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Final Deliverable – 4

Ownership and Operation Models for ER System Performance

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Final Deliverable - 4
Ownership and Operation Models for DER System Performance

How to Read this Document

The report will provide other utilities guidance about which technologies and ownership models result in the best overall Distributed Energy Resource (DER) system performance. While Final Deliverable 3 (FD-3) considered the design and deployment phases of the Austin SHINES project, this document addresses relational aspects, when roles and responsibilities transfer from installation to operation. Stakeholders can influence or serve as a barrier to successful DER ecosystems. For the purposes of this report, technology is defined as the control schemes of Direct Utility Control, Third-Party Aggregator Control, and Autonomous control -all more narrowly delineated in Section 1.1. And further, these schemes are considered as Operators. The ownership models, or Owners, as defined as Utility, Third-Party, and Customer, described in Section 1.2 . Based on the Owner and Operator of DER, certain opportunities and constraints exist. These are characterized by possible use cases, in Section 1.3.1. From here, Section 2 uses an Evaluation Matrix to facilitate discussion of the 9 arrangements possible between them. Thus, the best system performance is unique to each model, and utilities should consider their preference or interest, to determine why and how value can be maximized. Section 3 presents SHINES conclusions from the implemented and modeled configurations. Costs associated with ownership and control are to be understood as not influencing the System Levelized Cost of Electricity (System LCOE) equation, as the assets themselves remain the same and influencing stakeholders are considered outside the technical system boundary.

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Section 1 System Performance Framework

The first section of this report seeks to outline the scope of Distributed Energy Resource (DER) aggregation and ownership dimensions, studied in the Austin SHINES project. DER assets in Austin SHINES includes solar photovoltaic (PV), battery storage, both in combination, and facilitating equipment like smart inverters. For the purpose of delineation, Ownership is defined to include Utility, Third-Party business or investor, and direct Customer ownership. Ownership methodologies including Direct Utility, Third-Party Aggregator, and Autonomous are defined as Operational control. Thus, the same or different parties may own and operate DER, creating multiple ways to gain optimal functioning. And given these varied pathways, it is context dependent on the owner-operator relationship to determine best overall system performance.

1.1 Operation Overview

Within the Austin SHINES project, the control methods tested includes associated technology to manage. This technology can be applied to grid-scale, commercial, and residential DER. However, there are varied advantages and drawbacks to controls at each level. Each sub-section will outlay how these controls, or technologies, were employed in the project.

1.1.1 Direct Utility Control

Direct Utility Control (DUC) DER assets are controlled directly by the utility. These assets report directly to the utility without the intervention of a third-party aggregator. In some cases, a third-party vendor may provide communications and control tools, but those tools are operated by the utility, to control the assets. The number of assets with which a utility can or wants to control should be considered. For instance, in the case of grid-scale it would be assumed DUC can manage a reasonable number of solar or storage systems. The communication architecture of signaling to solar or storage assets of every residential customer would be an entirely different endeavor, that would likely require more support of a formal utility program or rate for participation, to achieve the desired use case outcome. In this model, the utility may have responsibility for maintenance and operational issues for the system, though these tasks can be contracted out to a third-party provider. For the Austin SHINES project, DUC assets included the following:

- Kingsbery Energy Storage System (KB ESS)
  - 1.5 MW / 3 MWh Li-Ion battery storage
- Mueller Energy Storage System (MU ESS)
  - 1.75 MW / 3.2 MWh Li-Ion battery storage
    - 7 Energy Storage Units (250 kW each)
- 12 Utility-Controlled Residential Solar PV via Smart Inverters

1.1.2 Third-Party Aggregation

Aggregated DER devices and systems are those where the individual DER resources are controlled and operated by a third-party and the aggregated sum of the resources are presented to the controlling entity, or a utility, as a generation, storage, or load management asset. In this operational model, the aggregator has the responsibility for maintaining operational capacity to the utility. This is likely in the form of availability guarantees and service level agreements. How the aggregated resource provider achieves these performance contracts is then up to them, and the utility is freed from developing operational maintenance programs. This incentivizes the aggregator to develop robust field systems to minimize operations and maintenance costs. It also frees the residential or commercial property manager from maintenance costs, though at the penalty of having to fund these activities through reduced financial reward. For the Austin SHINES project, aggregated battery energy storage installations included the following:

