IMPAX Asset Management

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The transition will not be televised

Part 3 – How technology is disrupting energy consumption

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IMPAX Asset Management

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“Technology is moving faster than policy, enabling consumer choices that will upend the future of energy.”

Executive summary

- Energy consumers, from industry to households, have an important but often underappreciated role in setting the pace and direction of an energy transition in the US. A potential re-ordering of the relationship between energy producers and consumers presents numerous opportunities for equipment suppliers, infrastructure providers and new market entrants.

- Technological advances are enabling consumers to take charge of their energy use. Early adopters are demonstrating the bottom-line benefits of wrestling control away from incumbent energy producers. The most proactive players are doing away with their monthly bills altogether.

- With this push from consumers, the US energy system could shift rapidly towards higher rates of efficiency, electrification and independence from fossil fuels. But the potential won’t be realized without substantial hardware and software upgrades to US power networks.

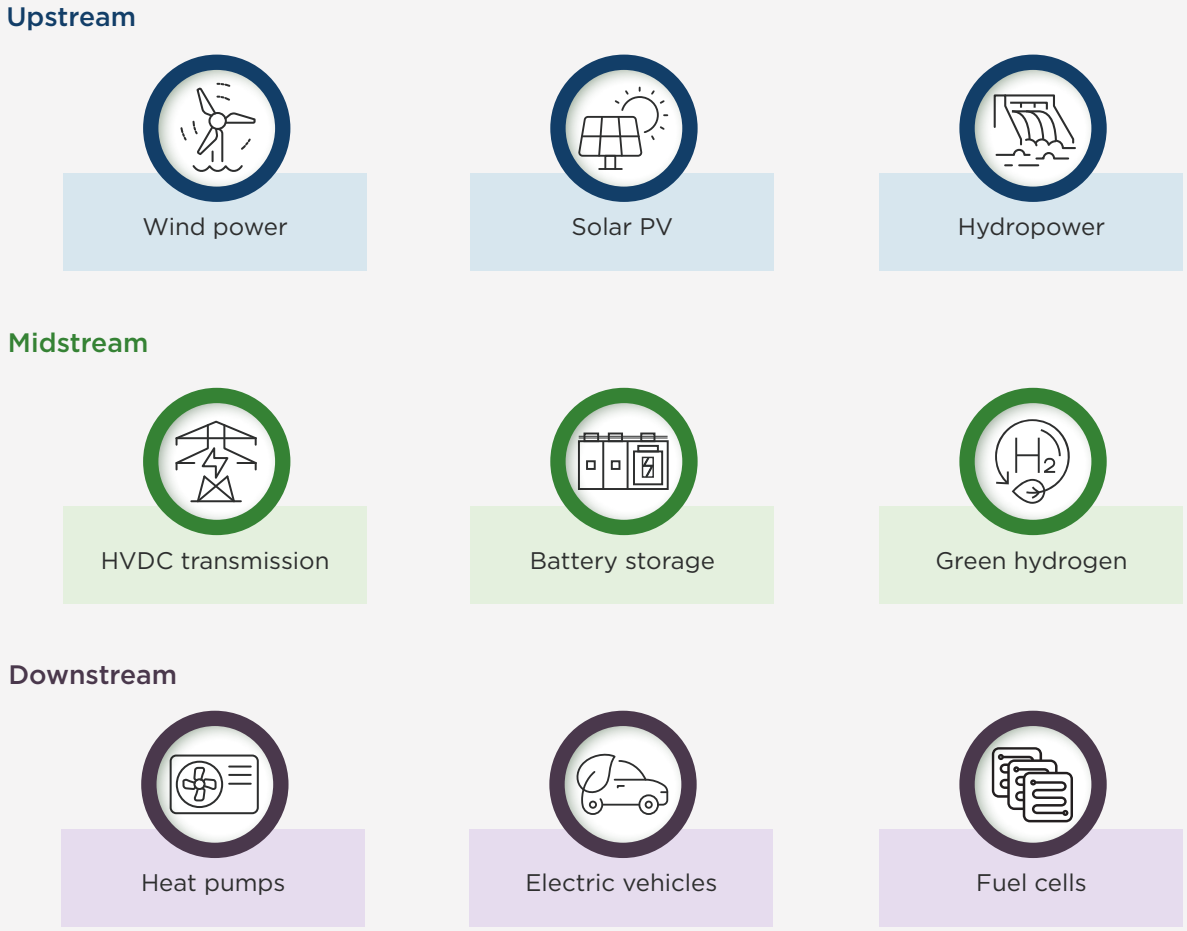
- Facing the loss of some of their best customers, some electric utilities have sought to curtail consumers’ freedom to invest in their own sources of clean energy. Regional and state agencies should resist their pressure to restrict the higher levels that distributed generation enables. Consumers can be an important catalyst for innovation – if regulators let them.

