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Future of Grid-Tied PV Business Models: What Will Happen When PV Penetration on the Distribution Grid is Significant?

Preprint

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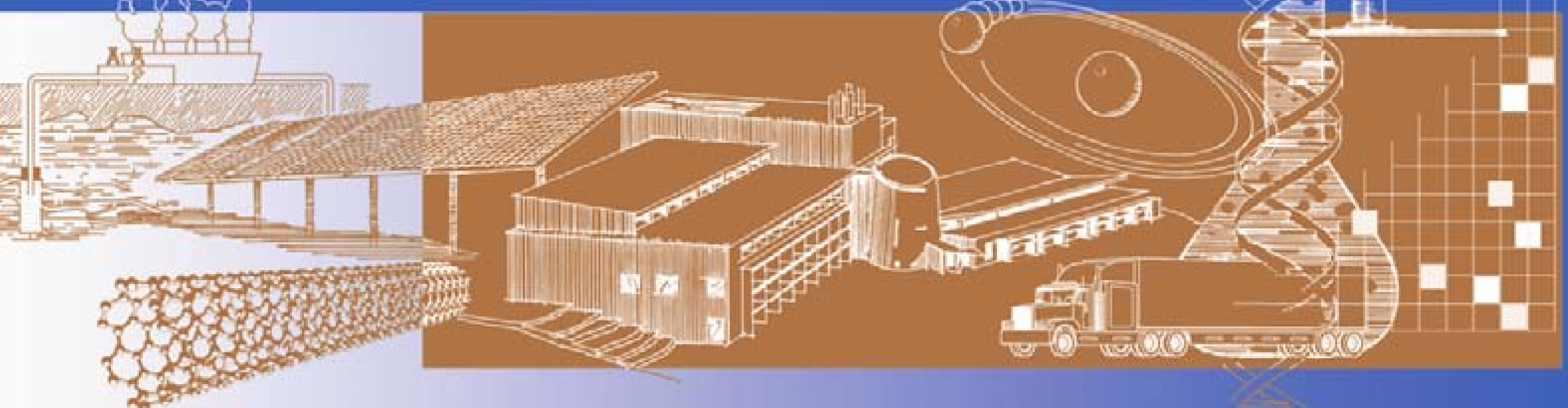

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FUTURE OF GRID-TIED PV BUSINESS MODELS: WHAT WILL HAPPEN WHEN PV PENETRATION ON THE DISTRIBUTION GRID IS SIGNIFICANT?

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ABSTRACT

Eventually, distributed PV will become a more significant part of the generation mix. When this happens, it is expected that utilities will have to take on a more active role in the placement, operation and control of these systems. There are operational complexities and concerns of revenue erosion that will drive utilities into greater involvement of distributed PV and will create new business models. This report summarizes work done by Navigant Consulting Inc. for the National Renewable Energy Laboratory as part of the Department of Energy's work on Renewable System Integration. The objective of the work was to better understand the structure of these future business models and the research, development and demonstration (RD&D) required to support their deployment. This report describes potential future PV business models in terms of combinations of utility ownership and control of the PV assets, and the various relationships between end-users and third-party owners.

1. KEY FINDINGS

As photovoltaics (PV) demonstrate the potential to significantly penetrate the electric generation market, a question arises: how might government action encourage business models that promote the development of PV? This report is a first structured, comprehensive and public attempt to answer that question. Our investigation identified several key findings:

- The question is dynamic, and has broad implications for a wide array of stakeholders – most notably utilities.
- While the number of installed distributed PV systems will eventually become a material and operational concern – or opportunity – for utilities, the full benefits of an extensive distributed PV resource are not likely to be realized without some degree of utility control and possibly ownership.
- Who owns and controls the PV facilities and the related flows of cash and other benefits is key to determining the potential viability of any PV business model.
- It appears that key industry stakeholders have considered changes to current models of ownership and control, but few have moved forward, indicating that barriers, such as the current regulatory structure, insufficient scale, and other priorities, impede optimum development.
- Smart-grid technologies are expected to be very important for the emerging PV business models. While this report does not focus on specific recommendations, it is clear that the ongoing RD&D in this area, both public and private, will be critical for distributed PV.