- 18 kW / 36 kWh Li-Ion battery storage + 57 kW Solar PV
- 72 kW / 144 kWh Li-Ion battery storage + 60 kW Solar PV
- 72 kW / 144 kWh Li-Ion battery storage + 100 kW Solar PV
- 6 homes w/ stationary battery storage systems (10 kWh each) + existing PV
- 1 Electric Vehicle installed as Vehicle-to-Grid (V2G)

1.1.3 Autonomous Control

Autonomous DER devices are those configured at the time of installation and then allowed to operate under those settings either for the lifetime of the device, or until the utility/owner undertakes an effort to change the settings based on needs or mandates. It is expected however, these systems will not have their settings changed after installation until the device lifetime is reached. Examples of autonomous systems are solar + storage systems configured for no-net-export, in order to minimize impact to the overall demand curve of a system through the aggregated sum of uncontrolled solar generation. Autonomous systems can also take the form of solar electric systems with fixed set points for the same types of Volt/VAR, frequency ride through functions as the DUC model. In these cases the autonomous settings are static and tend to be more moderate set points compared what might by dynamically controlled by the utility communicating to DER directly (or through an Aggregator).

In this operational model the system owner is responsible for system maintenance, but often has no incentive to ensure the functions important to the utility are operating correctly. An example would be solar electric inverter systems having a non-unity power factor. If, for any reason the solar inverter vendor pushes a firmware update to the system and the power factor setting is not maintained the utility may lose that function for the rest of the operating life of the inverter. For the Austin SHINES project, autonomous assets included the following:

- 6 Autonomously-Controlled Solar PV via Smart Inverters

1.2 Ownership Overview

The ownership of DERs plays a vital role in the development of a project. In this report, the owner is assumed to have procured the asset and assumes responsibility for the assets' operation, maintenance and eventual dispensation. One or more of these responsibilities may be outsourced, at a cost to the owner, but the owner retains title to the DER. This entity will typically drive the decisions on prioritizing applications, either for the owner's value or for the value of another entity in return for some form of compensation. In this report, we consider the three most likely ownership possibilities, the utility, a third-party, or a customer.

1.2.1 Utility

Utility ownership may seem one of the most obvious models. With vast experience in the electrical grid and as the role of power producer-transmitter-distributer, utilities have access to likely the largest diversity of value streams for DERs compared to other owner models. While the economic incentives play a large part in a utility's usefulness of DERs, other concerns such as reliability and carbon reduction provide additional potential value streams. As the DER owner, the utility has more leverage to prioritize the applications performed by the DERs, and is able to access these value streams at all levels, ranging from small residential sized systems to very large grid-scale projects. Access to energy markets provides a key incentive for utilities to own DERs, while utilities have experienced personnel who are trained in maximizing electrical grid technology value. The challenges of utility ownership stem largely from unfamiliarity with new technologies, requiring additional training, and perhaps staffing, for operation, troubleshooting and maintenance.

1.2.2 Third-Party

The ownership of DER by an entity other than the utility or a customer is defined as third-party ownership. The third-party provides the DER to create either energy or a service that is of value to a utility and/or an end-use customer. This business model can range from a grid-scale DER Power Purchase Agreement (PPA) with a utility to the commercial ESS installation, for peak reduction services for a recurring fee or shared savings. This arrangement can provide benefits to both utilities and customers beyond the obvious initial capital investment savings. Ownership typically includes responsibility for maintenance and repairs, an activity in which the third-party is the most likely entity to have the experience and support system in place to accomplish at a cost effective rate. In the frequent case where a third-party also handles sales and/or marketing, the utility is freed from having to supply the support infrastructure necessary for these activities required in customer-sited installations. Procurement activities may also be simplified for the utility from the perspective of having a single agreement with a third-party rather than an agreement with each end-use customer. Third-party ownership can also provide end of system life benefits. A third-party whose core business is the procurement and installation of DERs is much more likely than either the end-use customer or the utility to have the expertise to handle the reuse, recycling, and/or disposal of DER components.

1.2.3 Customer

Customer ownership of a DER in residential and commercial applications is the straight forward model whereby a utility end use customer purchases the system outright from a vendor. In these cases, maintenance, repairs, and sometimes even controls are supplied via a contract, either included up front or in an ongoing basis of payment, with a third-party. The utility realizes the same capital cost avoidance as the third-party model offers, as well as end of life activities. However, some DERs are typically incentivized by utilities to bring financials to an acceptable level for end use customers to justify the purchase, and/or to have the DER perform functions which benefit the utility which may not be of value to the customer. These incentives range from up front capital cost reimbursement to specialized rates designed to take advantage of DER functionalities. While these activities bring down the cost of dealing with each customer, it also brings up a utility opportunity to maintain the customer relationship.