Introduction

This is the third in a three-part series on key themes in the US energy transition. In Part 1, we focused on changes in the 'upstream' portion of the clean electricity value chain, exploring the potential for technologies like wind and solar to accelerate their existing growth rates. In Part 2, we unpicked the emerging 'midstream' in clean power that's using storage and hydrogen technologies to make renewables more flexible and reliable. Here in Part 3, we look at how energy users in the 'downstream' segment (industrial, commercial and residential customers) are changing the way they buy and use energy.

As described in Parts 1 and 2, we see clean electricity becoming the new backbone of the global energy system because electrification offers the most direct route to a cheaper, cleaner and safer energy system. We also noted that the challenges associated with building enough new power stations to meet the enormous potential demand for green electrons (including not just the replacement of coal-fired power, but also growth in demand for hydrogen and increased cooling loads). Shifting from hydrocarbons to electrons as the world's primary energy carrier will entail trillions of dollars of new investment. The switch is creating new value chains in the global energy system, which presents both significant opportunities and risks for investors.

Figure 1: Technologies in the clean energy transition: upstream, midstream and downstream



We describe in this paper how falling technology costs and accelerating government policies are creating new opportunities for companies at the cutting edge of shifts in US energy demand. Technological advances are breaking down conventional distinctions between producers and consumers. And while consumers are often referred to as a single entity, they are in fact a diverse bunch. Our discussion considers recent trends in three segments, as shown in the figure below.[1]

Residential demand	Commercial demand	Industrial demand
Energy used for heating, air conditioning, cooking, water heating and other residential uses by single and multi-family dwellings, apartments and mobile homes.	Business facilities, government offices and buildings associated with other professional, religious and social activities that use energy for activities like computing, space heating, water heating, air conditioning, lighting, refrigeration and cooking.	Facilities and heavy equipment used for producing, processing, or assembling goods. The industrial sector encompasses all forms of manufacturing, agriculture, mining (including oil and gas extraction), refining and construction. Energy use in this sector is dominated by process heat and cooling, powering machinery and manufactured products.

Why should investors care about these distinctions? Because for the first time in modern history, energy consumers are gaining the ability to become energy producers. Yet the technologies facilitating those changes are often unique to each segment. To understand the new prospects for growth in energy demand, one has to understand a bit about the differences between them.

In a distributed energy system, households and companies have the ability to generate their own energy supplies. Just think: how different would the oil embargo of the 1970s have been if consumers could have made their own gasoline? That is, in effect, what many of the world's largest technology companies are doing today by building on-site renewables and bypassing their utilities. They are spearheading a set of changes in the US energy system that will – if regulations allow – foster a transfer of power from producers to consumers.

1 Our categorization follows the conventions of the US Energy Information Administration. While transportation can be viewed as its own segment of demand, for the purposes of this paper it to be a subset of residential and commercial.

Drivers for shifts in US energy consumption

The US electric grid was originally built to connect large coal, natural gas and nuclear power stations to consumers in every part of the US. The move towards renewables, like wind and solar, entails a shift towards smaller power stations that operate intermittently. Optimizing these new sources of supply will require rapid evolution in how US power grids operate. We see shifts downstream being shaped by three economic drivers: commodity pricing, government incentives and consumer expectations. We describe each in turn below.

Commodity pricing

The prevailing cost of electricity, relative to natural gas, gasoline or heating oil, has the clearest influence on whether consumers switch from fossil fuels. In the residential segment, most people use fossil fuels because they have historically been cheaper than electricity. That said, only a fraction of the rate households pay to their utility goes toward the costs of generating electric power. The rest is a stack of transmission and distribution costs, taxes, and consumer service charges.

In Figure 2 below, we compare the prevailing cost of natural gas, gasoline and electricity for retail consumers, taking averages from the states of Massachusetts, Texas and Washington as examples.