Similarly, distributed PV may become an important enabler for deployment of these technologies, as higher levels of PV market penetration necessitate their use.

- Each potential future business model identified in this report has several permutations, and it is not yet clear which is likely to be the most successful, how multiple business models could co-exist, or if one may evolve into another over time. Attempting to pilot any particular one at this time appears to be premature.
- The scale of a potential pilot program involving utilities feeds back into the advisability of delaying the implementation of a pilot until a greater level of stakeholder engagement is achieved in the preliminary assessment.
- It appears to be a question of when, and not if, there will be a need for new PV business models, in order to accommodate and facilitate widespread adoption of distributed PV.

2. BACKGROUND

Current PV business models principally revolve around the ownership of PV systems by individuals and increasingly by third parties, rather than by utilities. At today's low levels of market penetration, distributed, grid-connected PV is not a central concern nor even of great interest to most utilities. However, as PV market penetration accelerates, utilities will become critical stakeholders, driven primarily by concerns about grid operation, safety, and revenue erosion.

Until now, utilities have mainly responded to regulators, who asked of them nothing more than to help customers who wanted to purchase or acquire a PV system. In the process, some utilities have removed key barriers to PV deployment to a limited extent, mainly by providing net metering and adopting simplified, standardized interconnection standards and agreements. In addition, regulators have sometimes obligated utilities to purchase renewable energy certificates (RECs) generated by PV owners, particularly in states with specific mandates for solar energy.

On the whole, however, the utility's role in the PV market has been passive. PV has not been a core utility business endeavor nor a concern, primarily because (1) the cost of PV has exceeded that of other energy delivery options, and (2) utilities have seen, up to the present, no clear business/regulatory model that will allow them to recover high distributed PV costs.

The basic premise explored in this report is that large amounts of distributed PV create a new paradigm that has the potential to radically alter a utility's business model. Of all stakeholders involved, it is the utility that will have its existing business model most disrupted as the PV market expands. However, it is also the utility that has the potential to best utilize the unique, quantifiable benefits of the electricity generated by a PV system.

3. OVERVIEW OF PV BUSINESS MODEL EVOLUTION

The PV industry is moving away from the early approach in which the customer not only owned and financed the PV system, but also managed most aspects of installation. This approach is referred to as the Zero Generation PV business model; its attractiveness was limited to a relatively small group of so-called pioneers who were committed to PV's environmental, energy security, and self-generation benefits. The PV industry has evolved to 1st Generation PV business models, in which the product is more attractive to a broader market, moving into the so-called early adopter customer category. (See Attachment 1)

2nd Generation business models have yet to emerge, but will emphasize greater integration of the PV systems into the grid because emerging technologies and regulatory initiatives are likely to make such integration more viable and valuable. 2nd Generation business models are the focus of the future business models explored in this report, as they are expected to become increasingly important to various stakeholders.

Although the utility has, to date, been generally reactive to state requirements (e.g. net metering, standardized interconnection), it is expected to become proactive in the distributed PV market as it is pushed to key stakeholder status. Once PV reaches significant market penetration (perhaps 10-15% of a utility's peak load), utility involvement will be driven by concerns for grid infrastructure, safety, and of course, revenue erosion. An appropriate business model can promote and accelerate the utility's willing promulgation of PV and help unlock its full value.

4. CONTEXT FOR FUTURE PV BUSINESS MODELS

At the same time that the PV industry is making great strides in the deployment of PV using 0 and 1st Generation approaches, significant activities are also occurring outside of the PV industry that have clear implications for long-term PV market penetration. In particular, changes in policy, technology and utility regulation may hold the potential to not only create opportunities to unlock additional value from PV systems, but may simultaneously create more demand for it (see Attachment 2).

Technology developments underway to manage the distribution grid more effectively will have many benefits for distributed generation, including PV. In particular, the development of distribution system automation, the transition to "smart grids," and the deployment of customer- and utility-controlled demand response are all likely to help utilities and others unlock additional value from distributed PV systems.