In certain cases, grid-scale installations are possible by an end-use customer. Industrial customers with large power demands are the most likely to consider ESSs on a scale large enough to tie directly into the distribution grid. These installations can be complex, typically involving not only the utility but perhaps an Independent Service Operator. Given the positive and negative impacts an ESS this size can have on a system, the utility should be an active participant in the planning and interconnection details.

1.3 System Performance Characterization

To define and consider what enables system performance or even the “best overall” system performance of an operational DER ecosystem, the context of stakeholder impact per use case primarily drives this measurement. The following section provides consideration of all original control functions, to serve as the value propositions of DER and the SHINES project assets.

1.3.1 Use Cases

The use cases considered for this report include all 19 of the original applications, selected as a part of the DER control software functionality and are shown in Figure 1-1. Although only six were chosen for software implementation, it is worthwhile to consider all value streams possible, for utilities to understand their potential.

Application	
Customer	*Demand Charge Reduction (DCR)* *Back-Up Power* *Time-of-Use (TOU)*
Renewable Integration	*Solar Variance* *Wind Variance*
Energy Market Operations	*Peak Load Reduction (PLR)* *Energy Arbitrage (EA)* *Load Marginal Price (LMP) Opportunities*
Ancillary Services	*Fast Frequency Response* *Emergency Response Service* *Regulation Up/Down*
Dist. Operations Support	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*
Tx. Operations Support	*Constraint Avoidance* *Voltage Support* *Peak Loss Avoidance*

Figure 1-1 DERMS Control System Applications

Section 2 System Performance Evaluation

System performance shall be considered through the Operation and Ownership models defined. Please note, costs associated with ownership and control are to be understood as not influencing the System Levelized Cost of Electricity (System LCOE) equation, as the assets themselves remain the same and influencing stakeholders are considered outside the technical system boundary. And limitations of the described methodologies of Section 2 are contingent on many industry uncertainties, including regulatory and business model potential. The following is not intended to serve as an exhaustive discussion of possibility, but rather feasibility. Considering what was evaluated and accomplished, the utility anticipates maturity in all described relationships, some of which were experienced during the scope of the project. Utilities can use their preference or interest in each section, to compare why and how value can be maximized.

Each of the 9 segments of the matrix, in Table 2-1, will be evaluated for the use cases in Figure 1-1.

Table 2-1: System Performance Evaluation Matrix

	Operator		
Owner	*Direct Utility Control*	*Third-Party Aggregator*	*Autonomous*
Utility	Section 2.1	Section 2.2	Section 2.3
Third Party	Section 2.4	Section 2.5	Section 2.6
Customer	Section 2.7	Section 2.8	Section 2.9

2.1 Utility Owned – Direct Utility Control

Several DER assets were demonstrated under the methodology where the utility both owns the DER as well as directly controls the operation of each asset. In this dynamic, while the grid-scale assets would be controlled strictly for utility value, it would be difficult to operate similarly in commercial and residential applications. In return for hosting the asset, it is reasonable for a customer to expect some benefit from the DER. In reference to Figure 2-1, it is clear there are many opportunities to obtain value in these locations, both for the utility and the customer.

Application	Grid-Scale	Commercial	Residential
Customer	*Back-Up Power*	*Demand Charge Reduction (DCR)* *Back-Up Power* *Time-of-Use (TOU)*	*Demand Charge Reduction (DCR)* *Back-Up Power* *Time-of-Use (TOU)*
Renewable Integration	*Solar Variance* *Wind Variance*	*Solar Variance*	*Solar Variance*
Energy Market Operations	*Peak Load Reduction (PLR)* *Energy Arbitrage (EA)* *Load Marginal Price (LMP) Opportunities*	*Peak Load Reduction (PLR)* *Energy Arbitrage (EA)* *Load Marginal Price (LMP) Opportunities*	*Peak Load Reduction (PLR)* *Energy Arbitrage (EA)* *Load Marginal Price (LMP) Opportunities*
Ancillary Services	*Fast Frequency Response* *Emergency Response Service* *Regulation Up/Down*	*Fast Frequency Response* *Emergency Response Service* *Regulation Up/Down*	
Dist. Operations Support	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*
Tx. Operations Support	*Constraint Avoidance* *Voltage Support* *Peak Loss Avoidance*	*Constraint Avoidance* *Voltage Support* *Peak Loss Avoidance*	