For the vast majority of households in the US, electricity is more expensive than gasoline or natural gas, per unit of energy. Washington is amongst a small group of outliers with cheap electricity (mostly from large hydropower) and relatively high gasoline taxes. But, as we will see in the next section, the nexus between renewable power and electric vehicles is altering the equation across the US.

Figure 2: Energy prices for residential consumers as at June 2023

	Price to consumer	Price per megajoule (MJ) of energy	% of retail electricity price
MASSACHUSETTS			
Electricity	$0.29/kWh	$0.08	N/A
Natural gas	$20.05/thousand cubic feet	$0.02	27%
Gasoline (petrol)	$3.50/gallon	$0.03	36%
TEXAS			
Electricity	$0.10/kWh	$0.03	N/A
Natural gas	$19.87/thousand cubic feet	$0.02	81%
Gasoline (petrol)	$3.11/gallon	$0.03	95%
WASHINGTON			
Electricity	$0.09/kWh	$0.03	N/A
Natural gas	$25.32/thousand cubic feet	$0.02	75%
Gasoline (petrol)	$4.73/gallon	$0.04	156%

Source: Energy Information Administration, June 2023. These states are included as representative examples to illustrate the disparity in relative energy prices for residential consumers across the US.

Government incentives

Nearly a year after its enactment, investors are still getting to grips with the enormous impact of the Inflation Reduction Act (IRA). While it's impossible to precisely gauge the total level of combined government spending that will be directed towards clean energy, federal spending under the IRA is poised to be much higher than the US$360 billion that was initially envisioned. Higher than expected uptake has led prominent analysts to forecast more than US$1 trillion of tax credits to be taken up by the private sector over the next nine years.[2]

But it's not just federal spending that matters. State and local policies will have an enormous influence on whether it's profitable (or indeed, feasible) for consumers to reduce the impact of their energy use. Complementary incentives, like those in New Jersey, offer significant rebates for residents installing – and eventually recycling – efficient heating, ventilation and air conditioning (HVAC) systems and electrical appliances.[3] States like Texas offer cash incentives to low-income households for weatherproofing.[4]

Government incentives, both big and small, are clear determinants of whether consumers invest in reducing energy demand. What's more difficult to diagnose is how the social and political winds behind those incentives shape consumers' long-term beliefs about what the future has in store.

Consumer expectations

The final piece of our puzzle is consumers themselves. Advances in behavioral approaches to the field of economics have taught us that how consumers think about the future is often an overlooked element of why they do what they do. Whether it's heat pumps in the home or electric arc furnaces in a steel mill, anticipating the financial return on these investments may seem like a simple matter of dollars and cents. In reality, it's a complex and highly subjective process.

Even more sophisticated industrial customers struggle to forecast important elements of a 20-year decision. What will be the cost of oil a decade from now? What are the prospects for higher carbon taxes in the next political cycle? Will equipment costs increase or decrease next year?

Residential consumers are famously risk-averse when it comes to making investments in energy efficiency measures.[5] Large commercial energy users such as Amazon, on the other hand, have moved aggressively to invest in renewable power projects as a hedge against energy price volatility. There is no single mental model for the motivations and beliefs held by consumers. Patterns of technology adoption vary as a result.

Residential consumers are famously risk-averse when it comes to making investments in energy efficiency measures.

2 Della Vigna, M.; Bocharnikova, Y., et al (Goldman Sachs), 2023: Carbonomics: The Third American Energy Revolution.
3 Montclair State University Clean Energy and Sustainability Analytics Center as at 18 August 2023: Clean Energy Programs and Incentives
4 Quick Electricity, 28 January 2023: Oncor Energy Efficiency Incentives
5 Hassett, K.A., and Metcalf, G.E., 1993: Energy conservation investment: Do consumers discount the future correctly? *Energy Policy*. This seminal study argued that high discount rates implied by observed household decisions regarding energy conservation measures are rational responses to future uncertainty.

How consumer behavior is shifting

Based on publicly announced national policies, 92% of global GDP is now covered by some form of net-zero commitment.[6] While target-setting can be an important precursor to action, investments made at the firm or household level are most responsive to asset-specific costs and benefits. As debate continues about whether companies will meet these targets, the more compelling question for investors is how they'll seek to get there. We see residential, commercial and industrial demand evolving in three areas: energy efficiency, process electrification and clean power purchasing.

Energy efficiency

Nearly a half century ago, Amory Lovins coined the term "negawatt" to describe the idea that the cheapest unit of energy is the one you don't use.[7] While the costs and benefits of energy efficiency are plain to see, consumers have historically been slow to adopt technologies that save them energy and money. In the residential and commercial segments, the question over who pays and who benefits (the landlord-tenant problem) is a recurring obstacle.