Policy trends that create a market for renewable energy, such as Renewable Portfolio Standards or RPS (especially those with solar set-asides) and greenhouse gas emission caps, are gaining momentum at the state and local levels, and may ultimately culminate in much higher average state targets and, eventually, a Federal-level policy.

Finally, regulatory changes in some states are altering the way a utility perceives its business. Beyond net metering and interconnection issues, performance-based ratemaking (in which incentive benchmarks, rather than budgets, determine cost recovery) and revenue decoupling mechanisms (in which rates are determined as a function of service delivery rather than as a strict return on hard assets) are being implemented to encourage energy efficiency, conservation, and renewable energy. Given these types of changes, the ability of a utility to realize revenue from rates that are based in part on reconfiguring its grid and altering its customer support to integrate PV will have obvious benefits for the further increase of distributed PV. In addition, some utilities have experimented with tariff structures to encourage desired consumer behaviors and the deployment of new technologies. For example, variations of time-of-use pricing can be very beneficial to PV economics. Also, adoption of transmission congestion pricing should have a beneficial impact on distributed PV, as the market value of distributed generation will be made plain by the congestion prices. These regulatory actions are increasingly being driven by the desire to encourage conservation or greenhouse gas reductions.

Looking forward 10 to 20 years, there is a strong case to be made that PV in distributed applications, primarily customer-sited, will become an inevitable and significant component of the electricity sector, and especially if forecasted PV cost reductions materialize. In the long-term vision presented in this report, PV will pass a "tipping point" beyond which it is competitive with retail power supplied by the grid. The point of wide-scale competitiveness with grid power may come sooner as a result of specific breakthroughs in technology, or later as a result of the steady march down the cost curve. In either case, this vision depends on the PV supply chain being able to ramp up capacity to meet market demand.

When PV achieves a high degree of market penetration, there will be significant implications for key stakeholders, especially for the utility. PV will eventually be an operational problem for the utility if it is not strategically managed. Additionally, as the cost of PV comes down, distributed PV generation could become a competitive threat to central-station generation.

Of all the stakeholders involved, it is the utility that will have its existing business model disrupted the most, and must therefore adapt to protect and enhance its business. Thus, greater utility involvement is seen as the key to future PV business models. In contemplating PV system ownership and control on the distribution grid, a utility can leverage what it already does well, including asset management and investment, customer service and system operations (see Attachment 3).
For the utility, PV could simply become another rate-based asset to own, manage, and operate to provide equal or higher quality of service than what it provides today. In addition, PV may allow a utility to take maximum advantage of the capabilities that distribution automation and smart grid technologies will provide. In fact, PV arguably has the potential to be one of the most significant distributed resources managed by these technologies.

5. FUTURE BUSINESS MODELS

Three basic types of business models were identified in this report, as illustrated in Figure 1. The main distinctions among them lie in who owns and controls the PV system. (A fourth option, in which the PV system is owned by the utility but not controlled by it, is not viewed as being a viable business model because the utility is unlikely to cede control of an asset that it owns.) As will be discussed in more detail below, the success of any of these business models will be tightly linked to ongoing technology and market developments in distribution automation and demand response, and may also require significant regulatory changes. In the full report variations of each basic type of business models are discussed.

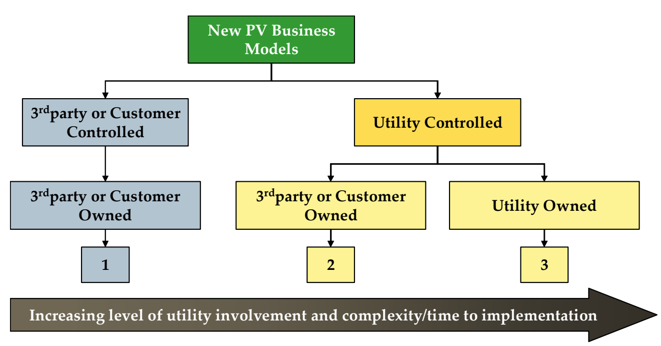

Figure 1: New PV Business Models Focused on System Ownership and Control

5.1 Third Party/Customer Controlled and Owned PV Business Model

In this business model, the customer or a third party controls the PV system as well as owns it. (There is also the possibility of customer ownership combined with third-party control.) This business model is primarily an extrapolation of current business models and trends (See attachment 4). The key difference is that additional sources of revenue are captured by the owner, based on various changes to the regulatory and policy regimes and on the deployment of "smart grid" technologies and energy storage that is integrated with PV system operation. In this model, the utility role remains mainly one of facilitation, primarily driven by regulatory or policy changes. The utility pays for value-added products and services obtained from the PV system and are then allowed to recover these costs through traditional rate-making proceedings.