Figure 2-1 Utility Owned – Direct Utility Control Use Cases

The difficulty lies in choosing the applications that provide the greatest value, while also ensuring conflicts among them minimal. Although this is true for all nine methodologies, in this case the utility is likely to prioritize the applications providing maximum value to the utility while enabling enough applications to benefit the customer to provide a satisfactory return, for hosting the DER. Ideally, applications that work synergistically are the most attractive options. For example, a demand charge customer which reliably peaks during the same hours as the utility would make a perfect candidate to enabling Demand Charge Reduction (DCR) when the utility seeks to obtain value from a Peak Load Reduction (PLR) application. Beyond this ideal situation, the utility would be interested in determining customer applications anticipated to have the least conflict with the desired utility applications. This determination can become quite complex, and is specific to each project, but in general customer characteristics, including load and energy profiles, billing analysis, applicable rates, planned expansions, back-up needs, and electrical service quality must all be considered in the investigation.

The benefit to the utility under this scenario is complete control over the assets, not only in operations but also typically in maintenance. The utility has the ability to prioritize operations to maximize utility value and closely monitor maintenance and repair work as needed. Decision making can be largely internal. However, the utility also assumes all responsibility for the system. This requires a level of expertise and staffing that, if not present, can result in great cost that would outweigh the benefits. Mitigation could include outsourcing some of the activities, such as maintenance, but overall a level of expertise will be required to successfully operate the systems. In this scenario, the utility is also responsible for the success (or failure) of operating the systems for the benefit of the customer. Such risk, along with the cost and logistics of securing and maintaining customer-sited systems, leads this arrangement best suited to grid-scale installations.

2.2 Utility Owned – Third-Party Aggregator Control

Several DER assets were also demonstrated under this methodology where the utility owns the DERs but direct control of individual assets is left to a third-party aggregator, as described in Section 1.1.2. As seen in Figure 2-2, many of the same applications can be accomplished as the previous methodology, but the involvement of a third-party introduces complications along with some benefits.

Application	Grid-Scale	Commercial	Residential
Customer		*Demand Charge Reduction (DCR)* *Back-Up Power* *Time-of-Use (TOU)*	*Demand Charge Reduction (DCR)* *Back-Up Power* *Time-of-Use (TOU)*
Renewable Integration	*Solar Variance* *Wind Variance*	*Solar Variance* *Wind Variance*	*Solar Variance* *Wind Variance*
Energy Market Operations	*Peak Load Reduction (PLR)* *Energy Arbitrage (EA)* *Load Marginal Price (LMP) Opportunities*	*Peak Load Reduction (PLR)* *Energy Arbitrage (EA)* *Load Marginal Price (LMP) Opportunities*	*Peak Load Reduction (PLR)* *Energy Arbitrage (EA)* *Load Marginal Price (LMP) Opportunities*
Ancillary Services	*Fast Frequency Response* *Emergency Response Service* *Regulation Up/Down*	*Fast Frequency Response* *Emergency Response Service* *Regulation Up/Down*	*Fast Frequency Response* *Emergency Response Service* *Regulation Up/Down*
Dist. Operations Support	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*
Tx. Operations Support			

Figure 2-2 Utility Owned – Third-Party Aggregator Control Use Cases

The prioritization of applications, for example, will need to be clearly defined in the agreement between the utility and the aggregator since the aggregator controls will be sending signals to each DER based on some or all signals originating from the utility. The decision-making algorithm in the aggregator software must be sophisticated enough to balance these utility requests with any customer applications running at the aggregator level. The utility will typically not have the granular view into the customer's system in this type of arrangement, so it must rely on the aggregator algorithms to process incoming data to make the final decisions at each site. This loss of visibility into the customer level data means agreements may be extremely detailed with regard to operations and maintenance. A trilateral agreement involving the utility, the customer and the aggregator may be necessary to clearly lay out the requirements and expectations of all stakeholders. This includes the communication to the DER fleet. Aggregators' preference for utilizing proprietary communication protocols should be avoided to ensure compatibility in the future with other aggregators or if control is shifted to the utility.