So what's changed? On one hand, not much. US energy consumption per unit of GDP steadily declined over the past three decades, but progress has stalled in recent years.[8] While some have suggested that the low-hanging fruit is gone, another possibility is that we've only begun to see the technological breakthroughs needed for another step-change in performance. Not just more efficient vehicles, appliances and machinery – but radically more efficient ones. Anyone who's bought a lightbulb recently will know that LED lighting is a case in point.[9]

Technological changes within the power distribution system also present big opportunities for efficiency gains.[10] The grid can be made more flexible through both hardware and software upgrades. Hardware fixes include batteries and network reinforcements. Software solutions include dynamic pricing and demand side management. Generative AI has an important role to play in anticipating the fluctuations from new sources of supply and demand.

Electrification

How relevant is the mantra of "electrify everything" to the rest of energy consumption?[11] Quite relevant, it turns out. According to the American Council for an Energy Efficient Economy, the US could electrify about 90% of its current energy use.[12] Cars, compressors and cooling units are just some of the new applications for electricity in residential, commercial and industrial settings.

But to make the switch, the US must bolster the resilience and efficiency of its electrical grids. While it's been transformative in other areas, the IRA does little to support the funding needs for new transmission and distribution lines, transformers and network communications equipment. Better cooperation between regulators at the state, regional and federal levels is urgently needed to establish incentives for the private sector to participate in the build out of smarter and more interconnected networks. Key actors here include state public utility commissions (PUCs), regional transmission organizations (RTOs) and federal agencies like the Federal Energy Regulatory Commission (FERC).

Although electrified equipment tends to be more efficient (because less energy is lost in the form of non-directed heat), pollution won't go down substantially if electricity is generated from fossil fuels like coal. That's why some of the biggest corporations in America are not only moving to use more electricity, but also to acquire their own supplies of renewable power.

6 Net Zero Tracker, 2023: Net Zero Stocktake
7 Foreign Affairs, 1 October 1976: Energy Strategy: The Road Not Taken
8 Statista, 19 July 2023: U.S. energy consumption per Real Dollar of GDP 1975-2022
9 Superior cost and performance of LED light bulbs led to a spectacular increase in their use in US households, rising from 4% to 47% in the space of just five years. https://www.eia.gov/todayinenergy/detail.php?id=51858
10 Superconductive cables are just one example. See Yahoo Finance, 14 August 2023: Prysmian's E3X Technology Added to Transmission Lines Across Northeast, Linking to a More Sustainable and Reliable Future
11 For a useful primer on "electrify everything", which has become an important element of decarbonization efforts around the world, please see https://www.vox.com/2016/9/19/12938086/electrify-everything
12 ACEEE, August 2023. *The United States Can Electrify Most Fossil Fuel Use: Here Is What Needs to Happen to Make This Possible*

Direct power purchasing

Corporations in the US bought more clean power than ever before in 2022, despite higher prices for corporate power purchase agreements (PPAs - see page 13).[13] Companies like Amazon have gone beyond buying electricity through bilateral contracts and are now investing in their own solar and wind generation projects.[14] All told, companies contracted nearly 20 gigawatts (GW) of clean energy capacity in 2022, 4 GW higher than any previous year.[15] Once operational, those facilities will power the equivalent of over 1,000 data centers, or 18 million American homes.[16]

Commercial buildings consume a staggering 40% of US energy, and have historically drawn electricity in one direction, from the grid.[17] Companies supplying their own needs through on-site generation, green power contracts, and third-party ownership will therefore enjoy the benefits of more stable input costs over time.

13 The American Clean Power Association, 18 January 2023: Clean Energy Powers American Business
Utility Dive, 18 April 2023: Renewable energy PPA prices continue to rise despite Inflation Reduction Act relief: LevelTen
14 Amazon, 31 January 2023: Amazon sets a new record for the most renewable energy purchased in a single year
15 The American Clean Power Association, 2022: Clean Energy Powers American Business Report
16 The American Clean Power Association, 2022: Clean Energy Powers American Business Report
17 Climate Tech VC, 2 December 2022: Buildings as Power Plants

Disruption in the real economy

Energy consumers in the US have a new opportunity to change the way they interact with the grid, and one another. Distributed generation (such as that enabled by rooftop solar PV) is 'in the money' for nearly all energy customers today. In fact, the potential savings are so great that states have scrambled to revise their net metering arrangements (the rules that govern how homeowners can sell excess generated power back to the grid), often under pressure from the utilities they regulate.[18] That's because for most incumbents, rooftop solar is not green and good – it's highly disruptive to their traditional business model.