This business model is considered the most likely to become established in the absence of outside influence, as various pieces of current regulation and policy are already in place to enable it in some jurisdictions.

If the customer/third-party controlled and owned business model becomes widespread, the distribution grid must be re-engineered to be highly responsive to changes in PV operating profiles (e.g., extremely localized power fluctuations), either due to transient changes in sunlight availability or to decisions taken by the owners, because the utility will not control the PV systems. An issue that will arise is the degree to which owners will be "free to choose" how to operate their systems. For example, if a customer chooses to participate in a demand response program, they might be obligated to respond to utility signals.

5.2 Utility Controlled, But Third Party or Customer Owned PV Business Model

This business model is somewhat similar to the one described above, in that it seeks to achieve similar objectives (Figure ES 1 7). The key difference is that greater utility involvement in the operation and control of the systems is contemplated as a way to increase the value of the assets. Like the customer controlled business model described above, regulatory and policy regimes will need to change, though more significantly here, to allow the utility to reach behind the meter where the PV system will reside. In this case, the customer will not respond to price signals because the utility is controlling the PV system, at least to some extent.

This business model may work best where aggressive demand response or other similar programs are being pursued or where high penetration of PV systems may pose serious grid control and operations issues. Under those circumstances, direct utility control—for example, to allow the utility to curtail PV system operation to maintain grid stability—instead of a complicated market for such services, may be preferable because the utility is assured response as it controls the asset as opposed to relying on optional response to price signals.

In this model, the utility would still pay for value-added products and services from PV systems and then be allowed to recover these costs through traditional rate-making proceedings. To the extent that PV systems a provide service and create value (e.g. avoid costs) for the utility, this would be factored into the cost of recovery calculation

This business model is expected to evolve more slowly given the additional regulatory changes required to permit utility control behind the meter. Additionally, distributed PV needs to exist at a significant scale in order for a utility to find value in controlling it. For example, the distributed PV installation would have value to the utility proportional to its capacity to substitute for generation, capacity, and transmission and distribution (T&D) investments.

The requirements for the utility controlled, customer/third-party owned business model are largely the same as for customer/third-party controlled model. The key difference is the regulatory regime, which would enable utility to control significant assets on the customer side of meter. To the extent that utility control is not just for grid benefits but also to enable the utility to offer other services to the end user, these regulatory changes will need to address the rules governing competition for providing these services. The main competitive issue is that the utility, as a monopoly, has an unfair advantage in its access to the customer. If the utility is allowed to access assets behind the meter for the benefit of the grid, but then is also allowed to leverage this access to offer customer-based services like backup power or energy management, other companies without such access might see this as unfair. To the extent that utilities were allowed to use the PV assets to provide value-added services to those customers who own them, the structure and pricing of these services must be determined in a transparent and equitable manner.

5.3 Utility Controlled and Owned PV Business Model

This business model represents the greatest departure from today, as the utility reaches unequivocally behind the meter to own assets and provide a range of services to customers (Figure ES 1 8). This model seeks to unlock greater distributed PV value by involving the utility directly in both ownership and control of the asset, and in monetization of the asset's value. This arrangement fits well with utility core competencies of asset ownership and operation. Given that

PV is a capital-intensive asset, there is merit in putting such utility-owned assets in the rate-base.

