prices and profit levels.

Some countries, Australia and Germany to mention only two, have made locally-generated solar accessible to substantial percentages of their populations through public policies, laws and regulations that specifically support residential solar. These public policy actions significantly brought down the “soft costs” of rooftop solar system installations, largely by creating a high-demand, low-fixed-cost business environment and concomitant economies of scale. Although those policy actions were taken at the national level, many could be replicated at the local level in the US now. The most propitious locations for LPNs are areas served by publicly-owned utilities and electric co-operatives, since their missions are most closely aligned with the non-profit, non-market nature of LPNs.

Electricity rates charged by private utilities are rising. Outages are increasing and centralized generation, with its dependency on inefficient, energy-wasting long-distance transmission, is failing to meet local needs. This Blueprint presents a model that can increase access to reliable, affordable electricity in the United States. It is an approach that can be piloted now and implemented nationally later, when the federal government returns to a clean energy transition and is seeking models on which to build.

Part A. Background and Purpose

1. Introduction

The environment in which the electric power industry operates in the United States is largely shaped by public policy.[1] Most Americans get their electricity from private, investor-owned utilities whose prices and profit levels are approved by public regulators,[2] [3] an arrangement that is nearly unique among US industries. That was not the case early in the era of electricity production in the late 19th and early 20th centuries – a period when local generation for self-consumption was common. But self-generation was displaced by large, centralized, commercial, fossil-fueled power plants.[4] Electricity supply was deemed to be a "natural monopoly" to be regulated by government entities charged with protecting customer interests. By 1914, 43 states regulated investor-owned electric utilities; now all do. The regulatory framework in the US guarantees a profit to shareholders in these private companies, which, in effect, control access to electricity for the majority[5] of households in the country.

The advent of local solar generation, however, disrupts this industrial model and topples the natural monopoly argument. As *The Economist* recently put it, "Rooftop solar offers an alternative to a monopoly that can no longer be considered natural."[6]

Renewables are deflationary.[7] With their near-zero marginal cost of production these energy sources could reduce electricity rates for customers. However, low or zero prices for solar and wind can drive prices down across the market – an unwelcome result for commercial electricity suppliers. Prices for solar electricity

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[1] An incisive point made by John L. Neufeld (2016), *Selling Power: Economics, Policy, and Electric Utilities Before 1940*, p. 3.

[2] Investor-owned utilities are overseen by state regulators who "review and approve utilities' recoverable costs, profit, and the division of rates between customer classes (e.g., residential, commercial, and industrial…"

[3] Even in states that are "deregulated" or have "competitive" markets, rates are wholly or partially approved by regulators. https://www.eia.gov/todayinenergy/detail.php?id=63024#:~:text=When%20regulated%20investor%2Downed%20utilities%20(IOUs)%20expect%20their,not%20be%20regulated%20in%20the%20same%20way

[4] Hydropower dominated electricity production in the US in the first part of the 20th century, but has greatly diminished its share of generation, supplying less than 6% now.

[5] The vast majority, 70s%, of electricity customers in the US get their electricity from private corporations, called investor-owned utilities (IOU). 16% of customers are served by publicly-owned, mostly municipal, utilities, whose rates are generally substantially lower than IOU rates. 14% are served by electric cooperatives.

[6] *The Economist*, "Cheap solar power is sending electrical grids into a death spiral", Feb. 15, 2025.

[7] Pollard, Matt and Tim Buckley (2024), "Queensland's Energy Transformation: From Coal Colossus to Renewable Energy Superpower;" *Climate and Energy Finance*.

can even drop below zero, and negative prices can result in electricity “curtailment”. With no market value, particularly during peak production hours, renewable electric power is, in effect, thrown away. Local solar self-generation for self-consumption can be an antidote to this problem.

Some countries have used public policy to target and expand local solar – reducing the acquisition cost of small-scale solar systems – by creating a high-demand, high-volume, lower-cost business environment for rooftop solar system installations. These policies have resulted in significant shares of the population self-supplying electricity. How these policies did so is detailed in this document.

2. Background

At this stage in human technological and social development, electricity has arguably become a basic human need. On national, regional, state and local levels, the design of the electricity supply system should reflect this reality. But under our current system of centralized power generation, with investor-owned utilities (IOUs) gating access to electricity for most people, rates are rising, more people are unable to pay their electric bills and electricity service is becoming less reliable. As impacts of climate change --severe weather, flooding and fires -- worsen, communities and whole regions suffer outages[8] for days or weeks, while centralized utilities struggle to restore power supply over their aging wires, strung between deteriorated towers and reliant on antiquated transformers.

This document presents a policy and technical blueprint for “Local Power Networks” -- an electricity generation and supply system designed to *make accessible* an energy source – solar – that is literally everywhere and nondepletable. LPNs are designed to address electricity as a basic human need and to decarbonize generation and supply -- a system that is optimized for accessibility, affordability, security and resilience, and for decarbonization. LPNs are mini-grids, locally-owned and operated, comprised of generation and storage at both the individual building level and at the network level. LPNs can operate in “island” mode most of the time, with the grid serving as the standby power source rather than the mini-grid being simply an emergency backup.

Other countries, such as Australia and Germany, have instituted policies and financial incentives that have brought down costs and resulted in large proportions of their populations benefitting from self-generated solar electricity. In Australia, 33% of homes have rooftop solar, compared to only 7% in the US. The price per watt of a 10 kilowatt system in Australia is 82¢ (USD) per watt (W) vs $2.53/W in the US. In Germany, which has brought the 10 kW system cost down to $1.69/W (USD), 70% of newly added solar capacity in the country came from rooftop solar systems in 2023.

[8] The frequency and duration of power outages in the U.S. are increasing, with outages from severe weather doubling in the past two decades.

While the US will not be instituting similar policies at the national level in the immediate future, LPNs are a model that could be instituted in the near term at a small scale at the local and regional levels by replicating other countries' national policies on a local basis, as discussed in this Blueprint. It is an approach that could be piloted locally now and implemented nationally later. The LPN design draws on a tapestry of "bottom-up" concepts that have emerged over the last few years, but the LPN model weaves in crucially distinctive threads.

3. Key Characteristics of the System Design

- Generation and storage are sited close to load, creating efficiencies both economically and in terms of reduced energy loss relative to remote generation sources that rely on long-distance transmission.
- The LPN system incentivizes self-generation for self-consumption.
- LPNs support energy efficiency, including self-determined load-shifting at the individual building or local network level.
- LPNs operate independent of the grid most of the time, which is enabled by a local electricity "Reservoir" (detailed in Part B).
- Electricity power-pooling at the local level – through the power Reservoir – is enabled and operated using a non-price mechanism.
- Economies of scale, and thereby installation cost reductions, are achieved through public policy actions like low-interest financing, bulk hardware procurement and standardizing and simplifying installation and permitting processes.
- Per-kilowatt-hour (kWh) costs for LPN members are reduced four ways: 1) economies of scale; 2) elimination of investor profit-taking at the LPN level; 3) absence of transmission charges; and 4) power pooling at the network level.
- Inverters and other controllers are programmed for control by the LPN operator and network participants.
- LPNs reduce the number of grid interconnections and move the concept of "virtual power plant" from the individual household level to the LPN level, simplifying bulk power system operations while undergirding local control.
- The LPN model is neither based on nor reliant on net metering programs to achieve economic benefit. Given that net metering compensation is being slashed or eliminated in much of the US, the LPN model is timely.
- The LPN model recognizes electricity as a basic human need. It reflects a view of electricity as a public good[9] not in a moral sense nor (necessarily) through

[9] See discussions of public goods at Sekera, J., "Re-thinking the Definition of 'Public Goods'", *Real World Economics Review*, July 9, 2014; and in Sekera, J. (2016), *The Public Economy in Crisis; A Call for a New Public Economics*.

public provision, but reflects the reality that public action – policy and financial supports – are required to ensure that electricity is universally accessible and affordable and its supply is secure and maximally decarbonized.

It is clear from a large body of technical literature and industry studies that locally controlled, operated and owned solar and storage networks are *technologically* feasible. The principal issues revolve around institutional structures and finance. These are discussed in this Blueprint.

4. Back to the Future?

<u>Self-production of electricity at the turn of the 20th century</u>

When electricity production for power and light began in the late 19th century, self-generation of electricity was common. Instead of centralized generation, as is overwhelmingly the case now, electricity was produced locally at individual buildings for self-consumption. Rather than buying power from a corporate utility company, factories, mines and electric railways had their own generating equipment. An estimated 50,000 self-generation plants were in operation by 1902.[10] Hotels, apartment buildings and office buildings generated electricity from their own small power plants.[11] By 1906, nearly 60% of electricity generation was from non-utility sources.[12] The industrial sector, in particular, developed its own power plants. By 1904, more than 70% of electricity in the manufacturing sector was self-generated.[13] As of 1912 independent power plants produced more electricity than the entire electric utility industry.[14]

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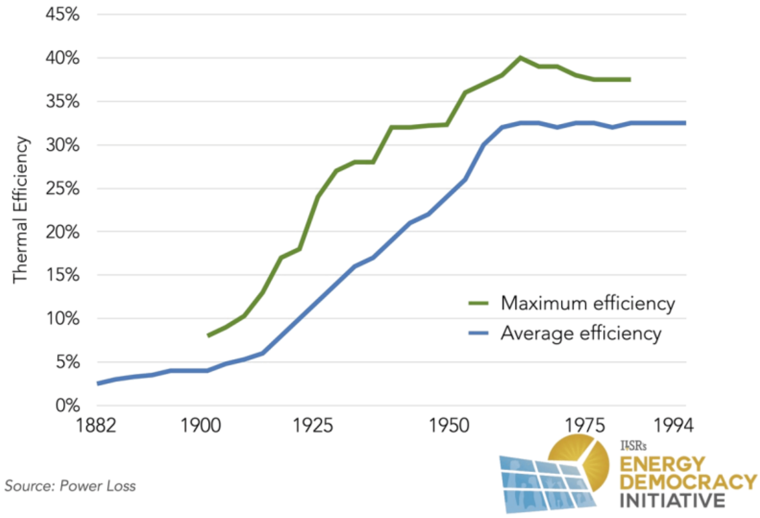
[10] 1902 special census, cited in Neufeld, John L. (2016), *Selling Power; Economics, Policy, and Electric Utilities Before 1940*, p. 41.
[11] Neufeld, 2016, p. 42.
[12] Neufeld, 2016, Fig 2.3, p. 42.
[13] Neufeld, 2016, Fig 2.4, p. 43.
[14] Neufeld, 2016. p. 42.

Centralization, Monetization and the Eclipse of Public Power

Figure 1 Power Plant Efficiency



As both the need and the demand for electricity became more widespread in the early 20th century, centralized generation made sense, primarily because the energy source was fossil fuels. When electricity is produced using fossil fuels, large-scale generation is more thermodynamically efficient.[15] That's true up to a point; then efficiency gains stop. As shown in Figure 1, from a report by John Farrell of the Institute for Local Self-Reliance, power plant efficiency gains plateaued in the mid-1960's as "challenges in operating giant power plants offset their economies of scale".[16]

In the early era -- before the entrenchment of the investor-owned utility (IOU) industry -- most of the electric utilities that did exist in the US were municipally owned and operated. Moreover, these earliest municipally-owned utilities were much more efficient than those privately owned.[17]

However, with the escalation of demand for electricity in cities and by industrial users, centralized, private corporate generation gradually eclipsed publicly-provided power. Investors understood the profit potential in large-scale electricity generation and supply and sought to build a new industry. Edison Electric, Westinghouse, Chicago Edison and other companies competed for customers and capital. Construction of large amounts of infrastructure – power plants and transmission and distribution systems – required large-scale agglomeration of capital. Industry leaders formed holding companies [18] to aggregate capital, buy up existing utilities and leverage their consolidated interests to act as a countervailing power against regulators.

[15] Communication March 4, 2025 from Deb Chachra, Prof. of Engineering, Olin College; author, *How Infrastructure Works* (2023).
[16] Farrell, John (2016), "Is Bigger Best in Renewable Energy?" citing Richard Hirsh, *Power Loss* 1999.
[17] Hausman W. & J. Neufeld (1991), "Property Rights Versus Public Spirit: Ownership and Efficiency of U.S. Electric Utilities Prior to Rate-of-Return Regulation", Rev Econ & Stats 73/3, cited in Neufeld 2016.
[18] Holding company pyramidal structures were eventually prohibited by the Public Utility Holding Company Act of 1935.

Electric utilities saw self-generation as a serious competitive threat.[19] By mid-twentieth century, self-generation was eradicated. Municipal utilities were curtailed; many were bought out by expanding private, corporate utilities. Electricity generation and supply had been deemed to be a "natural monopoly" to be regulated by government. Power plants increased in size and generating capacity.[20]

But bigger is not better when solar is the energy source. In terms of the energy yield of each module, a utility-scale solar photovoltaic (PV) plant is not thermodynamically more efficient than a small, local solar PV system.[21] In fact, there is greater energy efficiency in locating generation close to load because electrons travel from point of generation to nearest load[22] and because there is energy loss when electricity is transmitted over substantial distances.