Distributed generation enables customers to substantially reduce what they take from the grid. The first to take up that option are often those that utilities can least afford to lose: high-income ratepayers. Facing the loss of some of their best customers, utilities across the US have sought to curtail consumers' freedom to invest in their own sources of clean energy. Regional and state agencies must resist their pressure to limit the enhanced levels of market competition that distributed generation enables. Consumers can be a catalyst for innovation, but only if regulators let them.

Yet rooftop PV is just one of the more visible examples for changes that are underway with respect to consumption. As we describe in additional examples below, the drivers of commodity prices, government incentives and consumer expectations are, to varying degrees, shaping a range of new consumer activity. We highlight some of the more noteworthy developments within the residential, commercial and industrial segments.

18 Solar Energy Industries Association, as at 28 August 2023: Net Metering

Residential

‘Virtual power plants’

Coupling solar PV with advanced batteries and smart appliances not only offers homeowners a way to generate their own power when the sun shines, but also to become part of their own electric utility. Bundling together hundreds, or even thousands, of homes creates networks known as virtual power plants (VPPs) that can serve to increase the quantity and frequency of power generation, thereby recreating the reliability of the grid with less of the cost. They are becoming increasingly popular as renewable energy developers look to circumnavigate growing wait times for interconnecting large, utility-scale projects.[19]

Heat pumps

The IRA offers a 30% tax credit to install a residential heat pump, regardless of income levels or location. That’s made the financial return for homeowners on this investment better than ever. In 2022, heat pumps surpassed gas and oil furnaces in sales for the first time, and the trend has continued into 2023.[20] Heat pump manufacturers continue to see historical order book backlogs as demand continues to grow.[21] The reason is simple: heat pumps produce three to four times more in heat energy than they consume in electricity.[22]

How our examples reflect the trends

Residential	VPPs	Heat pumps
Energy efficiency		✓
Clean power purchasing	✓	
Electrification		✓

19 Utility Dive, 17 August 2023: Virtual power plants: Resource adequacy without interconnection delays
20 Air-Conditioning, Heating, and Refrigeration Institute, 11 August 2023: AHRI Releases June 2023 U.S. Heating and Cooling Equipment Shipment Data
21 Trane Technologies, 2 August 2023: Trane Technologies Reports Strong Results and Raises 2023 Revenue and EPS Guidance
The Washington Post, 17 May 2023: Who Wants to Become a Heat-Pump Billionaire?
22 US Department of Energy as at 25 August 2023: Air-Source Heat Pumps (Energy Saver)

Commercial

‘Smart’ buildings

Global funding for startups that outfit buildings with ‘smart’ technology to improve their energy efficiency has boomed in the past two years, reaching $5.9bn in 2022.[23] In a commercial real estate market with rising vacancy rates, buildings that better insulate tenants from volatile energy costs have a competitive advantage. In a recent report, 63% of agents and brokers said they found value in promoting energy efficiency in their listings. Almost half (48%) stated that tenants were interested in sustainability and nearly one-third (32%) were “concerned about the effects of climate change events on the real estate market”.[24]

Local laws in many jurisdictions require new and existing buildings to get efficiency ratings every year. In New York City, buildings that do not meet efficiency standards are fined – a proverbial ‘stick’ to complement the ‘carrots’ that are driving change.