A utility may see benefit in situations where the aggregator assumes responsibility for customer acquisition activities in customer-sited installations. The process of integrating software with the aggregator control software can also be a utility benefit compared to integrating to each individual DER. Perhaps the greatest benefit to a utility may be the expertise and experience an aggregator can bring in both customer and grid-scale systems, allowing a utility to gain value much quicker in the project.

Given the list of challenges listed, this methodology is not well suited to any particular application. Given the complexities and risks associated with customer-sited installations, this arrangement may be best suited for grid-scale applications, when utilities may lack the expertise and dedicated staffing to directly operate the DERs.

2.3 Utility Owned – Autonomous Control

Under this methodology when the utility owns the DER but control is reduced to an autonomous setting, the limited control results in a reduction of the number of effective applications, as seen in the Figure 2-3.

Application	Grid-Scale	Commercial	Residential
Customer	*Back-Up Power* *Time-of-Use (TOU)*	*Demand Charge Reduction (DCR)* *Back-Up Power* *Time-of-Use (TOU)*	*Demand Charge Reduction (DCR)* *Back-Up Power* *Time-of-Use (TOU)*
Renewable Integration	*Solar Variance*	*Solar Variance*	*Solar Variance*
Energy Market Operations	*Peak Load Reduction (PLR)*	*Peak Load Reduction (PLR)*	*Peak Load Reduction (PLR)*
Ancillary Services			
Dist. Operations Support	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*
Tx. Operations Support	*Constraint Avoidance* *Voltage Support* *Peak Loss Avoidance*	*Voltage Support*	

Figure 2-3 Utility Owned – Autonomous Control Use Cases

This can be an acceptable tradeoff, however, in all three types of installations. The most attractive benefit to a utility may be the reduced development and integration necessary for a system that is not reliant on real time remote signaling. While some remote capabilities will still be required, the reduced time and expense of establishing a less complex communication system can translate into significant cost savings up front. The relative simplicity can also be desired by utilities and customers alike with little experience in DER operation. In the case of customer-sited installations, this methodology may be suited for pilot programs as a strategy for utilities to increase customer adoption of DERs though first-hand experience, at a more affordable cost. Grid-scale installations may also utilize this model as a first step for utilities to gain DER experience with reduced costs for communication and controls. Less sophisticated controls also results in less potential value obtained by the DER, however. Although DER costs continue on a downward trajectory, the reduced value in limiting applications must be weighed carefully against the benefits. The rigidity in many autonomous controls also increases the possibility of conflicts between competing applications, further limiting the available applications.

This methodology is perhaps the most advantageous for customers, when they avoid upfront costs and maintenance, and applications for customer value are given priority. Without the need for monitoring or controlling daily operation, they gain experience with the value and operation of DERs. The utility driver is limited to increasing the adoption by customers through positive experience and finding compatible applications to derive utility value. In certain situations, willing customers may be amenable to having systems located at their site and operating primarily for utility value, simply to be participating in forward looking technology.

This methodology seems more unlikely in grid-scale applications given the equipment costs involved for limited application potential, but can serve as a first step strategy toward gaining experience with the equipment before delving into real time responses and large array of changing conditions which affect the grid.

2.4 Third-Party Aggregator Owned – Direct Utility Control

Under this scenario, the DERs are owned by a third-party aggregator, however after installation control is handed over to the utility. Rather than a third-party platform providing aggregated control to the utility, the utility is responsible for managing the field of assets in a holistic manner to achieve utility value, balanced with any applications enabled for customer value in commercial and residential DER installations. Figure 2-4 represents many options available however with other scenarios, complexity is greater with customer sited installations simply due to the greater number of assets to control holistically.

Application	Grid-Scale	Commercial	Residential
Customer	*Back-Up Power* *Time-of-Use (TOU)*	*Demand Charge Reduction (DCR)* *Back-Up Power* *Time-of-Use (TOU)*	*Demand Charge Reduction (DCR)* *Back-Up Power* *Time-of-Use (TOU)*
Renewable Integration	*Solar Variance* *Wind Variance*	*Solar Variance* *Wind Variance*	*Solar Variance*
Energy Market Operations	*Peak Load Reduction (PLR)* *Energy Arbitrage (EA)* *Load Marginal Price (LMP) Opportunities*	*Peak Load Reduction (PLR)* *Energy Arbitrage (EA)* *Load Marginal Price (LMP) Opportunities*	*Peak Load Reduction (PLR)* *Energy Arbitrage (EA)* *Load Marginal Price (LMP) Opportunities*
Ancillary Services	*Fast Frequency Response* *Emergency Response Service* *Regulation Up/Down*	*Fast Frequency Response* *Emergency Response Service* *Regulation Up/Down*	*Fast Frequency Response* *Emergency Response Service* *Regulation Up/Down*
Dist. Operations Support	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*
Tx. Operations Support			