The economics of solar electricity supply work in favor of local generation, as discussed in detail later. One salient factor is fuel access. Unlike fossil fuels, which must be found, extracted and transported to the generation site and whose supply is ultimately depletable, solar energy is everywhere, abundant and non-depletable. More solar energy hits the earth every hour than is needed to power the world for a year.[23]

Back to the future

Now – Just like mine operators in the early 1900's, mine operators today are looking for a stable electricity supply in remote areas and are turning to solar microgrids composed of PV generation plus battery storage.[24]

Now – Just like manufacturing plants at turn of the 20th century, data centers are developing their own electricity generation. Many will be fossil-fueled but some operators are looking to solar.

Now – Just like some residences in the early 1900's using fossil fuel generators, homes in the US and many other countries are equipped with rooftop solar for self-supply of electricity. In Australia 33% of homes have rooftop solar. In Australia, Germany

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[19] Neufeld, op. cit., p. 41.
[20] Morris, David (1983), *Be Your Own Power Company*, Institute for Local Self Reliance.
[21] Conversation with Deb Chachra, Professor of Engineering, March 4, 2025.
[22] Kristov, Lorenzo (2021), "Building the 21st Century Electricity System".
[23] "Solar energy is the most abundant energy resource on earth - 173,000 terawatts of solar energy strikes the Earth continuously. That's more than 10,000 times the world's total energy use;" NOAA. More solar energy hits the earth in *one hour* than is needed to supply the world for *one year*; Univ of Calif., Davis.
[24] *The Economist*, "Dig it. Mining" March 1, 2025. "…Smart Mine microgrid, a standalone power plant composed of a battery, solar panels and inverters, with a smart energy-management system…"

and other countries, not only the wealthy and middle class but also low-income households can reduce their power cost through self-generation.

Decentralized electricity generation is underway. Who will benefit?

The transition to renewable energy is underway worldwide. And despite actions in Washington now, it is reasonable to expect that the US will return to an energy transition, given the mounting climate-change-related disasters and their impacts.

Moreover, microgrids are already an important factor of electricity supply in the US. More than a thousand microgrids exist in the US. Dozens of these are solar-based. But these microgrids operate primarily as emergency resources. Many could be upgraded into more active systems that would supply electricity around the clock.

As decentralization of the electricity system gains popularity and regains industry and government interest, the questions are: (1) what form will decentralization take, and (2) who will benefit?[25] These are the questions addressed by this Blueprint.

5. Why Local Solar Self-generation is Needed Now

Electricity is already unaffordable for many

Already, electricity is unaffordable for many -- 20 million U.S. households are behind on their electricity bills; arrearages may be at their highest level ever.[26] Utilities have shut off residential electricity to millions.[27] Energy poverty is significant: 27% of U.S. households experience energy insecurity, sometimes foregoing food and medical care to pay for energy.[28] Thousands of people have died each year from extreme heat exposure and lack of cooling appliances, often because they cannot afford air conditioning or cannot afford to run it.

Electricity rates are rising

Electricity supplied by utilities is expensive and getting more so. Across the US, the highest rates are charged by private IOUs, which serve most electricity customers in the country. Even though 94% of US utilities are not-for-profit – publicly owned or co-op – the vast majority of electricity customers, 70%, get their power from IOUs. See Figure 2.

[25] Thanks to Deb Chachra for distilling the issues at hand.

[26] "…we believe that these numbers represent the highest level of arrearages on record." National Energy Assistance Directors Association (2023) "Utility Arrearages Continue to Increase".

[27] Utilities shut off power an estimated 4.2 million times in the first 10 months of 2022 - "Powerless in the United States" Center for Biological Diversity, 2023.

[28] Energy Information Agency data reported in Congressional Research Service Jan 31, 2023 https://crsreports.congress.gov/product/pdf/R/R47417

Figure 2. Types of Electricity Providers, U.S.

Electricity providers	#	%	# of customers	%
Publicly-owned utilities	2,003	**66%**	25,201,694	16%
Co-op's	866	**28%**	22,082,452	14%
IOU's (private corps.)	177	6%	108,247,368	**70%**
Federal Power agencies	10	0%	41,245	0%
total	3,056	100%	155,572,759	100%

Source: American Public Power Assn, 2025 Statistical Report; data for 2023

For two decades, demand for electricity had been essentially flat, and prices that utilities charged customers had been tracking inflation. But rates began a sharp increase from 2022 to 2025. Corporate utilities have sought, and gotten, rate increase approvals from Public Utility Commissions across the country. In California, which already has nearly the highest rates in the US, Pacific Gas & Electric raised its electricity rates 41% over the last three years. Georgia's largest electricity provider, Georgia Power, raised its rates for residential customers by 33% over the last two years. Across the US, demand is projected to surge with the buildout of new generation plants to meet the voracious power consumption needs of new data centers,[29] [30] [31] particularly for A.I., and to meet other demand. The demand surge caused by the massive data centers will challenge a grid already at or near capacity, with much of the cost for grid upgrades borne by residential ratepayers unless alternatives are found.[32] One study, focused on the Southeast, finds that ratepayers will be subsidizing the growth of the data center industry. This is a form of cost shifting – from private corporations to households – that generally goes unacknowledged.

Another contributor to high rates can be the decisions, and even the *lack* of action, by the organizations that operate power grids[33] across the country. A convergence of

[29] "The Era of Flat Power Demand is Over", Grid Strategies, John D. Wilson & Zach Zimmerman, Dec. 2023.

[30] The *Washington Post* in 2024 produced a series of eleven articles, under the rubric, Power Grab, on the surging demand caused by data centers, particularly A.I. data centers.

[31] One reviewer of the draft Blueprint expressed skepticism about the surging demand projections, which are derived from self-interested utilities whose profits increase with infrastructure buildout and ownership.

[32] "Amid explosive demand, America is running out of power", Evan Halper, Washington Post, March 7, 2024.

[33] For much of the country, seven Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs) manage the bulk electricity system. See Appendix 1.

financial self-interests by grid operators, IOUs and energy traders can raise costs and result in higher rates for customers.[34]

A recent poll found that 73% of Americans are worried about their rising electric and gas bills, with 80% saying they "feel powerless over how much they are charged for utilities".

Centralized generation and long-distance transmission are not designed to fix local problems

Unreliability and insecurity

A narrative being advanced by fossil fuel interests and their political allies is that the grid must be built on "dispatchable" generation – gas, coal and nuclear. IOUs and operators of the electric power system[35] look to expand transmission grids in order to increase private profits under the present regulatory framework. But these campaigns are not designed to solve the problems of faltering local systems that are no longer reliable nor do they address the issue of energy insecurity – electricity that is unaffordable for many.

Lack of warming and cooling centers

Thousands of people have been displaced or died amidst winter freezes and accompanying power outages. Thousands more die from heat exposure. Rooftop solar on community centers or local ground-mounted arrays could enable cities and towns to power warming and cooling centers.

Centralized, utility-scale generation is inefficient, costly and can be dangerous

- Inefficient –
  - Conventional fossil-fueled power plants waste ⅔ of their fuel's energy as heat.
  - An additional 6% to 10% of energy is lost in transmission of electricity over wires (even if the fuel source is renewable).
- Costly –
  - 40% to 50% of electricity bills' cost is for getting electricity from the site of generation to the user – transmission and distribution (T&D) costs.
  - Grid operators are failing to approve thousands of solar, wind and battery utility-scale projects. For the past several years, utility-scale solar, wind and battery proposed projects have been trapped in a "bottleneck". Nationally, nearly 12,000 projects, – representing more than 2,000 gigawatts (GW) of potential generating capacity – have been held up awaiting studies and approvals by grid managers. 95% of these are for renewable energy and batteries.

[34] Penn, Ivan (2025), "As Energy Costs Surge, Eastern Governors Blame a Grid Manager", *New York Times*, June 10, 2025.

[35] The Electric Power System (EPS) includes generation, transmission & distribution.

- Dangerous –
  - Power lines and related equipment have been the cause of thousands of wildfires. In California alone, since 1992, over 3,600 wildfires have been related to power generation, transmission and distribution.[36] The largest wildfire in Texas history was caused by a utility's power equipment.[37] It is no exaggeration to say that towns are being burned to the ground because of faulty utility-company power lines or equipment.[38]

In addition, utility-scale generation capacity to be added or extended in the near future is largely fossil-fueled, so will significantly increase carbon emissions. New gas-fired plants are being built,[39] and the previously-planned closure of coal- and gas-fired plants is being delayed. The Trump administration has ordered coal and gas-fired plants scheduled for retirement to remain open.

The current "distributed energy resources" (DER) strategy, designed by industry interests, would benefit those interests but not many consumers.

Electricity system experts, including consulting companies, industry-operated/government funded think tanks, and industry/government consortia (such as the "UNIFI" consortium) have been constructing a "distributed energy resources" (DER) strategy under the rubric of decarbonization. Households and other small customers are expected to become energy arbitrageurs, monitoring and responding to price signals from their smart devices. This market-based approach to energy transition, which was advancing rapidly under the previous federal administration, was designed to create a new business model that offers new income streams for industry actors and extracts "grid services" from customers. While the DER strategy might be attractive to financially secure customers with the inclination and time to be energy traders, it may disadvantage, in particular, low-income customers who cannot afford the expensive new appliances or the time flexibility to shift consumption and engage in energy arbitrage.

For-profit utilities and the fossil fuel industry have worked to block local solar self-generation.

A major issue of concern for electric system operators and owners has been "grid defection".[40] As the costs of rooftop solar PV and battery storage continued to decline,

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[36] White, Jeremy (2025), "Many of California's Most Destructive Fires Were Caused by Power Lines", New York Times, Jan. 13, 2025.

[37] Sacks, Brianna (2024), "Xcel Energy power equipment caused huge Texas fire, investigators say", Washington Post, March 7, 2024.

[38] Paradise, Calif., 2018, Pacific Gas & Electric; Lahaina, Hawaii, 2023, Hawaiian Electric; Eaton fire, Los Angeles 2025, Southern Calif Edison equipment found faulty.

[39] 220 new gas fired power plants are in stages of development across the U.S.

[40] Grid defection has been a concern of utilities for decades. And a new research paper suggests it is economically sensible in some solar-rich U.S. locations (Sadat, S. A. & J. M. Pearce; Nov. 2024, "The threat of economic grid defection in the U.S. with

increasing numbers of customers have opted for self-generation where it is financially feasible. Over the last decade, investor-owned utilities and their financial beneficiaries have expressed concern about a utility and grid "death spiral" as customers opted to self-supply at less cost.[41]

Corporate utilities and allied interests have, for decades, worked to undermine or preclude local solar self-generation.[42] A campaign, launched jointly by private utility companies in concert with the fossil fuel industry in the 2010s, continues today to effectively undercut the development of rooftop solar – putting out false information such as the now widely believed idea that rooftop solar net metering imposes substantial costs on other utility customers, especially low-income customers. While this claim, that rooftop solar financially harms other customers, has been repeatedly debunked,[43] the campaigns have been effective in moving state regulators to substantially decrease the benefits of small-scale renewable electricity generation.

A different model is needed.

The increasing value of self-generation for self-consumption

The LPN model is timely because the value of rooftop solar is increasingly derived from "self-generation for self-consumption". Until recently, the purchase of rooftop solar systems was rational for many homeowners because of the compensation they received for electricity exports to the grid under "net metering" programs. But that compensation is being slashed in many states. In California, the compensation is down from over 40¢ per kWh to 2¢ to 3¢ per kWh. So, the value of rooftop solar is increasingly tied to its ability to displace high-cost utility-supplied electricity.

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solar photovoltaic, battery and generator hybrid systems"; *Science Direct*). Also see RMI reports; 2014 and 2022: "The Economics of Grid Defection: When and Where Distributed Solar Generation Plus Storage Competes with Traditional Utility Service" 2014; Dyson, M & R. Gold, April 17, 2022; "Grid defection and net energy metering".

[41] e.g., see "The Economics of Grid Defection", RMI 2014.

[42] Crystal, Howard, Roger Lin, Jean Su (2023), "Rooftop Solar Justice; Why net metering is good for people and the planet and why monopoly utilities want to kill it", Center for Biological Diversity March 2023; Eisner, Gabe (Mar. 7, 2015), "Edison Electric Institute Campaign Against Distributed Solar", Energy and Policy Institute; Weissman, Gideon & Bret Fanshaw (Oct 2015), "Blocking the Sun"; Frontier Group; Blocking Rooftop Solar (June 2021) U.S. Public Interest Research Group.

[43] See, for example: *How Rooftop Solar Customers Benefit Other Ratepayers Financially to the Tune of $2.3 Billion*, M. Cubed, November 2024; Crystal, Howard, Roger Lin, Jean Su, Center for Biological Diversity (2023) op. cit.; "Debunking the 'Cost-Shift' Debate"; Calif Solar + Storage Assn., June 7, 2021; and Eisner, Gabe, "Edison Electric Institute Campaign Against Distributed Solar" Energy and Policy Institute, March 7, 2015.