Electric vehicle fleets

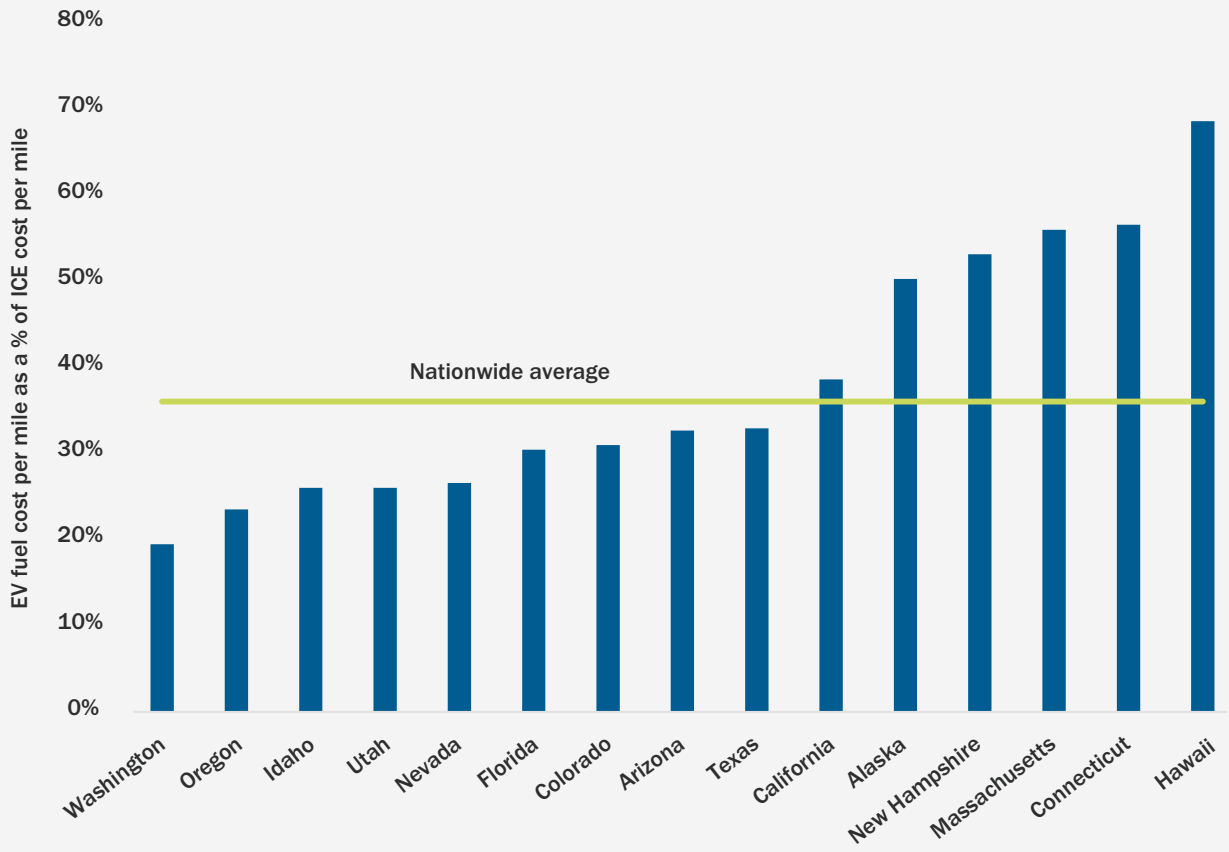
It’s less expensive to power a car with electricity than with gasoline thanks to the supreme efficiency of electric motors. Our ‘EVICE metric’ measures the fuel cost per mile travelled for electric vehicles (EVs) as a percentage of the cost for internal combustion engines (ICEs). As shown in Figure 3, it costs less per mile to move an EV than an ICE vehicle in every US state.[25] In some, it’s shockingly cheaper. The main obstacle is now charging infrastructure.

Incentives like the US$7,500 rebate provided by the IRA (and state-level rebates in places like Colorado for up to US$8,000 more) have substantially reduced the cost of EV acquisition. Companies running large delivery fleets have been amongst the first to notice. Amazon, for example, is set to deploy 100,000 electric delivery vehicles by 2030.

23 Memoori Research AB, 2022: Funding for Smart Building Startups Reached $5.9 Billion in 2022
24 National Association of Realtors, 3 May 2023: Majority of Agents, Brokers Find Value in Promoting Energy Efficiency in Listings, According to NAR Report
25 Our model assumes 3 miles/kWh for electric vehicles and 30 miles per gallon for gasoline vehicles.

Figure 3: Getting from A to B: it's cheaper in an EV

EV cost as a percentage of gasoline vehicle cost per mile travelled for selected US states



Source: Impax analysis based on data from ElectricChoice.com and AAA, August 2023. These states are included as representative examples to illustrate the breadth of relative costs across the US. For the full dataset, including all states, please see the Appendix.