Figure 2-4 Third-Party Aggregator Owned – Direct Utility Control Use Cases

It is more likely customer acquisition activities will be handled by the aggregator in this scenario,, but along with the direct control for commercial locations will come utility responsibility for meeting customer performance expectations. A variation on this scenario is possible, whereby the aggregator controls the DER only for customer applications, and control for utility value is handled by the utility itself. The utility control could be through a separate communications path, or a "pass-through" signal, utilizing the aggregator communication path. Either variation requires complex integration between the aggregator and the utility.

Grid-scale applications may be implemented as PPAs, where the third-party provides the assets and allowing control by the utility. This can carry the same benefits as previously described scenarios, saving the utility the costs of installation and maintenance while providing an environment to gain experience in the control of DERs. Given the simplified nature of this arrangement compared to customer installations, third-party aggregator owned with DUC is better suited for grid-scale applications at this stage of technology.

2.5 Third-Party Aggregator Owned – Third-Party Aggregator Control

The methodology involving third-party aggregator ownership and control of DERs has been a common scenario in the past several years in both commercial and residential installations, and Figure 2-5 lays out many options.

Application	Grid-Scale	Commercial	Residential
Customer	*Back-Up Power* *Time-of-Use (TOU)*	*Demand Charge Reduction (DCR)* *Back-Up Power* *Time-of-Use (TOU)*	*Demand Charge Reduction (DCR)* *Back-Up Power* *Time-of-Use (TOU)*
Renewable Integration	*Solar Variance* *Wind Variance*	*Solar Variance* *Wind Variance*	*Solar Variance* *Wind Variance*
Energy Market Operations	*Peak Load Reduction (PLR)* *Energy Arbitrage (EA)* *Load Marginal Price (LMP) Opportunities*	*Peak Load Reduction (PLR)* *Energy Arbitrage (EA)* *Load Marginal Price (LMP) Opportunities*	*Peak Load Reduction (PLR)* *Energy Arbitrage (EA)* *Load Marginal Price (LMP) Opportunities*
Ancillary Services	*Fast Frequency Response* *Emergency Response Service* *Regulation Up/Down*	*Fast Frequency Response* *Emergency Response Service* *Regulation Up/Down*	*Fast Frequency Response* *Emergency Response Service* *Regulation Up/Down*
Dist. Operations Support	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*
Tx. Operations Support			

Figure 2-5 Third-Party Aggregator Owned – Third-Party Aggregator Control Use Cases

In the demand response industry, aggregators have long leveraged existing customer electrical end use equipment, such as air conditioning, pumps and lighting, for financial incentives from utilities. Through various types of control, this equipment acts in response to utility requests for dropping load. In this newer methodology, the DER equipment is provided by the aggregator in addition to assuming responsibility for control. An agreement between the customer and the aggregator typically provides for some performance metrics that benefit the customer for a monthly fee paid to the aggregator. This arrangement provides benefit to the customer in eliminating equipment and maintenance costs, as well as leveraging the expertise of the aggregator in controlling the DERs for maximum customer value. The utility also can obtain these same benefits, typically through incentive programs or rate structures. Under this scenario, utility value is achieved through the same mechanisms described in Section 2.2. The similar challenges of integration, complex agreements, and loss of visibility down to the customer level are all factors utilities must contend with for a successful implementation. Despite these hurdles, the operational simplicity for the utility combined with the outsourcing of customer acquisition activities make this an attractive option for consideration in customer-sited installations.

Similar benefits can be obtained by utilities in grid-scale installations, with the additional benefit of the reduced application conflicts due to unnecessary customer applications. The lack of control and visibility into these larger systems can be significant concern for utilities, as aggregators may not have the experience in controlling utility value applications. Some applications, such as ancillary services, may require a Qualify Service Entity (QSE) certification, potentially disqualifying DERs under this methodology depending on the aggregator and the specific energy market.