The biophysical need: decarbonization

A transition to non-carbon fuel sources for electricity generation is essential for reducing carbon dioxide (CO2) emissions (and other gases, such as methane,[44] that increase net warming). 31% of CO2 emissions in the U.S. come from electricity generation, so ending those emissions would be highly consequential. This biophysical[45] need cannot be met by market systems, which intrinsically optimize for profit production, not for meeting biophysical needs,[46] nor by the counter-productive methods being widely advanced such as "carbon capture and storage",[47 48] at power plants. But the biophysical need *can* be met by moving to non-carbon energy sources such as solar photovoltaics (PV).[49]

6. The Economics of Solar -- An Abundant Energy Source That Has Been Inaccessible for Most People

Solar energy is an abundant, non-depletable energy source, unlike fossil fuels,[50] which are limited in supply and ultimately depletable. Once the infrastructure is in place, the marginal cost to produce electricity from solar is near-zero.[51] But access to this abundant supply of energy for electricity has been gated, and therefore limited, by the electricity supply system prevalent in the US -- the IOUs that control electricity access and the fossil fuel industry that profits from their fuel sales to gas, coal, and oil-fired power plant operators.

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[44] https://climate.nasa.gov/vital-signs/methane/

[45] The term 'biophysical' as used here is in line with the definition used in biophysical economics: "the study of the ways and means by which human societies procure and use energy and other biological and physical resources to produce, distribute, consume and exchange goods and services, while generating various types of waste and environmental impacts."

[46] Sekera, June, "Missing from the Mainstream: The Biophysical Basis of Production and the Public Economy;" *Economics, Management, and Financial Markets* 13(3), April 5, 2018.

[47] There is a growing literature on the failures and counterproductivity of "carbon capture and storage" and "direct air capture"; Sekera, J. et al., Carbon dioxide removal–What's worth doing? A biophysical and public need perspective; *PLOS Climate* 14 Feb 2023.

[48] Sekera, June and Andreas Lichtenberger (2020), "Assessing Carbon Capture: Public Policy, Science and Societal Need; A review of the literature on industrial carbon removal", *Biophysical Economics and Sustainability*.

[49] While this document concerns only solar PV, other forms of harnessing solar energy, such as solar thermal, could also be incorporated into Local Power Networks.

[50] This paper does not discuss nuclear energy as it represents only about 19% of U.S. electricity generation. and because, in terms of energy sector interests, the fossil fuel industry has been the primary obstacle to local generation for self-consumption.

[51] Pollard, Matt and Tim Buckley (2024), "Queensland's Energy Transformation: From Coal Colossus to Renewable Energy Superpower;" *Climate and Energy Finance*.

Solar and wind generation are deflationary. With their near-zero marginal cost of production these energy sources could reduce electricity rates charged to customers. However, low or zero prices for solar and wind can drive prices down across the market – an unwelcome result for commercial electricity suppliers. Prices for solar and wind-generated electricity can even drop below zero, and negative prices can result in electricity "curtailment". With no market value, particularly during peak production hours, renewable electric power is, in effect, thrown away.

For more detail on the economics of solar electricity supply see Appendix 2.

7. The Public Policy Environment of the Electricity Sector

The environment in which the electric power industry operates is largely shaped by public policy.[52] This is the case in the US, where private utilities and electricity suppliers are regulated at the federal level and by all states. It is also the case in most other countries. Federal and local oversight powers in other nations have been used to specifically target and support local self-generation, with the result that far larger proportions of their populations self-generate their electricity. In Australia, where rooftop solar costs 1/3 of what Americans pay, national policy created a high-demand, high-volume business environment that reduced costs and enabled solar installers to slash prices. Localities simplified inspection and permitting processes, further reducing costs. In Germany too, government policies have vastly expanded uptake and reduced the cost of local solar; in 2023 70% of newly-added solar capacity came from rooftop installations. Localities in the US can replicate many of the techniques and policies used in other leading countries, as discussed in the System Design section below.

To be sure, in the US, the codified incentives of the current regulatory regime that supports IOUs, the monopoly model and the guaranteed profits based on large infrastructure construction and ownership, work together to disincentivize and even thwart local, and locally-owned, generation and storage. This regulatory framework needs a complete overhaul. This Blueprint does not make comprehensive recommendations for such a regulatory system overhaul. It does present specific policies and actions that could be taken at the local, regional and state levels, to enable a local solar saturation strategy. The Blueprint also provides a framework for longer-term public policy development that could usher in wider system reform.

Numerous researchers have identified the ways in which the current U.S. electricity supply system has been counter-productive for ratepayers. John Farrell, Co-Director of the Institute for Local Self Reliance, in his 2024 report "Upcharge: Hidden Costs of Electric Utility Monopoly Power", aims to educate activists and policymakers about

[52] An incisive point made by John L. Neufeld (2016), *Selling Power; Economics, Policy, and Electric Utilities Before 1940*, p. 3.

the problems, costs, and conflicts-of-interest in the profit-driven, monopolistic IOU model of electricity supply. Tyson Slocum in 2007 and McKay & Mercadal in 2023[53] revealed the failures of "deregulation" to reduce prices as had been predicted. Instead, deregulation resulted in higher wholesale prices and an increase in retail rates to end users. Energy system expert and engineer Bill Powers, in a 2020 report for the city of San Diego,[54] showed how replacing the incumbent IOU with a not-for-profit utility could enable the city to move to a decarbonized electric system and lower rates for customers largely by moving to local solar generation and storage. Welton (2021)[55] discusses how the "United States' functionally privatized mode of electricity governance", and control of the grid by fossil fuel corporations, produces results that favor "private interests at the expense of societal goals."

Evidence suggests that the least-wasteful and likely least-cost[56] model for a decarbonized electricity system that can enable universal access and affordability will be one in which generation and storage are sited close to load and under local control. In other words, a "bottom-up system" (as Lorenzo Kristov has put it[57]). The foundational layer is solar PV -- on rooftops, parking lots, and other sites in the built environment – which, in the LPN model, is integrated with local storage at both the building level and community level. Local control is necessary so that these systems can be *optimized for user benefit* -- affordability, accessibility and security.

Small-scale, locally-generated solar power could meet much of the nation's electricity demand now and in future. One study[58] conservatively estimates that rooftop solar alone has the technical potential to generate electricity equivalent to about 45% of all national electricity sales at the 2022 level of U.S. demand. The Center for

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[53] Slocum, Tyson (2007), "The Failure of Electricity Deregulation: History, Status, and Needed Reform" https://www.ftc.gov/sites/default/files/documents/public_events/Energy%20Markets%20in%20the%2021st%20Century:%20Competition%20Policy%20in%20Perspective/slocum_dereg.pdf. And see MacKay, Alexander & Ignacia Mercadal (2023), "Do Markets Reduce Prices? Evidence from the U.S. Electricity Sector"; Working Paper 21-095, Harvard Business School. https://www.hbs.edu/ris/Publication%20Files/21-095_5398d456-f1de-432d-9a0b-cc7a58b51145.pdf

[54] Powers, Bill; "Roadmap to 100 Percent Local Solar Build-Out by 2030 in the City of San Diego" (2020) https://tinyurl.com/2p5txywx

[55] Welton, Shelley (2021), "Rethinking Grid Governance for the Climate Change Era", University of Pennsylvania Carey Law School Legal Scholarship Repository.

[56] E.g., Pollard, Matt and Tim Buckley (2024), "Queensland's Energy Transformation: From Coal Colossus to Renewable Energy Superpower;" *Climate and Energy Finance*.; Role of Distributed Generation in Decarbonizing California by 2045 Vibrant Clean Energy (2021).

[57] Kristov, Lorenzo, "Power System Evolution From the Bottom Up", Oct. 2018; Kristov, Lorenzo, "Building the 21st Century Electricity System" 2021; Kristov, Lorenzo, "A new value proposition for electric distribution networks" in *The Future of Decentralized Electricity Distribution Networks*, F. Sioshansi Ed. 2023.

[58] Neumann, Johanna & Tony Dutzik (2024), *Rooftop Solar on the Rise*; Environment America and Frontier Group.

Biological Diversity in a 2023 report,[59] estimated that the generation potential of solar PV on rooftops is 37% of the amount of electricity sold in 2022, and that adding parking lots puts the generation capacity at *greater than* the total 2022 level. A 2021 international study[60] estimated the rooftop solar potential in the U.S. at 4,247 terawatt-hours per year (TWh-yr), which is greater than U.S. total electricity demand of ~4,000 TWh-yr.

> *"The bulk power system supplements local production."*
> Lorenzo Kristov "Building the 21st Century Electricity System"

If implemented on a national scale, LPNs would not entirely displace utility-scale generation and transmission of renewable energy. But prioritizing the LPN concept means that local generation sources would eventually supply the major share of electricity for residential demand. The bulk power system (See Appendix 1) would supplement LPN generation and storage, and would be much smaller in geographic footprint -- and require less generation and transmission capacity -- than is currently being envisioned and planned by energy interests and policymakers. *The bulk power system becomes the reserve system, "the last resort, not the first"*.

8. Short-term and Long-term Objectives

This Blueprint has both short-term and long-term objectives:

- Short term – Use the LPN principles and system design to implement LPNs at pilot sites in the near-term.
- Long term – Articulate the concept and system design for a program of national scope. Legislation and regulatory reform would be required to achieve the long-term vision.

The following sections articulate the system **design principles** and the **technological, institutional and financial design features**, and related public policy, which flow from the system design principles.

[59] Center for Biological diversity (2023), "Pursuing a Just and Renewable Energy System; A Positive & Progressive Permitting Vision to Unlock Resilient Renewable Energy and Empower Impacted Communities".

[60] Joshi, Siddarth et al., (2021), "High resolution global spatiotemporal assessment of rooftop solar photovoltaics potential for renewable electricity generation"; *Nature Communications*; doi.org/10.1038/s41467-021-25720-2. This study assumes rooftop availability on the high side (100% availability) but assumes panel efficiency on the low side, at 10%, whereas panels are now at ~20% efficiency.

Part B. System Design:

Technological, Institutional and Financial

This section addresses the technological, institutional and financial aspects of an LPN system. The system design outlined here flows from the principles.

System Design Principles: Benefit Users and Decarbonize

- **Benefit Users**

The electricity generation and delivery system design should be optimized for user benefit, meaning:

a. Affordability – electricity is affordable to all, including low-income users;
b. Accessibility – electricity is physically and financially available;
c. Security – local system reliability and resilience.
  - Reliability – generation and distribution capacity; frequency and voltage stability; black start capability.
  - Resilience – ability to seamlessly island; local control over when to island; ability to speedily recover from power outages. Demand management (load prioritization) and the decision to connect to or disconnect from the grid is locally controlled. Resilience is a local attribute.[61]

Based on empirical evidence and a growing body of literature, it is clear that a system of localized generation and control can best be optimized for user benefit. This is unlike current rooftop generation in the US, which, in most places, is configured to disconnect and cease electricity supply to the house in the event of a grid power outage.

Another design principle is that the system must assure that the following groups can benefit:

- renters;
- middle income and low-income homeowners;
- fixed-income populations (e.g., students and older Americans);
- workers (system construction, operation and maintenance must generate jobs with family-supporting wages; organized labor should be engaged in helping to achieve these ends).

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[61] "Resilience entails preparation for more frequent and damaging climate-related disruptions, as such it is essentially a local attribute" Lorenzo Kristov, "A new value proposition for electric distribution networks" in *The Future of Decentralized Electricity Distribution Networks*, F. Sioshansi Ed. 2023. And "resilience is a local attribute": Lorenzo Kristov, "Building the 21st Century Electricity System" 2021.

Moreover, the system should produce *local* economic benefit; i.e., for communities and small businesses/entrepreneurs, rather than optimizing financial rewards for corporate managers and producing profits exported to distant shareholders and investors.

➢ **Decarbonize**

The design of the electricity generation and delivery system should be optimized for:

a. Effectiveness in decarbonizing generation and delivery; and
b. Efficiency in decarbonization; e.g., generation and storage should be close to load.

1. System Design – Technological

1.1 LPNs are a form of mini-grids.

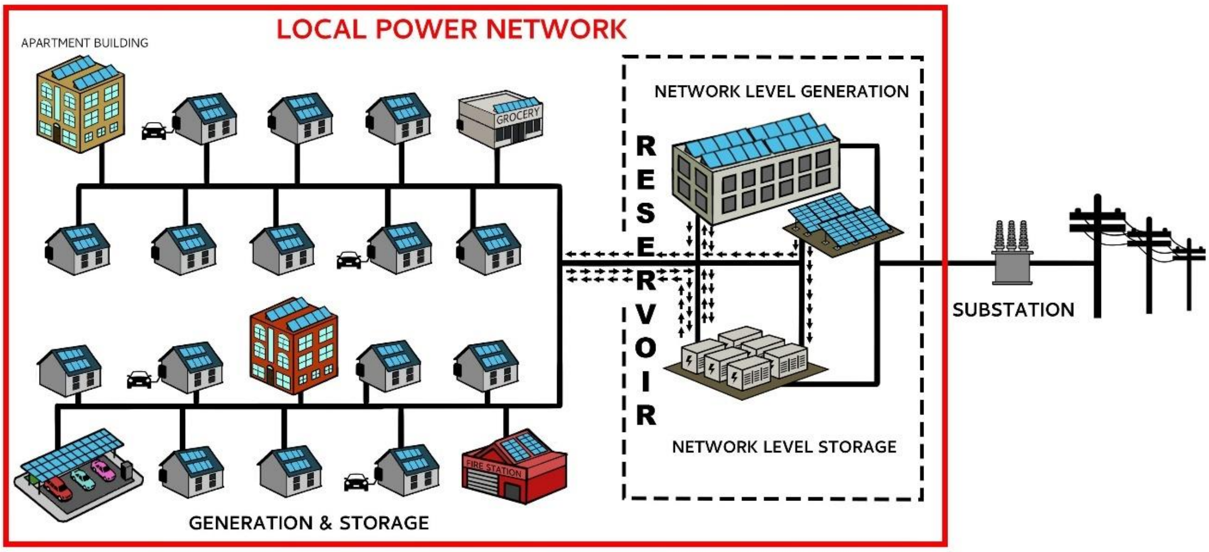
Structurally, an LPN is a mini-grid comprised of solar PV generation and battery storage and physically/electronically connected. It will have grid interconnections at the border of the mini-grid, as well as metering and telemetry at key points in the network, including all participant sites. LPNs would be organized at the neighborhood level (substation or feeder line level). See Figure 3.