How our examples reflect the trends

Commercial	Smart buildings	EVs
Energy efficiency	✓	✓
Clean power purchasing		
Electrification	✓	✓

Industrial demand

Electric boilers and smelters

Over the lifetimes of the most common industrial equipment, like boilers and furnaces, the cost of fuel is more than 10 times the initial capital investment. For medium- and high-temperature heat applications, the financial attractiveness of electrification heavily depends on the energy cost differential. Some estimates state that the transition to electric boilers could result in a US$2.5 trillion saving to industry.[26] Use cases for this technology can be found in an increasingly broad range of enterprises including stadiums, airports and office buildings.

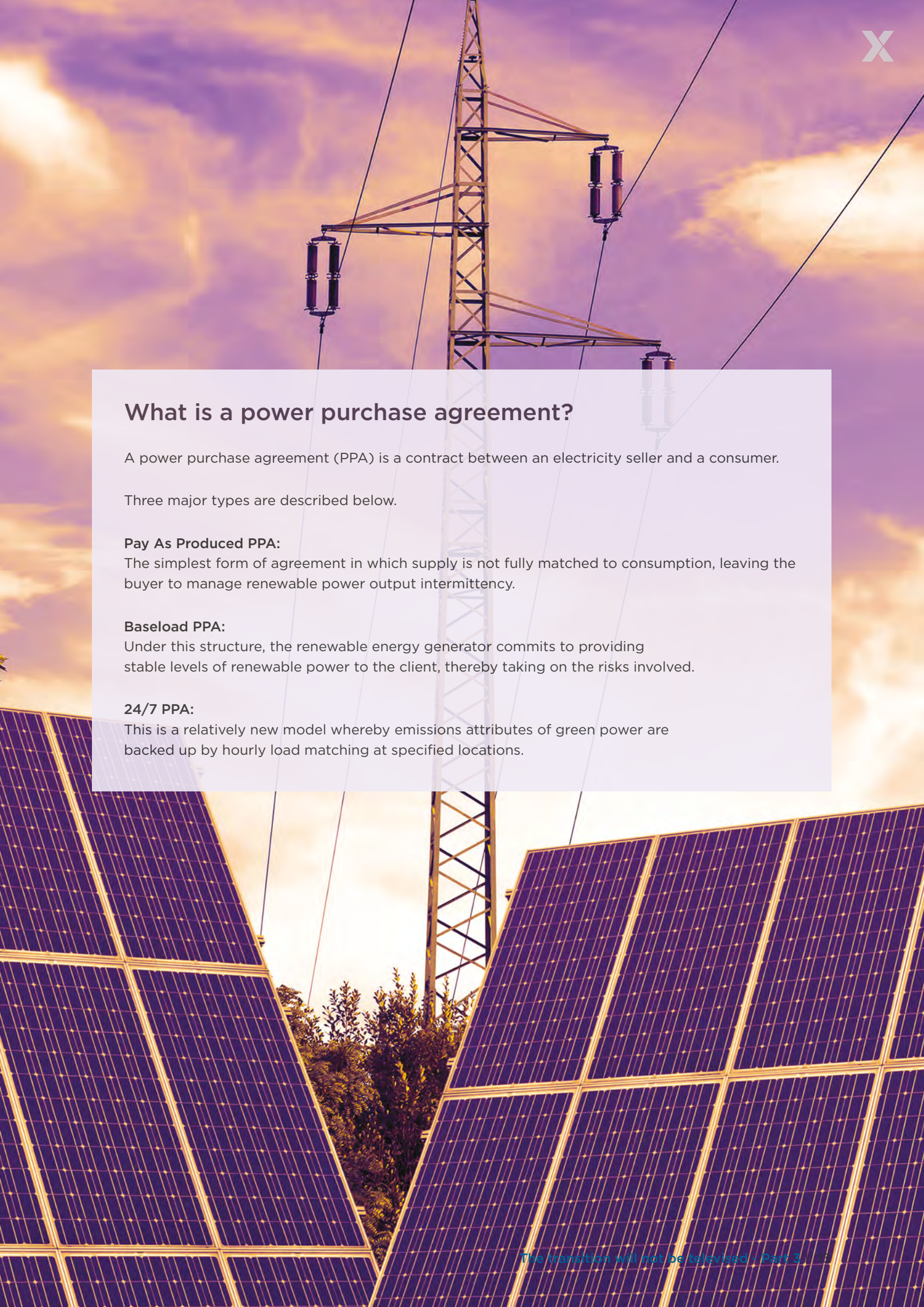
‘Energy as a service’