2.6 Third-Party Aggregator Owned – Autonomous Control

DERs under autonomous control bring many of the same benefits, as well as the same limitations, regardless of ownership, shown in Figure 2-6.

Application	Grid-Scale	Commercial	Residential
Customer	*Back-Up Power* *Time-of-Use (TOU)*	*Demand Charge Reduction (DCR)* *Back-Up Power* *Time-of-Use (TOU)*	*Demand Charge Reduction (DCR)* *Back-Up Power* *Time-of-Use (TOU)*
Renewable Integration	*Solar Variance*	*Solar Variance*	*Solar Variance*
Energy Market Operations	*Peak Load Reduction (PLR)*	*Peak Load Reduction (PLR)*	*Peak Load Reduction (PLR)*
Ancillary Services			
Dist. Operations Support	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*
Tx. Operations Support			

Figure 2-6 Third-Party Aggregator Owned – Autonomous Control Use Cases

The main differences from the discussion in Section 2.3 are centered on capital costs and maintenance costs. Typically, these costs are borne by the owner, which can provide a benefit to the utility in this case from both an installation and operational cost perspective. Another difference is the owner will be seeking financial gain for this investment, from the utility and/or the customer. This will again involve agreements up front and can affect the prioritization of the applications chosen depending on the financial structure outlined in these agreements.

Grid-scale projects with this arrangement have the highest potential for utility value, once again due to elimination of potential conflicts with customer value applications. It also carries the same benefit regardless of owner of providing a potentially less costly installation for gaining DER experience. The autonomous control is a limiting factor when it comes to obtaining value, however, due to the less sophistication.

This methodology can also be attractive to commercial customers when the customer value applications are prioritized. Depending on rate structures and incentive programs, both commercial and residential customers gain benefits.

2.7 Customer Owned – Direct Utility Control

Customer ownership brings the obvious benefit to the utility that capital and maintenance costs are not the responsibility of the utility. Direct utility control provides the utility with maximum continuing flexibility in optimizing the operation for utility benefit while balancing with the requirements for customer applications detailed in the agreement. Many other similar benefits and risks described in Section 2.1 apply to this methodology, shown in Figure 2-7. A key difference may be the prioritization of applications. With the customer as the owner, customer applications would be more likely to take precedence over utility applications, when divergent values are present.

Application	Grid-Scale	Commercial	Residential
Customer	 *Back-Up Power* *Time-of-Use (TOU)*	*Demand Charge Reduction (DCR)* *Back-Up Power* *Time-of-Use (TOU)*	*Demand Charge Reduction (DCR)* *Back-Up Power* *Time-of-Use (TOU)*
Renewable Integration	*Solar Variance* *Wind Variance*	*Solar Variance*	*Solar Variance*
Energy Market Operations	*Peak Load Reduction (PLR)* *Energy Arbitrage (EA)* *Load Marginal Price (LMP) Opportunities*	*Peak Load Reduction (PLR)* *Energy Arbitrage (EA)* *Load Marginal Price (LMP) Opportunities*	*Peak Load Reduction (PLR)* *Energy Arbitrage (EA)* *Load Marginal Price (LMP) Opportunities*
Ancillary Services	*Fast Frequency Response* *Emergency Response Service* *Regulation Up/Down*	*Fast Frequency Response* *Emergency Response Service* *Regulation Up/Down*	*Fast Frequency Response* *Emergency Response Service* *Regulation Up/Down*
Dist. Operations Support	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*	*Congestion Management (CM)* *Voltage Support* *Harmonics* *Loss Avoidance* *Power Factor Correction*
Tx. Operations Support	*Constraint Avoidance* *Voltage Support* *Peak Loss Avoidance*	*Constraint Avoidance* *Voltage Support* *Peak Loss Avoidance*	*Constraint Avoidance* *Voltage Support* *Peak Loss Avoidance*

Figure 2-7 Customer Owned – Direct Utility Control Use Cases

This scenario seems most obviously advantageous to customer sited installations. However, grid-scale can fall under this category in an indirect way, whereby the utility purchases and installs the DER assets, then offers the services provided to its customers. An example would be a community solar installation. The utility, either directly or through a third-party, completes a grid-scale installation of a solar field, then offers the opportunity for customer to "purchase" subsets of solar panels and/or the power produced by the panels. While customers are not true "owners" of the systems, it provides them the sense of ownership in renewable energy.