We use the term mini-grid to distinguish LPNs from local systems called microgrids, which generally do not include a local generation and storage reservoir.

LPNs:

- Consist of a local (e.g., neighborhood-level) mini-grid network plus a network-level reservoir of generation and storage.
- Are 100% powered by renewable energy (except when an LPN must import electricity from the bulk power system). In some parts of the country, wind generation may supplement solar generation. But no diesel or fuel cell generators are anticipated.
- Operate autonomously using grid-forming inverters, electronic controllers and other electronic hardware needed for autonomous control and management of electricity flows; controllers are programmed to maximize efficiency and self-reliance.
- Could be located at the substation level, or by making a single feeder a dedicated, islandable mini-grid.

Figure 3. Schematic diagram of a Local Power Network



1.2 Siting

Solar PV generation would be sited on residences, parking lots, municipal and commercial buildings and other areas of the built environment, and potentially on disturbed land (such as capped landfills). Storage, including batteries and other means of energy storage, would also be locally sited, and would include both batteries at individual buildings (residences, public facilities, small businesses, etc.) as well as the reservoir-level battery array (see reservoir description below).

1.3 Interfacing with the distribution and bulk power systems.

In the LPN model, the local network operates in an "islanded" mode most of the time. The reasons for doing so include: a) maximum reliability: b) stable and moderate power costs: c) assures use of 100% green power (no question about power source); d) minimum exposure to bulk grid price arbitrage events.

Control of whether and when to "island" – operate independently of the grid – would be in the hands of the local LPN owner/operator (which would act in coordination with the distribution system operator), a power that would be granted institutionally (by the overseeing utility) and is enabled through technology. The electronic controls would need to be programmed to allow local choice rather than top-down control by the utility. In addition, "anti-islanding" features typically built into solar-only inverters would be absent, disabled or reprogrammed. Devices with transactive control technology would need to be programmable, and programmed to enable local choice and decision-making (in coordination with the distribution system operator).

Eventually, there could be multiple layers of LPNs, with each LPN interfacing with the LPN in the next layer above. This concept is patterned after the "layered architecture" approach that has been envisioned and described by Lorenzo Kristov

("Building the 21st Century Electricity System" 2021; and "Two Visions of a Transactive Electric System" 2016). Each LPN only needs to manage its interface with the layers above and below it. The top layer LPN interfaces with the bulk power system (grid). In some areas there may be only one LPN layer; other areas may have more layers. The number of layers would be based on local choice (i.e., the number and size of LPNs that are formed in a city or geographic area) as well as technological and financial considerations (opportunities or constraints).

1.4 Grid system balance.

Balancing the bulk power system grid (transmission and distribution functions) would not significantly differ from how it is done now, and might be simpler, since: 1) there would be less load to balance at the regional level than would otherwise occur because more generation and storage would occur at the local level, close to load; and 2) problems such as curtailment when there is "overgeneration" of solar will be reduced at the regional grid level as surplus generated electricity would go to a local LPN storage reservoir. Only when the LPN storage is full would excess power be fed into the grid or curtailed.

1.5 Interconnection and maintenance of voltage and frequency.

Integrating electricity from an inverter-based resource system (e.g., solar PV) into a grid that is powered mainly by synchronous generators has raised some technical issues, but these are being addressed and overcome via new technologies (e.g., grid-forming inverters).[62] The technical literature indicates that inverter-based resources may enable improved grid stability. Experts observing from an institutional perspective have also weighed in. See, for example Welton et al. (2022)[63] who show that "much of the perceived tension between clean energy and reliability is a failure of law and governance." Delays in interconnection can no longer have a technological rationale, except in the sense that enabling technology is not being adequately deployed and infrastructure upgrades are lacking.[64] Likewise, the inverter technology (grid forming inverters) has the ability to regulate voltage and frequency at least as well as the current system, and may be capable of more rapid and efficient "black starts" than the synchronous generators that mainly power the grid currently (see publications at NREL).

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[62] e.g., see Kroposki, Benjamin et al. (2017), "Achieving a 100% Renewable Grid: Operating Electric Power Systems with Extremely High Levels of Variable Renewable Energy" *IEEE Power and Energy Magazine Vol 15 No2. March/April 2017;* and Lin, Y, et al. (2020), "Research Roadmap on Grid-Forming Inverters" National Renewable Energy Laboratory. NREL/TP-5D00-73476.

[63] Welton et al. (2022), "Grid Reliability Through Clean Energy", 74 Stan. L. Rev. 969.

[64] There many sources on this point; for an early one see "Grid Integration and the Carrying Capacity of the U.S. Grid to Incorporate Variable Renewable Energy" (2015) J. Cochran, P. Denholm, B. Speer & M. Miller; National Renewable Energy Laboratory; Technical Report, NREL/TP-6A20-62607, on the point that "carrying capacity" is a function not of technology but is based on what is considered economically desirable.

1.6 Self-generation for self-consumption; demand self-management.

Within an LPN, all participating entities (homes, schools, public buildings, small businesses, etc.) ideally would have the solar PV plus storage capacity necessary to meet their total electricity needs. In cases where home electricity demand may exceed the capacity of the existing onsite power supply, a homeowner can use an energy management system to prevent too many high demand devices operating at the same time so that building electricity demand can be met with the existing power supply. These energy management systems, sometimes called “smart panels”, can be simple and cost as little as a few hundred dollars. They can prevent the principal high demand devices, such as a central air conditioning system and an EV charger, from operating at the same time. They can also be much more sophisticated, costing several thousand dollars, and modulate many of the home electric loads to maximize efficiency while keeping total demand within the design capacity of the power supply.

In some instances, such as homes with tree-shaded roofs, the building may not have a sufficient onsite power supply to meet its needs, and in those cases would have to, at times, draw power form the network-level reservoir.

1.7 Local network connections.

Within an LPN all generation sources and storage devices, as well as load sources, would be connected with each other. Options include: 1) in areas currently served by IOUs, create LPNs at the substation level (or feeder level) and contractually assign control of all generation and load sources in the LPN to a designated LPN operator (who is independent of the IOU); 2) in areas served by a municipal utility, special district or co-op utility, obtain contractual authorization to operate the local distribution system poles and wires as an LPN, and to rewire/reconfigure as necessary to maximize LPN operational efficiencies; 3) construct a new physical and electronic network.

1.8 LPN-level generation and storage reservoir.

“Reservoir” is the name used in the LPN model to designate network-level generation and storage capability that serves all LPN participants. See Figure 3.

A solar PV array at the network level (e.g., substation, feeder or community level) would supply power to LPN participants as needed – including entities without self-generation capability or with limited solar insufficient to meet all of their demand. This solar PV array also supplies the LPN-level storage system.

The storage system would receive inputs from three sources: network-level solar array(s); surplus electricity sent from individual LPN participants (as described below); and out-of-network sourcing when and if needed. The storage system would in most cases be a battery array (in the expected range of 0.5 MW/2 MWh to 10 MW/40 MWh capacity), unless site-specific conditions economically favor another form of storage, such as pumped storage hydro.

The network-level solar array and storage system – the reservoir -- would be owned and maintained by the LPN (see ownership options discussed earlier).

There are two chief reasons that each LPN would have its own generation and storage reservoir. One reason is to have a source of resilience that is under local control, rather than control being in the hands of an IOU or other body exercising top-down control. With proper sizing, the network reservoir should enable LPN participating entities to meet their load needs most of the time. When they cannot, the LPN will purchase power from outside the network.

The second reason is to enable participation by renters and low-income households. The LPN design is optimized to keep costs down for end-users. First, keeping generation (and storage) close to load, if efficiently implemented, would lower the cost of electricity supply by avoiding the expense of long-distance transmission. In addition, generation by commercial-size (LPN-owned) PV systems at the network level will contribute to cost reduction. Commercial-size solar PV systems cost less per watt than generation by small-scale (e.g., residential rooftop) systems,[65] thus reducing costs. (For other cost savings see the energy pooling system and accounting section below.) Renters will be able to draw on electricity supply from solar PV on their apartment buildings (see discussion below on incentives for apartment building owners to participate) as well as from the network-level PV array.

1.9 Energy pooling system and accounting.

As outlined above, electric power is pooled by generation inputs to the storage reservoir from three sources: the network-level solar PV array(s); individual LPN participating entities with solar PV and onsite battery storage sending their surplus electricity to the reservoir; and, via purchases from outside the network when the first two sources are insufficient to keep the storage reservoir at target capacity.

Each LPN participating entity (residences, including single-family and multi-family apartment buildings; municipal buildings; other public buildings like schools, libraries and fire stations; shops and local small commercial buildings; parking lots; ware houses, etc.) would: a) self-generate and self-store to meet its own demand as much as possible; b) export its surplus energy to the LPN reservoir; and c) draw from the LPN reservoir as needed. The amount of energy input to and drawn from the LPN reservoir -- expressed in kWh's -- would be electronically automatically tracked by a "Power Tracker". This type of system has been implemented in Australia; in a pilot project, the system tracks where energy is coming from and going to within a "hub". In this model, "If your neighbor has been importing electricity, at the same time as you have been exporting electricity from your solar power system, we say this energy has been "shared." That model also sets up energy "trading" – financial transactions between individuals – something the LPN model does not do.

[65] Wood Mackenzie (2022) reports: average per-watt cost of small scale (8 kW rooftop systems) - $2.99/W; mid-size (500 Kw rooftop systems) - $1.77/W.

The LPN model is not based on *ascribed* sharing or on *financial* trading transactions. Rather, it operates by participants contributing to and drawing from a common reservoir. This is tracked by a *non-financial* mechanism -- a monthly accounting of how much (in kWh) each entity supplies to the reservoir and how much it withdraws. There is a periodic financial settlement, as discussed in the System Finance section.

Network- or neighborhood-level energy pooling is novel, although some forms of it are being applied in some places, (e.g., Australia[66]). Structures to pool and share solar-generated power at the local level on *a non-financial basis* are nascent. There are proposals and ideas for electricity as a "commons".[67] This concept does not appear to have been implemented, and as yet lacks a full articulation of the institutional, legal, and statutory supporting structures that would be required to enable the commons idea. LPNs are not based on an informal idea of a "commons", but rather are legally-instituted and constructed entities, enabled and supported by government laws, regulations and financing, as delineated in this section.

"The difference between this technology on one hand, and large wind and solar farms on the other, is that it is being owned and operated outside of corporate control."
Simon Pirani – reviewer of the draft Blueprint

The LPN concept in broad strokes is this: A layered electricity supply system in which the foundational layer is comprised of entities at the community level that are simultaneously electricity self-generators (producers) and users. The popular term for users who are also producers is "prosumers". But that term typically applies to individual households or businesses. In the LPN concept, a prosumer would also be an entire neighborhood or substation area.

In sum, three design features core to the LPN concept are: 1) keep generation (and storage) close to load (i.e., reduce reliance on long-distance transmission); 2) enable energy pooling in each LPN, and do so using a non-price mechanism; 3) enable local control. Crucially, contrary to the DER pathways being envisioned by mainstream planners now, in which data is utilized by IOUs, centralized operators [68] or DER aggregators to manage customers' activity primarily for the operators' or aggregators' self-benefit, in the LPN model, data is utilized by LPN operators to optimize the system for users' benefit.

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[66] Totally Renewable Yackandandah; Project: Yack01 Community Battery; undated; accessed 7-21-24.
[67] Giotitsas, C, Nardellim P. et al. (2022), "Energy governance as a commons: Engineering alternative socio-technical configurations", *Energy Research & Social Science* 84; Farrell, John (2024), Upcharge: Hidden Costs of Electric Utility Monopoly Power, Institute for Local Self-Reliance.
[68] Independent System Operators - ISO's, or Regional Transmission Organizations – RTOs.

2. System Design – Institutional

2.1 System entities, legal forms

LPNs would be not-for-profit entities. Their legal forms and structures would vary from place to place; options include: municipal, co-operative, local special-purpose district, tribal non-profit entity, and other non-profit (principally 501(c)(3)) forms.

2.2 Autonomy and control

An LPN mini-grid would control – electronically and with institutional/legal authority – connection to and disconnection from the electric power system layer above it.

2.3 Relationship to the grid

As discussed in the Technology section, LPNs would operate in an islanded mode the majority of the time in many parts of the U.S. LPNs would also have a grid-connection to enable power transfers with the wider grid.