‘As-a-service’ models for clean energy generation are run by energy services companies that install, manage and maintain equipment under an energy performance contract. They allow customers to pay for performance (in the form of increased efficiency) rather than requiring high upfront capital expenditures. Caterpillar, a multinational that makes and services construction equipment and power systems, has installed solar arrays for customers who’ve chosen these ownership structures. One such project was a solution for a Caterpillar dealer in Southern California with one of the largest repair and sales hubs in the US. The project is projected to save the dealership over US$2 million in electricity bills over 25 years and protect it from future rate increases, while offsetting about 560 metric tons of CO_2 annually.[27]

How our examples reflect the trends

Industrial	Electric boilers	‘Energy as a service’
Energy efficiency	✓	✓
Clean power purchasing		✓
Electrification	✓	✓

26 Sustainable Energy & Environmental Systems, Berkeley Lab (US DOE), November 2021: Electrification of Boilers in U.S. Manufacturing
27 Caterpillar as at 22 August 2023: Solar Power System Delivers Energy Savings to Hawthorne Cat



What is a power purchase agreement?

A power purchase agreement (PPA) is a contract between an electricity seller and a consumer.

Three major types are described below.

Pay As Produced PPA:
The simplest form of agreement in which supply is not fully matched to consumption, leaving the buyer to manage renewable power output intermittency.

Baseload PPA:
Under this structure, the renewable energy generator commits to providing stable levels of renewable power to the client, thereby taking on the risks involved.

24/7 PPA:
This is a relatively new model whereby emissions attributes of green power are backed up by hourly load matching at specified locations.

Harnessing the opportunity

Consumers have often been overlooked in the drive towards net-zero greenhouse gas emissions, perhaps because they've never had much in the way of choice. We see that historical trend set to change with electrification, energy efficiency and direct purchasing helping energy buyers to move into the driver's seat. Economic drivers like commodity prices, government incentives and their own beliefs about the future will accelerate or put a brake on these changes underway.

Technology can enable consumers to shape a cleaner, more electrified US economy, while potentially making America more economically resilient. The scale of the US energy transition means vast opportunities for companies whose products and services enable the switch to clean power. And while government stimulus like the IRA has combined with economies of scale to make key energy technologies cheaper, regulators must not forget the benefits of setting minimum standards. From heavy trucks to leaf blowers, there remains a public health imperative to phasing out the worst polluting technologies.

More work lies ahead for governments and the private sector in realizing a safer, more affordable energy system. With electricity market deregulation having mostly stalled over the past two decades, retail choice has been off the agenda in most US states. While enacting permitting reform, modernizing the electricity grid and establishing domestic supply chains have rightly taken center stage in policy debates, there remains an opportunity to re-imagine the future of energy. Technology makes it possible. Policymakers and regulators should let it happen.

Appendix

EV as percentage of ICE cost per mile travelled, by US state and region[28]

Northeast	48.3%
Connecticut	56.6%
Maine	42.3%
Massachusetts	56.0%
New Hampshire	53.2%
New Jersey	42.1%
New York	49.3%
Pennsylvania	36.8%
Rhode Island	49.5%
Vermont	48.6%

South	32.4%
Alabama	36.2%
Arkansas	28.7%
Delaware	32.4%
District of Columbia	32.9%
Florida	30.5%
Georgia	33.7%
Kentucky	29.9%
Louisiana	27.3%
Maryland	36.7%
Mississippi	34.8%
North Carolina	31.2%
Oklahoma	29.7%
South Carolina	37.0%
Tennessee	31.5%
Texas	32.9%
Virginia	33.8%
West Virginia	32.3%

Midwest	34.4%
Illinois	30.2%
Indiana	32.2%
Iowa	36.6%
Kansas	31.5%
Michigan	41.0%
Minnesota	37.1%
Missouri	36.6%
Nebraska	30.5%
North Dakota	31.9%
Ohio	34.7%
South Dakota	32.8%
Wisconsin	38.2%

West	33.8%
Alaska	50.3%
Arizona	32.7%
California	38.6%
Colorado	31.0%
Hawaii	68.6%
Idaho	26.0%
Montana	29.6%
Nevada	26.6%
New Mexico	35.8%
Oregon	23.5%
Utah	26.0%
Washington	19.5%
Wyoming	31.2%
Nationwide average	**36.0%**

28 Figure 3, these numbers are based on Impax analysis based on data from ElectricChoice.com and AAA, August 2023. Regional numbers reflect averages of all states in the region, based on census designations.

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