By allowing the utility the greatest control over the placement and subsequent operation of the asset, this model should generate the greatest overall value for the utility. Moreover, in this model, the utility can readily incorporate the grid benefits into its basic cost of service, as well as sell value-added services to the end-user. Of the three groups of business models, this one is the easiest model for the utility to incorporate deployment of PV into their capital planning, as the ultimate decision to install is in their control. However, the issue of competition will be a complication as the utility could have unfair advantage in providing value-added customer-oriented (vs. grid oriented) services that a third party may want to provide.

Like the other business models described above, regulatory and policy regimes will need to be changed significantly to allow the utility to reach so overtly behind the meter. To mitigate the potential scope of such regulatory and policy changes, the PV systems could be located on customer premises but placed on the utility side of the meter. In the past, states have prohibited utilities from owning and operating distributed energy resources (DER) because of concerns regarding market power. This concern will need to be addressed if and when PV systems become very inexpensive or otherwise attractive to utilities.

This business model is expected to evolve more slowly than the others, given the additional regulatory changes required to permit utility control and ownership. In addition, in order for utility control to have significant value to the utility, distributed PV has to exist on a sufficient scale to have material impact on key values such as ability to offset generation, capacity, and T&D investments.

In a business model in which the PV assets are both controlled and owned by the utility, the structure of the system-wide control architecture would be different than in models in which the customer or a third party either controls or owns the assets. There would be no need to be able to send or other signals to a large number of owners. Instead, the control of the PV assets would be integrated into the utility's overall distribution network. Moreover, the deployment and use of PV systems would be more readily integrated into the utility's planning processes; PV systems would become extensions of the distribution grid. Thus, as PV is continually added, the utility would have the opportunity to make sure that the grid configuration remains optimal. This business model would also likely make it easier for utilities to justify investments required for grid reconfiguration, as this becomes necessary.

6. CONCLUSIONS

Currently, PV business models revolve around access to lower-cost financing, increasing the efficiency of the supply chain, and reducing hassles and complexity for the customer. These types of incremental improvements will occur naturally as 0 and 1st Generation business models continue to evolve.

Up until this point, there has been little reason to address system control or consider PV aggregation as an explicit policy matter, given the limited number of PV systems installed on the distribution grid. However, a time will come—in some areas of the country much sooner than others—when the sheer number of installed distributed PV systems becomes a material and operational concern—or opportunity—for utilities. Policy and regulatory considerations will then be paramount.

The most significant finding in this study to date is that the full benefits of an extensive distributed PV resource are not likely to be realized without some degree of utility control and ownership. The need to have active management and control of an increasingly large number of distributed PV systems implies that utilities will most likely become more involved in one way or another. As market penetration increases, distributed generation will reach a scale (i.e. generally greater than 100 MW) that could translate to significant value. For example, utility involvement could help optimize distributed PV assets by incorporating them into grid and generation planning. This is likely to reduce new peaking power requirements, distribution substation upgrades, and other system investments, thus unlocking latent value in the electric grid as a whole.

The results of recent analyses performed on the value of PV show that the real value of PV lies in its potential to offset generation, capacity and T&D investment.[1] Such value greatly outweighs the value PV has for providing ancillary services on the distribution grid. Therefore business model development will not be driven by the potential for ancillary grid services. It is the possibility that a large quantity of distributed PV systems will be installed that provides the greatest potential benefit to the nation's energy infrastructure, as these systems in aggregate could actually offset significant investment requirements in new generation, transmission, and distribution capacity.

Aside from the technological changes that will be required to accommodate a large capacity of PV on the grid, the organizational structure of today's utilities does not facilitate the adoption of the new business models discussed in this report. For example, current grid planning and operation practices do not explicitly take into account the potential value from PV, and these functions are largely separate within utility organizations, which hampers inclusion of PV and other distributed resources in system planning.

7. ACKNOWLEDGMENTS

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We would also like to thank our colleagues at Navigant Consulting Inc. that provided valuable input, including Craig McDonald and Stan Blazewicz.

In addition, we would like to acknowledge that in our informal conversations with industry on the topic of future business models we confronted a great spectrum of opinions regarding how things will unfold; in particular this was true for utility involvement. Some industry leaders felt that utility involvement in distributed PV will remain limited, while others view utility involvement, including control and ownership, as inevitable. This report examines the spectrum of options for the future.