Regionally, and nationally, if LPNs became the standard building block, these networks would eventually supply the major share of electricity to end users (residences, municipal buildings, small business, etc.). **The bulk power system would supplement the LPNs and would be much smaller in geographic footprint and require less generation and transmission capacity than is being envisioned by bulk power system stakeholders and most policymakers currently**.

2.4 Regulatory frameworks

(a) State level

LPNs would initially need to be created under existing regulatory frameworks, which are managed by public utility commissions (PUCs) whose rules apply to IOUs. Although IOUs serve more customers than publicly-owned utilities (POUs) and electric co-ops – see Figure 2 – there are far more PUCs and co-ops than IOUs in the US, presenting a great many opportunities in which to potentially implement the LPN model.[69]

> *"[Local] energy generation should be as reliable and cheap as being on the municipal geothermal heating grid in Reykjavik where you don't worry about your heating bills, your house is just…warm."*
>
> Deb Chachra – reviewer of the draft Blueprint

(b) Local level

It is likely that LPNs initially could most easily be introduced in areas served by municipal or other public utilities or

[69] Some states have laws that might inhibit the LPN model. For example, it is unclear whether an LPN might be deemed a "utility" under a Minnesota statute; see pg 39, https://mn.gov/commerce-stat/pdfs/microgrid.pdf

electric cooperatives.[70] Unlike, IOUs, these entities do not rely on maximizing profit as their key driver, and so would likely be more hospitable to the not-for-profit LPN model. Moreover, municipalities and counties can exercise their statutory powers to enable, create and support LPNs. Examples of favorable actions include: ordinances to enable legal structures and frameworks; laws to authorize municipal battery arrays and to secure or appropriate funding for them; creation of bonding authority and bond issuance; bulk purchasing of solar panels to lower the cost for residential and municipal entity buyers; and other actions that could usher in a cost-reducing, solar saturation strategy.

In addition, there is an economic development incentive for municipal utilities to set up LPNs, since more of the expenditures on energy will be kept in the local economy. MOUs would spend less on market purchases of electricity. In turn, LPN participants would spend less on market-purchased electricity and, importantly, their monthly bill payments would instead support salaries for LPN staff, again recirculating more money in the local economy.

(c) Federal level

The Federal Energy Regulatory Commission (FERC) regulates interstate transmission of electricity. Assuming LPNs are not engaged in interstate transmission, they would not be subject to direct FERC regulation.[71]

2.5 Operation and staffing

As noted earlier, LPN ownership could be by any type of not-for-profit entity. A particularly viable option for initially piloting LPNs may be for each LPN to be owned, operated and staffed by an existing municipal utility or electric co-op. There are over 2,000 publicly-owned utilities and almost 900 electric co-ops in the U.S. (American Public Power Assn. 2022). In this option, the LPN staff would be employees of the municipal utility or the electric co-op.

Advantages of this option are:

- expertise in electricity systems already exists at the municipal utility or co-op;
- these entities have the capacity for personnel vetting and hiring;
- economies of scale in terms of operations, maintenance and administration could be realized if multiple LPNs were formed in the utility's service area.

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[70] Publicly owned utilities are distinguished from electric cooperatives. The former are utilities owned and operated by municipal, county, state, federal or territorial governments or governmental special purpose districts. Electric cooperatives are private not-for-profit entities. Two reasons the distinction is significant are that governments have powers, such as enacting laws and ordinances, that cooperatives do not, and they can undertake bond financing at lower cost than private issuers. The distinction between public power utilities and electric cooperatives follows the convention of the American Public Power Association.

[71] A reviewer of the draft Blueprint raised a FERC jurisdictional question. If the LPN is connected to the grid and can buy/sell power from the wider grid, would this put the LPN under FERC jurisdiction regarding rates?

2.6 Apartment buildings / Renters

An important policy objective of the LPN model is to enable renters to participate in localized solar plus storage. Since a single distribution line typically feeds an apartment building,[72] it will be necessary for the apartment building owner to participate in the LPN. There are two types of incentives that could interest apartment building owners in participating – inherent and added. Inherent incentives include: a) a lower cost of electricity for all common areas of the building; b) a potential competitive advantage in attracting renters who prefer clean energy as their electricity source; c) competitive advantage in attracting renters by being able to offer islanding capability during power outages.

An example of an added incentive is low-cost financing for installation of solar PV and batteries in apartment buildings. This could be done via a municipal bond issuance, as described in the Finance section. This financing should be conditioned on, first, the owner installing sufficient generating capacity to serve all units in the building; and, second, allowing all rental units to automatically participate in the LPN. Also, if the municipality chooses, this financial assistance could be preferentially targeted to low-income neighborhoods.

2.7 What the LPN owns

As discussed above, the LPN overall is a legal entity, which could take different forms of ownership in different places; options include municipal, co-operative, local special-purpose district, tribal non-profit entity, and other non-profit.

But another aspect of LPN design is – What does the LPN itself own? In short, it may own:

- The electronic control equipment/systems (electricity management system);
- The solar PV system and battery array that comprise the reservoir;
- Output from the PV system and the battery array that comprise the reservoir;
- Output from the individual PV systems delivered to the storage reservoir.

The incumbent utility would own existing infrastructure, such as “poles and wires”. The customer would own all behind-the-meter (BTM) infrastructure.

The LPN might or might not own the reservoir PV system and battery array. Most likely those assets would be owned by the POU, electric co-op or tribal entity in whose service area the LPN is located. In that case, those entities would own the output from those assets. Whether the reservoir assets are owned by the LPN or by the utility in whose geographic area the LPN is located would be determined on a case-by-case basis by the parties involved.

[72] Typically, supply is then sub-metered to individual units.

As noted, the LPN would not own the behind-the-meter assets -- PV or storage systems located at and owned by the individual participating entities – homeowners, apartment building owners, small businesses, public entities, etc.

2.8 Piloting the LPN model

The LPN model first needs to be implemented at pilot sites, since broad-scale, nation-wide implementation in the long-term would entail fundamental regulatory reform and federal or state financial support for local infrastructure. But pilots are feasible in local areas in the near-term. Within the LPN network, ideally every residence (including apartment buildings), every small business and every publicly-owned building would self-generate with a solar PV array, and most would have battery storage. Ideally, there would be a mix of residential participants including not only low-income, but all income levels, as well as commercial and municipal participants. Each LPN would have community-level generation and storage. As discussed in the Finance section, public financing would facilitate this infrastructure build-out and low-income household participation.

As discussed above, there is undoubtedly greater opportunity for the LPN model in municipal or electric co-op utilities than with IOUs because consumer-owned utilities are not-for-profit and are not regulated by PUCs as investor-owned utilities are.[73] Their non-profit structure is, in principle, most compatible with the LPN design and mission.

However, many electric co-ops and some municipal utilities are bound by "All-Requirements Contracts" (ARCs)[74] which may restrict the co-op's or municipal utility's ability to implement large-scale LPNs. ARCs are agreements between a local utility and a seller of electricity that the utility will buy all of its power from that provider for a specified period. Some ARCs may place limits on the amount of local generation permitted, while others allow for a substantial amount of self-generation. It is not clear that ARC constraints would apply to the operation of LPNs. This matter requires investigation on a case-by-case basis when considering potential pilot sites. It may be advisable to seek sites without ARCs.

[73] "Consumer-owned utilities, such as municipal utilities or rural cooperatives, are generally not regulated by PUCs"; pg 7 State Microgrid Policy, Programmatic, and Regulatory Framework *National Association of Regulatory Utility Commissioners (NARUC) and National Association of State Energy Officials (NASEO)*.

[74] Veazey, Liz and Matt Grimley (2016), "Overview of Generation & Transmission Co-ops & All Requirements Contracts", We Own It; John Farrell (2016), "Local Utilities Have Lost Local Control"; Institute for Local Self-Reliance; Klass, Alexandra. B., & Chan, Gabriel (2021), Cooperative Clean Energy. *NCL Rev., 100*, 1.

3. System Design – Financial

As underscored throughout this Blueprint, the LPN model is designed to enable access, affordability and energy security. The financing structure is likewise designed to achieve these goals. The policy reversals and recission of renewables funding by the federal government in 2025 have erected formidable barriers to, but not completely destroyed, avenues to achieving these goals. When this document was drafted there were multiple sources of federal financial assistance for local solar, for example a 30% residential solar tax credit and a $7 billion "Solar for All" program. The 30% tax credit is being terminated and some of the funding for Solar for All may be rescinded. However, the Rural Utilities Service (RUS) program (formerly Rural Electrification Act (REA) and the Rural Energy for America Program (REAP) are still operating, albeit at a scaled-back level. And state and local governments retain financing capabilities. Reducing costs of solar installation is a crucial part of the financial solution, and is addressed below.

A cost study is being undertaken to estimate and project the construction and operational costs of implementing an LPN in different scenarios in terms of numbers of participants and generation/storage capacity.

3.1 Least-cost system

"When you buy solar cells and put them on your roof, you're paying for 20 years of energy up front,,,you're paying a fixed interest payment. So you've inflation-proofed your energy inputs…So in fact, your cost of energy stays dead flat at your price of finance. [It's] the substitution of finance for fuel."

Saul Griffith, Founder, Rewiring America & Rewiring Australia
Interview of Saul Griffith by David Roberts, 2023

Although a transition to a decarbonized electricity system nationally will require major investment, no matter how it proceeds, evidence suggests that a system of not-for-profit, locally-controlled generation and storage could provide the least-cost, most affordable system for electricity supply and access. Studies indicate that decentralized generation and storage could cost billions of dollars less nationally than centralized generation and transmission. A 2021 study by Vibrant Clean Energy found as much as $120 billion in cumulative savings for California ratepayers from 2018 to 2050 in total system costs ('Local Solar & Storage Future' scenario compared to 'Utility-scale Only' Nussey, 2018). Referencing Lazard, the study states that "community-scale solar power can cost as little as $0.07 per kilowatt hour." In a "roadmap" to 100% local solar for San Diego, energy expert Bill Powers lays out the cost advantages and financing options for local solar power. A 2024 study (Pollard & Buckley[75]) of renewable energy in Queensland,

[75] Pollard, Matt and Tim Buckley (2024), "Queensland's Energy Transformation: From Coal Colossus to Renewable Energy Superpower;" *Climate and Energy Finance*.

Australia found rooftop solar "to be the lowest cost source of electricity", with a solar system retail price to customers (including incentives) of 96 cents (Australian)/ 62 cents USD per watt for a 10 kW array.

3.2 Financing strategy for current conditions in the US

There are two aspects to LPN financing: a) infrastructure creation and b) ongoing operations.

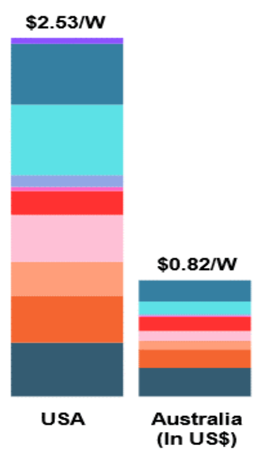
(A) Infrastructure financing – reducing system acquisition cost

System acquisition cost – paying for the solar PV system hardware and its installation – is a major barrier to widespread adoption of rooftop solar. Likewise, infrastructure cost will be the largest hurdle for LPN implementation. Once that hurdle is overcome, the "fuel" is essentially free. And, as Saul Griffith has put it, "you've inflation-proofed your energy inputs."

Low-interest-rate public financing mechanisms can lower the system acquisition costs for the hardware and its installation for individual households participating in an LPN, and for the network-level reservoir. Localities could choose to provide extra financial supports to low-income households to facilitate their participation in the LPN. See the discussion below on municipal bond finance.

A Local Power Network consists of three types of infrastructure: a) individual level generation and storage; b) a network level reservoir (generation and storage), and c) the electronic management system for network operation.

Fig. 1 Cost per watt of residential rooftop solar US and Australia (in US $) 2023



Reducing infrastructure costs through public policy actions

In the US the average installed cost of residential rooftop solar is $2.53 per watt. In Australia, a country with a similar standard of living, that cost is 82¢ per watt USD,[76] a third of the US. In Germany the cost is $1.69 USD[77]. Australia has been able to reduce the installed cost largely through public policy and financial supports. The public policy actions created a high-demand, high-volume, low-fixed-costs business environment that reduced prices for solar system installations. In addition,

[76] This cost is for an assumed 10 kW direct current (DC) system prior to incentives for US and Australia. IEA, *National Survey Report of PV Power Applications in Australia 2023*, July 2024, Table 11, p. 20. This is the representative cost for an AU 10 kW (direct current) system prior to government subsidies. The $1.30 AU$ is converted to US$: $0.82. For more information see Powers, Sekera & Woolfolk (2025), "Local Solar: International Cost Comparisons; Australia, Germany, United States".

[77] Powers, Sekera & Woolfolk, op. cit.

localities simplified inspection and permitting processes, further reducing costs. These strategies can be replicated in localities in the US, as discussed below.

Despite the near-elimination of federal-level financial supports for renewable energy in the United States at the present time, there is a viable approach to the LPN model. It rests principally on two factors:

- public policy actions at the state or local level that lower installation costs of small-scale solar PV systems; and
- public finance at the local and/or state level, and the remaining federal programs.

Cost Reductions Strategy

Other countries, like Australia and Germany, have taken public policy actions that reduced the cost of local solar far below the costs found in the US. Although those countries took action at the national level as well as local levels, many of their policy actions can be replicated at local and state levels here, lowering costs through economies of scale. Following are techniques to reduce both "soft costs" and "hard costs" of local solar that can be replicated in US communities.

"Soft costs" include businesses' expenses like marketing/advertising, administrative costs and profit margin. They include utility/distributor approval and other aspects of the installation process.[78] Soft costs also include expenses that are under the control of public authorities and utilities, such as permitting and inspection processes. Standardizing technology platforms can further speed up processes and reduce costs.

Achieving low soft costs is significant because more than half of the US system installation cost involves soft costs, including marketing, labor, general and administrative (G&A), permitting, and interconnection approval.

"Hard costs" include solar modules, inverters and other system hardware. The techniques described below can be used to reduce all three types of LPN infrastructure costs: generation and storage at the individual building level and network level, and system management hardware.

- **To reduce costs overall**
  - **Create a high-volume solar business environment**, which was done at a national scale in Australia, but do it at the local level here, making solar economically attractive to customers. A municipal utility or electric co-operative can institute a local area solar saturation strategy to establish one or more LPNs in a community or a neighborhood on

[78] McDevitt, C & S. Fields (2025) "Why are solar panels so expensive in the U.S.? Soft costs add up, but prices have fallen $15K"; Energy Sage, Oct 1, 2025.

a single substation feeder,[79] for example, and then incentivize and enable all or most customers on the feeder to have rooftop solar and storage and participate in the LPN.

- **To reduce soft costs**
  - **Minimize marketing and advertising costs installers normally have to bear**. Creating a high-volume business environment for participating installers will, in effect, eliminate or minimize marketing and advertising costs, which typically make up 20-29% of per-watt cost for US residential rooftop systems. A high-volume business environment enables solar installation companies to access to a steady pipeline of customers and minimize customer acquisition costs. Installers' planning cost is negligible so there is little to no down time after an order has been placed. Operating on a high-volume business model enables installation companies to spread their fixed costs over a larger sales base, thereby reducing the cost for each installation.
  - **Standardize installation practices to increase efficiency and reduce installation labor cost while paying workers a living wage**. Australian solar installers often complete the installation process in a single day and are paid a fixed fee for installation based on per project "industry typical" installation labor cost. Australian installation labor cost has historically been about one-third less than US installation labor cost on per kW installed basis,[80] while workers are receiving a living wage.[81]
  - **Simplify and streamline permitting and interconnection** to reduce processing time and expenses. Stipulate the system size and solar panel and inverter elements that can be automatically approved.
  - **Eliminate or minimize interconnection fees** for residential PV systems connecting to the distribution grid.
  - **Institute an independent certification authority** for solar installers and hardware. This would establish a pool of pre-certified installers and pre-certified hardware. This will make the installer selection process more efficient and faster.

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[79] Distribution substations typically have four "feeder" circuits. These feeder circuits loop through neighborhoods and business districts to supply power to customers. A typical feeder may have hundreds, or even thousands, of individual customers.

[80] Aurora Solar, *Lessons From Down Under: Ways to Lower PV Solar Soft Costs*, 2019: https://aurorasolar.com/blog/lessons-from-down-under-ways-to-lower-pv-solar-soft-costs/ .

[81] Average base salary, solar installers AU, April 2025 ~$109,125 AU$, which is ~$68,700 US$, and ranging from $117,300 US$ to $47,200 US$: https://au.indeed.com/career/solar-installer/salaries .

- **Certify and pre-approve experienced solar installer firms** to install the systems.
- **Adopt other practices from Australia:**
  - Permitting and commissioning can be managed by the installer, primarily with software and apps.
  - For most residential installations, there is no interconnection approvals process because there is blanket pre-approval for rooftop PV systems below a specified inverter size, generally 10 kW or less.[82]
  - Installers can quote remotely. The homeowner can decide, place an order within a week, and have the work start nearly immediately.
  - With the above techniques, a simple, standard installation could be completed in a day.
- **Offer low-cost financing to households**, so that they can avoid the high costs of dealer fees and commercial loans. The Lawrence Berkeley National Laboratory estimates that those expenses can add 5-50% of the cost of a rooftop solar system.

  On-bill, meter-based, financing is one way to deliver low-cost financing to households. Under this type of financing, customers continue to pay an electric bill at a rate lower than they previously paid for grid electricity, while at the same time, the bill payment is used to pay off their rooftop solar system.

➢ **To reduce hard costs**

- **Bulk-buy hardware**[83], modules, inverters, panel mounting materials, other electronic equipment and batteries. Bulk purchasing alone can reduce solar system hardware costs by one-half.[84] A publicly-owned utility or co-op can eschew any markup on the hardware they bulk-buy and furnish for system installation.
- **Standardize hardware and systems**. Offer LPN participants a standard PV system and battery. This can elicit bulk-buy discounts to secure lower prices and thereby reduce installation prices. Shipping and carrying costs are minimized. Aggregate hardware stocks can reduce or eliminate potentially costly delays for installers in sourcing hardware. In addition, standardized equipment can later reduce operating and maintenance costs.

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[82] Solar Choice, *Solar system size limits: How much does your local network allow?*, August 8, 2024: https://www.solarchoice.net.au/learn/design-guide/solar-system-size-limits-by-network/ .

[83] In Australia, buyers have the advantage that there are no tariffs, only nominal taxes, on imports. United States Studies Centre, *Should Australia make solar panels? Supply chain security through global engagement*, December 1, 2024.

[84] 2023 IEA US 5-10 kW panel cost is $0.38/W. Wholesale panel cost in US is $0.12 - $0.18/W. See: https://a1solarstore.com/wholesale-solar-panels.html

- **Design the standard system at a capacity that meets the needs of most participants in the network**. This will maximize self-generation for self-consumption in the targeted community or neighborhood.

Utility environment

The residential rooftop solar cost reduction strategy described above is most applicable to public or not-for-profit electric utilities because the focus of these types of utilities is on low rates and high reliability. In contrast, corporate utilities have an interest in expanding conventional infrastructure to increase profits. This has resulted in private utilities generally being averse to mass adoption of residential self-generation.

Infrastructure financing options

(1) Public financing

Public financial support of some type is crucial for infrastructure construction to assure that all income levels can participate; public financing is not necessary for ongoing system operation.

Federal financing

Although most federal financing supports for local solar have been eliminated, the Rural Utilities Service (RUS) program (formerly Rural Electrification Act (REA) and the Rural Energy for America Program (REAP) are still operating, albeit scaled back. It is unclear how much of the $7 billion Solar for All program will remain available, but currently (July 2025) local programs are still able to access this funding. Appendix 3 discusses prospective sources of federal financing for the longer term.

State financing

Some states have maintained funding programs for local solar even in the face of the federal pullback. Illinois, for example, created the “Illinois Shines” program to support rooftop solar and community renewable energy systems.

Local financing

(a) Low interest rate bonds

Municipalities can use their bond-financing authority to issue revenue bonds to provide low-interest financing to support the buildout of local, locally-owned solar PV generation capacity and storage. The bond proceeds could be used for bulk purchasing of equipment and for other actions, such as those listed above, to bring down the cost of individual rooftop solar systems. Proceeds would be used to create the reservoir (build the network-level generation and storage facilities) and could be used to help finance individual-level rooftop solar and storage -- both for new installations and to enable entities with existing solar PV to expand or add storage.

Beneficiaries of the bond financing service the debt via on-bill financing. There would need to be a sufficient number of participating entities (households, commercial businesses, public entities, etc.) to support the costs of bond issuance and debt service.

Such revenue bonds can be authorized either by the local government body (e.g., city council) or by voter referendum. The bonds are repaid by the beneficiaries of the infrastructure that is built.

There is precedent for this type of bond financing. In 2001 in San Francisco, voters approved two ballot initiatives authorizing the city to issue bonds for the construction of solar PV systems and other renewables and for energy conservation. One bond would finance the construction of solar PV systems on city facilities and properties; the other bond would allow provision of electricity to residential and commercial customers. The City never exercised its authority to issue the bonds, in part because of opposition from the IOU that already served residential and commercial customers in San Francisco.

Offer low-cost financing to households, so that they can avoid the high costs of dealer fees and commercial loans. The Lawrence Berkeley National Laboratory estimates that those expenses can add 5-50% to the cost of a rooftop solar system in the US.

(b) On-Bill and Meter-Based Financing of Rooftop Solar

On-bill financing is a simple and straightforward mechanism for enabling households and other LPN members to benefit directly from the bond issuance. "On-bill" financing is a common mechanism in the electric utility sector. An amount (based on usage or some other proportional factor) is part of the monthly electricity bill.

An uncommon and creative version of this mechanism is meter-based billing – a model in which the meter at the customer site is the entity billed, not the individual customer "behind" the meter. Billing in this manner makes the credit history of owner/renter irrelevant. All that matters is that the bill is consistently paid. This financing model is being used in Hawaii's GEM$ program.[85] Rental properties can be accommodated by utilizing meter-based financing. Meter-based financing is designed on the actuarial analysis and experience that electric customer bill payments have proven to be a reliable and secure debt repayment stream. This repayment approach eliminates the problem of individuals with less than good credit ratings, who typically do not qualify for financing, being excluded. The GEM$ program in Hawaii has a specific focus on rental properties serving lower-income customers.

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[85] Hawaii Green Infrastructure Authority, Green Energy Money $aver (GEM$) On-Bill Program, webpage accessed March 20, 2025: https://gems.hawaii.gov/participate-now/for-homeowners/ .

A bulk customer base can be generated by implementing the rooftop solar project as an "opt-out" program. An "opt out" program structure is routinely used by utilities to achieve high levels of adoption for new programs. "Opt-out" means that all customers are automatically enrolled in the program but can affirmatively "opt out" if they chose to do so.

A crucial requirement of this "wholesale" approach to financing is ensuring the minimum number of participants to achieve critical mass. Thus, the LPN design overall must **result in a customer rooftop solar production cost that is significantly less than the grid power being displaced so customers see a clear economic benefit**. As noted earlier, a cost analysis of LPN scenarios compared with utility rates is being undertaken.

(2) Private financing

While public financing is essential, private capital is also needed. Public financing can catalyze private finance. Public capital expenditures "crowd in" private financing, both in general[86] and specifically in the case of renewable energy and "consumer energy resources". This Blueprint does not explore the sources of private finance, which will vary greatly by location.

(B) Ongoing system operation finance

Participants in an LPN pay for the cost of system operation.

LPN participant entities (households, businesses and public entities like schools, libraries, town halls, etc.) are billed monthly for:

(1) Services: system operational costs (management, maintenance, and other operational costs) debt servicing, etc.;

(2) Energy: electricity drawn from the LPN power pool, based on a volumetric kWh charge.

This billing is for cost recovery only; no markup for profit is permitted.

The sources of electricity input to the reservoir are:

(1) In-network electricity supply

(2) Out-of-network electricity supply.

Export of electricity from LPN to bulk power system

LPN's may choose to export surplus power to the bulk power system when advantageous to the local network. Such out-of-network exports can bring

[86] "The Macroeconomic Effects of Public Investment: Evidence from Advanced Economies" International Monetary Fund; WP 15/95; 2015.

in revenue to the LPN, further reducing kWh costs to LPN participants who use electricity supplied by the power pool reservoir.

- **Electricity supply**

In-Network electricity supply; power pooling/reservoir creation
LPN participant entities with solar PV send to the reservoir any surplus electricity they produce in excess of their load needs. As discussed earlier, the reservoir is a network-level energy storage system. Electricity inputs to the reservoir are *not compensated financially* at the time of input; i.e., they are not "selling" power to the reservoir. Rather, LPN participants understand that input power to the reservoir will receive kWh credits that will reduce their bill for any electricity they draw from the reservoir.

All LPN participants' monthly bills would show:
- kWh's input to the reservoir
- kWh's withdrawn from the reservoir
- Balance – credit or debit – shown in kWh's

Each participant's account would be settled annually or semi-annually. Those with a kWh credit would receive a financial deduction on their bill at the end of the year or mid-year; those with a kWh debit would owe a financial amount. In both cases the financial amount is based on the average kWh rate the LPN billed all participants during that year or half-year. LPN participants who do not input to the reservoir (because they do not have generating capacity) are billed monthly for their kWh usage.

A financial benefit of this system is that the "free" inputs to the reservoir will lower the kWh cost of energy for everyone drawing from the reservoir.

LPNs would have network-level solar PV generation and potentially could have wind or geothermal generation. However, this Blueprint does not address wind or geothermal provision.

Out-of-Network electricity supply
The source of out-of-network supply is purchases of electricity from the bulk power system. (Also, LPNs could exchange power with each other on a non-financial or financial basis, but such arrangements would need to await the development of multiple LPNs in a geographic region).

Grid standby charge

A standby charge will be paid by the LPN to the utility in whose service area the LPN is located. The fee contributes to covering the fixed costs of grid operation and enables grid access at times chosen by the LPN. But as noted in the Technology section earlier, each LPN will manage its load so it rarely has to draw power from the grid.

As noted in the Technology section earlier, each LPN would have the technological ability and legal authority to determine when to operate in a grid-connected mode and when to operate off-grid (island).