8. REFERENCES

1. J.L. Contreras, L. Frantzis, S. Blazewicz, D. Pinault, and H. Sawyer (Navigant Consulting Inc.), *Photovoltaics Value Analysis*, February 2008.

Attachment 1: Evolution of PV Business Models

Evolution of PV Business Models

0 Generation — PV System Supply

- Business models focus on manufacturing, supply and installation of PV systems
- End-user is the owner
- Utility is largely passive, providing net metering and standard/simplified interconnection, but otherwise, unaffected.

1st Generation — Third-Party Ownership & Operation

- Business models driven by third parties which develop projects and own PV systems, resulting in:
  - Reduction of hassle & complexity for end-user
  - Better access to financing
  - Leveraging of current incentives structure (especially for commercial building applications)
- Utility gradually takes on a facilitation role as PV market share grows

2nd Generation — Full Integration

- Business models allow PV to become an integral part of the electricity supply and distribution infrastructure
- Business models emerge with variation of system:
  - Ownership
  - Operation
  - Control
- Utility becomes more deeply involved, as PV becomes major consideration
- PV product supply chain becomes "commoditized"

Attachment 2: External Factors with Implications for PV Market Development

Technology

- Development and deployment of distribution automation technologies
- Transition to "smart grids"
- Continued development and deployment of other distributed generation technologies
- Development and deployment of plug-in hybrid vehicles (implications for grid operations, load growth and battery technology development)

Policy

- Further development of Renewable portfolio standards (increasingly with solar set asides)
- Greenhouse gas emission cap & trade programs and other climate change initiatives
- State-level economic development initiatives
- Growth of state solar energy initiatives and system benefits charge funds

Regulatory

- Performance-based ratemaking
- Revenue decoupling to encourage energy efficiency and conservation
- Tariff structures optimized for PV and other distributed generation
- Demand response programs (customer and utility controlled)

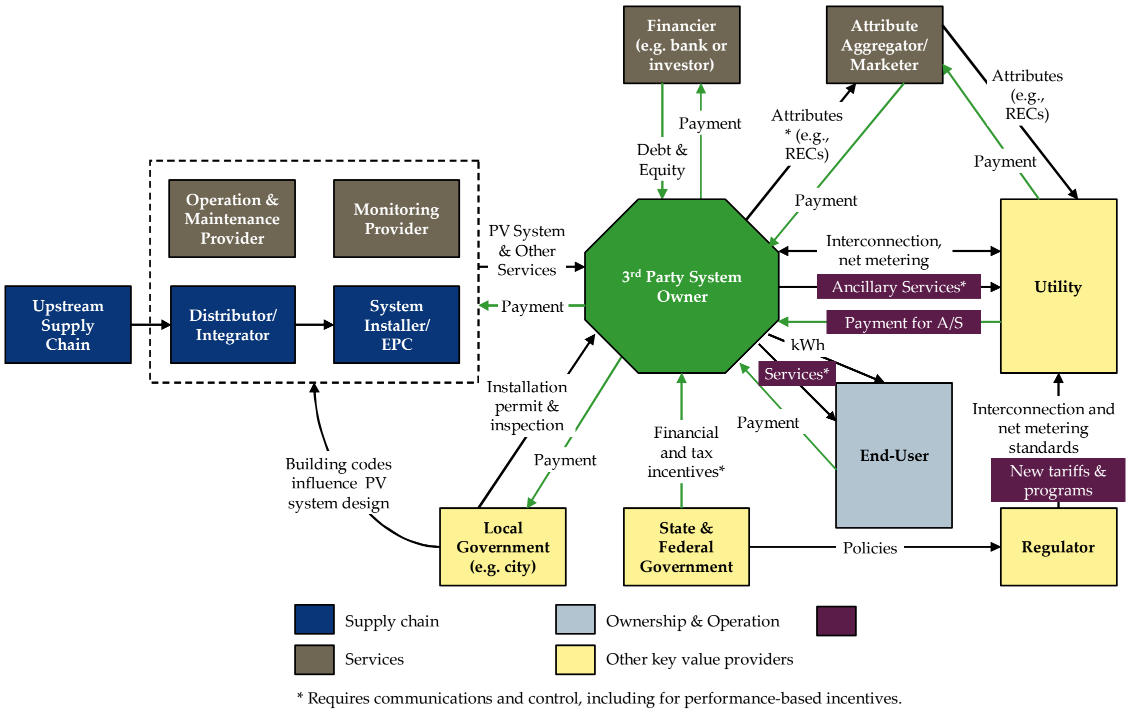
Attachment 3: Implications of Widespread Distributed PV Deployment on Key Stakeholders