- **"Power Tracker"**

A "Power Tracker" system keeps an accounting of all energy inputs to and withdrawals from the power pool reservoir. The kWh credit or debit for each LPN participant is automatically calculated by this system. Since the amount of power sent to the reservoir and the amount purchased from the bulk power system will vary each month, the kWh price likewise will vary monthly.

- **Demand Management and Peak Shaving**

"Demand management" and "peak shaving" refer to financial incentives often built into utilities' pricing practices, usually in an effort to tamp down electricity usage during high peak demand periods -- In the late afternoon and early evening. In the LPN model, most houses and other buildings would have a sufficient power supply – from self-generation and storage -- to meet all or most of their load most of the time. So external demand management should be minimal or unnecessary. (Many LPN participants might self-manage to distribute their consumption to optimize their own generation and storage.) However, if a substantial portion of LPN participating entities cannot self-generate adequately to meet their needs, and are drawing daily from the reservoir, it might be advisable for the LPN as a whole to establish incentives for reservoir-users to shift their draws away from peak times to the extent possible.

- **Subsidies for low-income households:** Municipalities or electric co-ops may choose to subsidize the kWh billing to low-income LPN participants, and particularly low-income renters or low-income homeowners who cannot afford to install rooftop solar and battery systems onsite.

- **Management, maintenance and administration of each LPN**[87]
  Expenses for system operation are billed at cost; there is no markup for profit. Expenses include:

[87] This section borrows from Hannegan (2023) in which he describes a system that decouples utility revenue from volumetric sales (kWh's sold) and instead institutes fees for explicitly-defined services; purchased electricity is supplied with no markup for profit. Bryan Hannegan, "How an innovative co-op is planning to thrive amidst the market disruptions: The case of Holy Cross Energy", pp. 364-368 in *The Future of Decentralized Electricity Distribution Networks*, F. Sioshansi Ed. 2023.

- System manager/s
- Operations
- Maintenance & Repair
- Power Tracker (tracking kWh's)
- Customer service
  - Troubleshooting
  - Handling outages
  - Technical assistance
  - Public education
- Administration
  - Billing
  - Collections

➢ **Meeting – Not Monetizing – People's Needs**

The LPN design is fundamentally different from the "distributed energy resources" (DER) systems and "demand-response" programs that have been heavily promoted in the US. Those strategies are based on the monetizer model of electricity supply, whose assumptions are lifted out of neoclassical economics but whose benefits accrue principally to the for-profit utilities, demand aggregators and consulting companies who seek to advance them. That model is shaped by the idea of people as monetizers; it casts electricity users as energy price arbitrageurs. Ordinary energy users are expected to be motivated by, and become adept at, monitoring and responding to price signals in order to capitalize on electricity market volatility by shifting times of usage or exporting power to the grid. This approach may attract financially secure customers who have the time and technology to track prices and shift usage or power export.[88] But this strategy can be unrealistic for, and even disadvantage, many customers, particularly low-income homeowners and renters whose breadwinners may work multiple jobs and could scarcely afford the time and expense for the technology, or the new home appliances, to engage in electricity market trading.

Even for people who do have the interest, financial luxury and time flexibility for shifting times of consumption or electricity export in order to eke out price advantages, the result can be perverse. Observers have noted that current options for utility-managed DER programs for load-shifting provide a "false empowerment", as these programs are housed within a stratified system designed to favor those with the most economic and political power. In the U.K., objectives are shifting from

[88] These systems are often forbiddingly complex, as Kristov explains in "Building the 21st Century Electricity System" (2021): The program requirements are all different, typically complex, and often require extensive utility control that often undermines the value of the battery for the customer. The terms and conditions utilities place on third-party DER providers and aggregators are also complex and often place most risk on participating households.

urging households to make money by selling electricity to save money by fully meeting home energy needs.[89]

Rather than the monetizer model that sees customers as market actors and profit-maximizers, the LPN design addresses what evidence shows most people want – **lower bills and energy security**. At the network level, the LPN is an energy manager that can leverage time-of-use (TOU) pricing by utilities and engage in price arbitrage *on behalf of the LPN as a whole* if and when it chooses to.

This LPN system:

- Incentivizes maximum self-generation for self-consumption. Entities that can own and maintain solar PV plus battery systems will generally not have to purchase electricity, or can greatly minimize their purchases.
- Reduces the per-kWh costs for all participants who need electricity supplied from the reservoir, because much of the electricity input to the reservoir is supplied via the non-monetary mechanism for inputting to the reservoir by participants with solar PV plus battery systems.
- Reduces or eliminates "curtailment" of solar power by utility companies since what is now regarded as "excess" generation of no commercial value and is curtailed on the bulk power system, can instead be sent to local storage, whether at individual buildings or community-level storage systems.
- Incentivizes energy efficiency, including load shifting that is *self-determined*.

Conclusion

Although 2025 may not be a propitious time for espousing a national policy initiative on solar, it is, arguably, a strategically useful time to pilot an approach to local solar self-generation that can serve as a model to build on when the Unites States returns to an energy transition, which it surely will.

Early in the era of electric power generation, self-production of electricity was common. It was only after corporate conglomerates displaced local generation and we entered the era of centralized, commercial electricity supply that the industry was deemed a "natural monopoly" that required government regulation to attend to consumer interests. When fossil fuels are the energy source, centralized generation can be justified on thermodynamic efficiency grounds. But when solar is the energy source, centralized generation, with its requirement for long-distance transmission, is no longer justifiable thermodynamically or economically. As *The Economist* has put it,

[89] Brown, Paul (2024), "Solar power becoming standard even in UK's soggy summer; Previously the idea was to sell electricity back to the grid, now the object is to power all of a household's needs", *The Guardian*, 19 July 2024.

“Rooftop solar offers an alternative to a monopoly that can no longer be considered natural.”[90]

The current generation and supply system from which most Americans get their electricity is market-based and optimized for profit generation for corporate electricity suppliers, energy traders and other large players in the energy sector. Under this system, electricity is expensive and getting more so. Electricity is already unaffordable for many in America. 27% of U.S. households experience energy insecurity, sometimes foregoing food and medical care to keep the power on. All electricity customers are at risk for outages, which are becoming more frequent and longer, whether caused by severe weather, wildfires or the aging and decaying infrastructure of centralized generation and transmission.

It is time for a return to local generation for self-consumption – an approach that makes sense thermodynamically and that can supply non-carbon, affordable, accessible and reliable electricity to the smaller players, whether individual households, small businesses, or local or remote communities.

[90] *The Economist*, “Cheap solar power is sending electrical grids into a death spiral”, Feb. 15, 2025.

Summary

Reasons to Launch Local Power Networks

Reasons for **public policymakers**.....***to finance and support*** **LPNs**

- Expand the population who can participate in zero carbon electricity and benefit from lower costs.
- Avoid building new transmission lines.
- Eliminate conflicts over utility-scale solar and wind farms and transmission lines.
- Decarbonize more rapidly than with centralized generation and transmission.
- Provide affordable electricity for low-income households.
- Enable renters to participate in zero carbon electricity and benefit from lower cost.
- Provide more secure electricity for public services.
- Provide more secure electricity for all users during grid outages.

Reasons for **publicly-owned utilities and co-ops**.....***to set up*** **LPNs**

In addition to the reasons above --

- Reduce reliance on volatile markets and high peak prices; less expensive source of electricity
- Decarbonize more effectively and more efficiently (generation & storage are close to load)
- Avoid curtailing rooftop solar
- Supply power for public services during grid outages, e.g., cooling centers (summer) or warming centers (winter)

Reasons for **people, communities and small businesses**...***to be in*** **LPNs**

- **Energy security** - no loss of power during lengthy grid outages.
- Lower cost (relative to most IOU billing).
- **Choice and control**: decisions are made locally, by user-owners, not by remote corporations.

The **frequency** and **length** of power outages are at their highest levels since reliability tracking began in 2013. Power outages from **severe weather** have **doubled** over the past two decades, rising from 50 to 100 annually, with U.S. customers on average experiencing more than eight hours of outages in 2020.
Source: AP News, April 2022

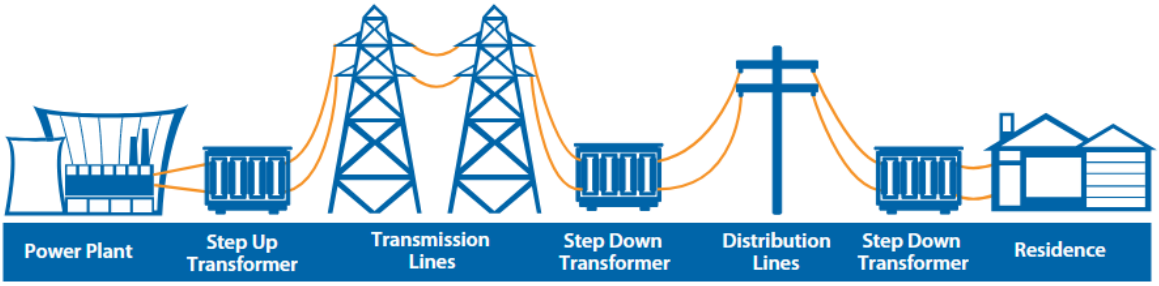
APPENDIX 1

The Bulk Electric Power System

The Bulk Electric Power System: Generation, Transmission, Distribution

The main components of the bulk Electric Power System (EPS) are generation, transmission and distribution. See Figure 1. The generation and transmission portion is also referred to as the Bulk Power System (BPS). (See “Grid Engineering Practices and Standards”, U.S. Dept of Energy.)

Figure 1. Diagram of Electricity Generation, Transmission and Distribution System



Source: National Association of Clean Air Agencies
https://www.4cleanair.org/wp-content/uploads/Documents/Chapter_10.pdf

U.S. Utilities

Investor-owned utilities (IOUs), which are large corporate entities, provide most of the electricity in the U.S. There are 177 IOUs serving 70% of U.S. electricity customers. 866 electricity cooperatives serve 14% of US customers. And over 2,000 publicly-owned utilities (municipal, state and special district) serve 16% of US electricity customers. (Source: American Public Power Assn). See Figure 2.

Figure 2. Types of Electricity Providers. U.S.

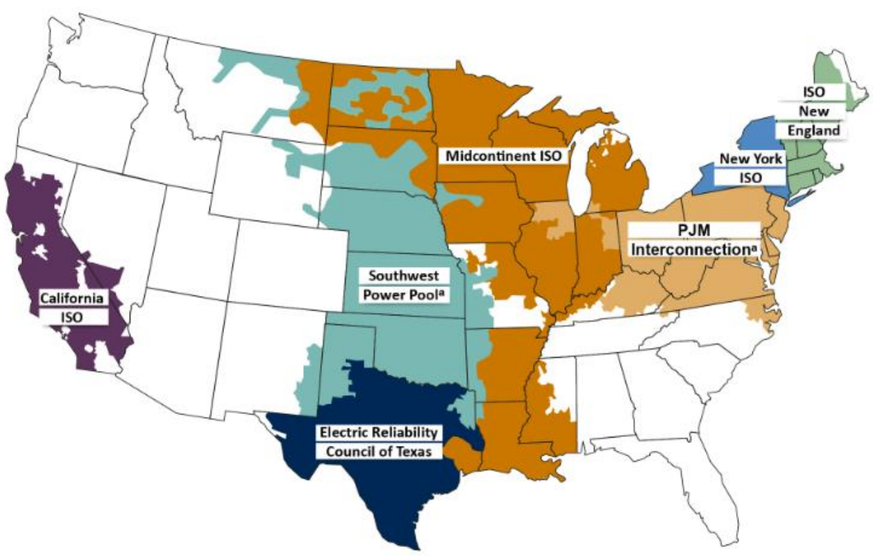
Electricity providers	#	%	# of customers	%
Publicly-owned utilities	2,003	**66%**	25,201,694	16%
Co-op's	866	**28%**	22,082,452	14%
IOU's (private corps.)	177	6%	108,247,368	**70%**
Federal Power agencies	10	0%	41,245	0%
total	3,056	100%	155,572,759	100%

Source: American Public Power Assn, 2025 Statistical Report; data for 2023

The Supply System

Electricity supply system as it exists now in this country is complicated and opaque, not least because of the structures created by "deregulation", which ultimately resulted in the creation of Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs) – grid operators. 17 states are *not* covered by the RTO/ISO structure in whole or in part; see map below. In those states, electricity generation, transmission and distribution are operated by vertically-integrated utilities. In the "deregulated" states, the functions of generation, transmission and distribution are broken up; a layer of middlemen – "power marketers" – was created, and grid operation is done by ISOs and RTOs. Utility companies still exist in all these states, and are mainly involved in the distribution of electricity to end users. In all states, regulation still applies to the private IOUs, shaping their prices and profits. These private companies receive a guaranteed rate of return on infrastructure they build and own, a regulatory regime that undercuts localized generation and local control.

Figure 4: Independent system operators and regional transmission organizations



ISO = Independent System Operator

Sources: Federal Energy Regulatory Commission; Map Resources (map). | GAO-23-105583

[a]PJM interconnection and Southwest Power Pool are Regional Transmission Organizations.

Map source:
[US Government Accountability Office, 2023].