Stakeholder	Implications
End-User	PV system: • Is cost-effective alternative to the grid • Provides improved reliability (over grid) • Helps meet environmental desires of consumers • Generates a range of value streams (driven in part by environmental and climate change policy) • Is part of a bundle of new technologies to improve energy service at end use and reduce cost as cost drops (low-cost energy storage, distribution system automation, “smart homes”, plug-in hybrid vehicles)
System Owner	• PV system output has multiple value streams that can make it competitive in the market relative to grid power • Owner needs to be able to identify and capture multiple PV value streams

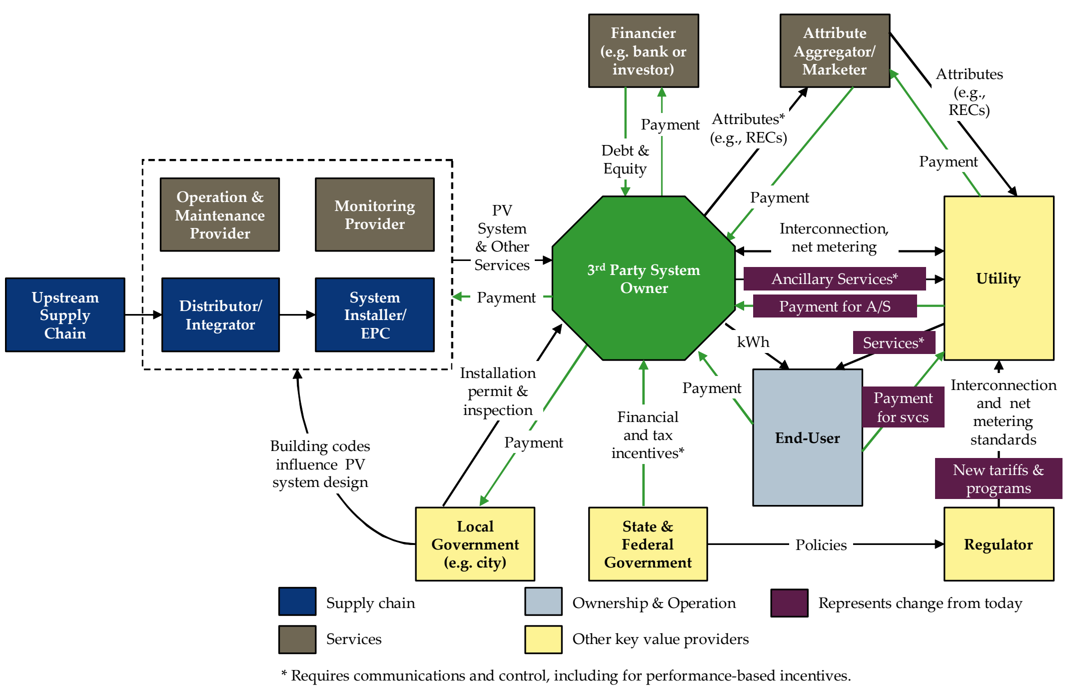
Distribution Utility and Vertically Integrated Utility	• High degree of PV market penetration creates:
	  ○ Reduced throughput leading to revenue loss under traditional tariff structures
	  ○ Need for control of PV systems and/or new distribution system architectures to ensure safety, operational integrity and reliability of the distribution grid
	• In addition, new technologies used in conjunction with PV could radically change utility operations and product/service offerings to customers (low-cost energy storage, distribution system automation, “smart homes”, plug-in hybrid vehicles)