APPENDIX 2

The Economics of Solar Energy Supply: Public Policy Implications

In the electricity supply system that now dominates in the U.S., in which the majority of customers are serviced by investor-owned-utilities (IOUs), all costs are paid for by ratepayers and taxpayers. Equity investors and debt holders *increase* their wealth, as do energy traders. The profits received by investors are at a guaranteed rate of return set under the current regulatory framework[91] and paid by ratepayers. The fact that ratepayers bear the cost of the electricity system is, in itself, not remarkable or untoward: electricity supply is a service that must be paid for. But from other perspectives, the present financing system is deeply flawed in terms of both economics and physics, and it is disadvantageous for small end users, like households and small businesses.

First, given that electricity in most states is supplied through a monopoly system[92], customers lack choice (despite "community choice aggregators"[93] in some states). Second, generation is not located close to load, since, for most users, electricity is generated centrally and transmitted over substantial distances – an arrangement that is inefficient both financially and in terms of energy loss. Further, solar energy is an abundant, non-scarce, non-depletable resource, yet access to it is gated by the market actors controlling the existing electric power system. This financial system, which is designed to optimize for profits to investors, developers, marketers and operators, limits and even denies access to solar energy to the small, individual ratepayer. To be sure, public electricity suppliers may sometimes behave like profit-driven companies and impede access to renewables or local solar, TVA being an example.[94]

[91] Under the current regulatory framework, investor-owned utilities earn profits by building and owning infrastructural assets.

[92] Monopoly power exists even in so-called "deregulated" states. Texas has "competitive" electricity suppliers, but customers cannot easily choose to self-generate.

[93] Community Choice Aggregators (CCAs) aggregate electricity demand and then purchase electricity to meet that demand and sell it to end users. They are not organized to prioritize the ability of electricity users to self-generate, e.g., through rooftop solar. Thus, they do not offer "choice" in that sense. CCAs exist in 10 states in service areas covered by IOUs; they are non-profit organizations created under state and local laws. It is conceivable that their authorizing legislation could be revamped to help support local self-generation. However, instead, current planning sees CCAs as vehicles to organize and deliver "grid services. E.g., the US Energy Dept., in discussing rooftop solar and community solar, suggests that a virtual power plant (VPP) could "provide additional revenue streams for VPP owners and operators"; U.S. Dept. of Energy "Pathways to Commercial Liftoff: Virtual Power Plants" Sept 2023; pg 61.

[94] Tabor, Nick (2024), "The TVA helped electrify the South — but now its plans are sparking backlash", *Washington Post*, Sept. 9 2024.

Due to the capital intensiveness of creating electricity infrastructure, and in order to make electricity affordable to all, some observers argue that the state should provide electrical infrastructure. [95] Given the increasing impetus for decentralization of generation and storage, this argument would apply to the building of infrastructure for local solar networks.

However, the "distributed energy resources" (DER) approaches being devised and rolled out in the U.S. are, like the legacy electricity system, based on commercial profit-generation. Leading government entities, such as the U.S. Dept. of Energy and the regional labs it funds (e.g., National Renewable Energy Laboratory, NREL), assume profit-seeking as integral to system design. See for example, "Pathways to Commercial Liftoff: Virtual Power Plants" and "Innovative Grid Deployment; Pathways to Commercial Liftoff". A spate of reports on the electricity system transition and the DER strategy by leading energy consulting firms also use profit generation and market penetration as fulcrums for their analyses, identifying, for example "monetization pathways" for a DER strategy.[96]

Both mainstream economics and the majority of the U.S. energy supply system rely on the idea that markets are the optimal method to allocate resources, which, in neoclassical economics, are assumed to be scarce. However, unlike fossil fuels, solar energy is not a scarce resource; it is abundant[97] and non-depletable. What *is* scarce is the ability to access this energy source, access that is currently gated by a market system. Although 94% of electric utilities in the US are not-for-profit (publicly owned or co-op), 70% of U.S. customers are serviced by for-profit corporations (IOUs). See Figure 2, Appendix 1. Thus, the vast majority of U.S. customers get their electricity from a system that is designed to optimize for profit generation for investors, developers and operators.

The physical properties of solar and wind as primary energy sources can revolutionize electricity access. With solar and wind, once the infrastructure to utilize it is in place, the cost of generation approaches zero because the "fuel" does not have to be purchased. In contrast, with fossil fuels, even when the electricity generation and delivery infrastructure is in place, there is perpetually a cost to obtain, transport and utilize the fuel.

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[95] Pirani, Simon (2021), "How energy was commodified, and how it could be decommodified"; Durham University, Working Paper.

[96] *Real Reliability: The Value of Virtual Power* by The Brattle Group, prepared for Google, 2023; Wood Mackenzie (2023), "North America virtual power plant (VPP) market"; 23 Feb. 2023.

[97] "Solar energy is the most abundant energy resource on earth - 173,000 terawatts of solar energy strikes the Earth continuously. That's more than 10,000 times the world's total energy use;" NOAA.

More solar energy hits the earth in *one hour* than is needed to supply the world for *one year*; Univ of Calif., Davis.

These properties mean that whereas a market system might be suitable for fossil-fueled electricity supply, the dynamics of a market system can be unsuitable and even counter-productive when the energy source is free and abundant. For example, in U.S. regions where solar is a significant share of supply, there have been frequent instances of "excess generation" when solar production is at its peak and solar power is "curtailed". With no market value, production of electricity is impeded or the product is in effect discarded. In part, curtailment is due to an inadequate grid that is unable to handle, export or store the power, but the fundamental problem is pricing dynamics. At times of "oversupply" the energy produced has zero value, and sometimes even negative value in the market system that now controls electricity supply for most people in the U.S.

The marginal cost of electricity produced from wind and solar is near-zero,[98] and in competitive markets, prices will tend toward marginal production costs[99]. As Pollard and Buckley[100] point out, "Renewables are deflationary…" While the deflationary impact of renewables would be a positive for customers, it is a negative for a market-organized electricity supply system, undercutting the profit expectations of electricity producers, bulk system traders and oil and gas suppliers to conventional power plants. What is needed is an electricity supply system, like Local Power Networks, that is non-market organized and not profit-driven, whose design is, rather, optimized to meet human needs.

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[98] Pollard, Matt and Tim Buckley (2024), "Queensland's Energy Transformation: From Coal Colossus to Renewable Energy Superpower;" *Climate and Energy Finance*.

[99] Economists letter to U.S. Sen. Christopher van Hollen Oct. 26, 2021 on the "Polluters Pay Climate Fund Act" legislation introduced in Aug. 2021.

[100] Pollard, Matt and Tim Buckley (2024), "Queensland's Energy Transformation: From Coal Colossus to Renewable Energy Superpower;" *Climate and Energy Finance*.

APPENDIX 3

Financing Infrastructure Creation Long-Term

Transforming the electricity supply system requires up-front capital investment that must be enabled by public financing. Private capital alone, with its requirement for profit maximization, cannot produce a system that will supply electricity that is affordable by all, is locally reliable and maximally decarbonized.

Public financing

Much of the *current* energy system is already publicly financed or subsidized. Huge existing subsidies for fossil fuels,[101] which are the fuel source for most electricity generation in the U.S., need to be redirected toward local, renewable generation and storage. New, focused, public financing is also required. In terms of debt capital, public financing is almost always less costly and offers better value than private capital because public finance rates are normally lower and transactions costs are less; see the study by Hall and Nguyen, 2018.

Long-term *public financing*

Redirect existing fossil fuel subsidies

U.S. government subsidies for fossil fuels are estimated at around $20 billion annually. There are additional billions in subsidies for "carbon capture and storage", which is primarily used to subsidize fossil fuel operations – $23.7 billion as of 2022[102] plus tens of billions of dollars annually[103] in carbon capture and storage tax credits. These subsidies should be curtailed and the funding redirected to support local solar infrastructure creation. This requires federal legislation and so is a long-term objective whose achievement requires overcoming the power and legislative influence of fossil fuel interests. Though difficult to accomplish, nevertheless, it is important to target, and redirect, this source of funding.

[101] The worldwide fossil fuel industry receives $1.3 trillion in *explicit* subsidies annually according to the International Monetary Fund 2023. The U.S. government provides an estimated $20 billion annually according to the Senate Budget Committee 2023.

[102] Sekera et al. (2023), Carbon dioxide removal–What's worth doing? A biophysical and public need perspective; *PLOS Climate* 14 Feb 2023.

[103] Walsh J, Hart P., Will the Manchin Climate Bill Reduce Climate Pollution? Food and Water Watch. 2022 Aug 10. Available from: https://www.foodandwaterwatch.org/2022/08/10/will-the-manchin-climate-bill-reduce-climate-pollution/

Focus Federal supports for solar on creating local generation and storage

Many of the previously-enacted tax credits, grants and loan programs for renewable energy (e.g., under the Inflation Reduction Act - IRA) were created to help finance the purchase and installation of local solar PV systems and battery storage systems. A major support was the 30% tax credit for residential rooftop solar. Almost all of these financial supports for local solar and storage are being eliminated by legislation enacted in July 2025. Some funding may remain. The Rural Utilities Service (RUS) program (formerly Rural Electrification Act (REA) and the Rural Energy for America Program (REAP) are still operating, albeit at a scaled-back level. Funding under the "Solar for All" program, authorized at $7 billion, was distributed to states, tribal governments, municipalities and nonprofits across the U.S. in 2024-25, but it is unclear how much, if any, of that funding will be rescinded under the July 2025 legislation.

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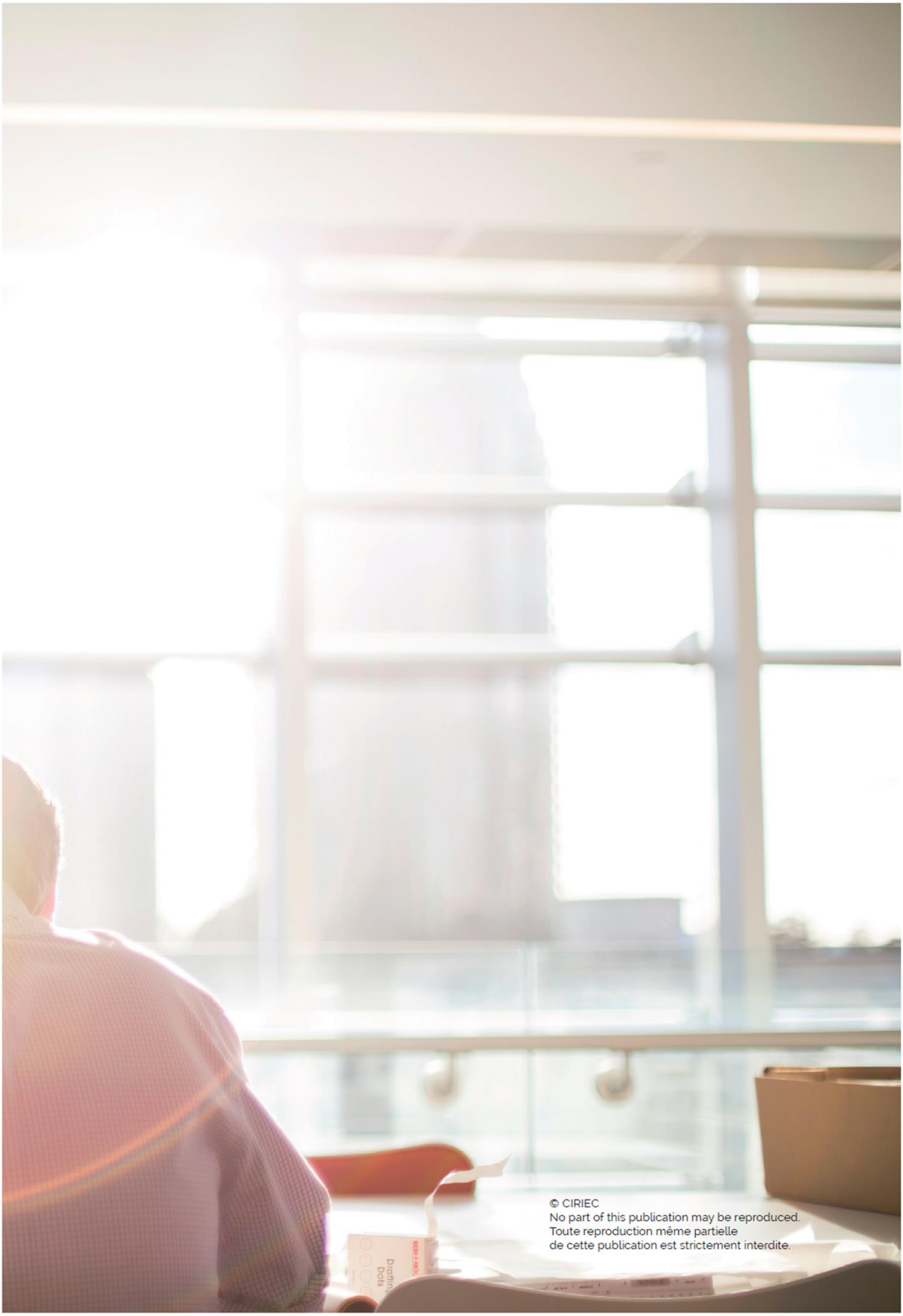

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