Wholesale Generator	• High degree of PV market penetration could provide competition in the wholesale market to more expensive generating assets
Regulator	• Emergence of cost-effective PV and other complementary technologies creates need for major transformation of how utility industry is regulated
Transmission Company	• High degree of PV market penetration could impact the demand for transmission services

Attachment 4: Third Party/Customer Controlled and Owned Value Network[1]



Attachment 5: Utility Controlled but Third-Party/Customer Owned Value Network[1]



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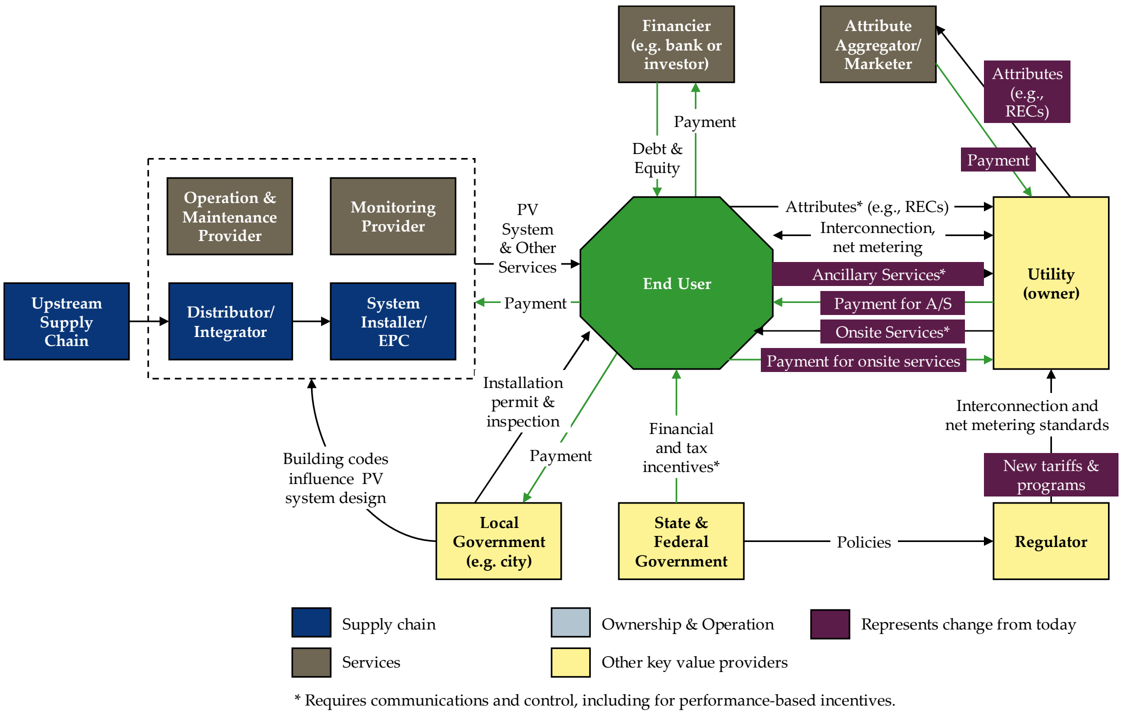
[1] As an example of this business model, we selected the 3rd party owned variant, although the end-use owned variant would illustrate the issues as well. In addition, this diagram represents all of the major functions as separate, even though there may integration of some functions as the industry grows and matures.

Attachment 6: Utility Controlled and Owned Value Network[2]



[2] This diagram represents all of the major functions as separate, even though there may integration of some functions as the industry grows and matures.

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Eventually, distributed PV will become a more significant part of the generation mix. When this happens, it is expected that utilities will have to take on a more active role in the placement, operation and control of these systems. There are operational complexities and concerns of revenue erosion that will drive utilities into greater involvement of distributed PV and will create new business models. This report summarizes work done by Navigant Consulting Inc. for the National Renewable Energy Laboratory as part of the Department of Energy's work on Renewable System Integration. The objective of the work was to better understand the structure of these future business models and the research, development and demonstration (RD&D) required to support their deployment. This report describes potential future PV business models in terms of combinations of utility ownership and control of the PV assets, and the various relationships between end-users and third-party owners.

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