A second application of customer owned grid-scale may be large commercial/industrial customers, connected at transmission level service. The role of the utility providing the control may be a fit for customers without the desire/experience to manage day-today operations of a large, complex technology. Detailed performance agreements would be required for success.

2.8 Customer Owned – Third-Party Aggregator Control

The methodology in which the DER fleets are owned by customers and controlled through third-party aggregators bring similar utility benefits to those described in Section 2.5 and are represented in Figure 2-8. The utility can be free from the initial capital costs, enjoy less cumbersome communication setup, and maintain some level of control over the assets through the aggregator platform. The same drawbacks of reduced visibility down to the asset level, the potential for complex multi-party agreements, and integrating to a vendor platform also apply. The key difference could be again the prioritization of applications providing value to the owner, the customer in this case.

Application	Grid-Scale	Commercial	Residential
Customer	Back-Up Power Time-of-Use (TOU)	Demand Charge Reduction (DCR) Back-Up Power Time-of-Use (TOU)	Demand Charge Reduction (DCR) Back-Up Power Time-of-Use (TOU)
Renewable Integration	Solar Variance Wind Variance	Solar Variance Wind Variance	Solar Variance Wind Variance
Energy Market Operations	Peak Load Reduction (PLR) Energy Arbitrage (EA) Load Marginal Price (LMP) Opportunities	Peak Load Reduction (PLR) Energy Arbitrage (EA) Load Marginal Price (LMP) Opportunities	Peak Load Reduction (PLR) Energy Arbitrage (EA) Load Marginal Price (LMP) Opportunities
Ancillary Services	Fast Frequency Response Emergency Response Service Regulation Up/Down	Fast Frequency Response Emergency Response Service Regulation Up/Down	Fast Frequency Response Emergency Response Service Regulation Up/Down
Dist. Operations Support	Congestion Management (CM) Voltage Support Harmonics Loss Avoidance Power Factor Correction	Congestion Management (CM) Voltage Support Harmonics Loss Avoidance Power Factor Correction	Congestion Management (CM) Voltage Support Harmonics Loss Avoidance Power Factor Correction
Tx. Operations Support			

Figure 2-8 Customer Owned – Third-Party Aggregator Control Use Cases

This scenario can be applied to either residential or commercial installations, depending on available rate structures and/or utility incentive programs. Similar arrangements as described in the previous Section 2.7, could also be applied for grid-scale projects by large commercial/industrial customers.

2.9 Customer Owned – Autonomous Control

In this final methodology, the customer is likely to enjoy the benefit of full control over the DER with customer value applications prioritized, or perhaps the only applications enabled. Although limiting the potential value, Figure 2-9 represents the less complex nature of autonomous control with simplified operation, for customers without extensive knowledge of the electricity industry.

Application	Grid-Scale	Commercial	Residential
Customer	Demand Charge Reduction (DCR) Back-Up Power Time-of-Use (TOU)	Demand Charge Reduction (DCR) Back-Up Power Time-of-Use (TOU)	Demand Charge Reduction (DCR) Back-Up Power Time-of-Use (TOU)
Renewable Integration	Solar Variance	Solar Variance	Solar Variance
Energy Market Operations	Peak Load Reduction (PLR)	Peak Load Reduction (PLR)	Peak Load Reduction (PLR)
Ancillary Services			
Dist. Operations Support	Congestion Management (CM) Voltage Support Harmonics Loss Avoidance Power Factor Correction	Congestion Management (CM) Voltage Support Harmonics Loss Avoidance Power Factor Correction	Congestion Management (CM) Voltage Support Harmonics Loss Avoidance Power Factor Correction
Tx. Operations Support			

Figure 2-9 Customer Owned – Autonomous Control Use Cases

In certain cases, the utility may see a benefit even without enabling applications specific to utility value. As described in Section 2.1, customers with peak demands coincident with utility system peak demands may provide indirect benefit to the utility through DCR applications. This methodology may also apply to grid-scale. An example may be a large commercial/industrial customer installing a grid-scale system for backup power. On the other end of the spectrum, the ease of operation may be appealing to residential customers.

Section 3 **Conclusion**

3.1 SHINES Implementation

The Austin SHINES project attempted to incorporate as many of these models as possible for evaluation purposes. All DER assets in the project were, in fact, owned by the utility, Austin Energy, as per the structure of the partnership with the Department of Energy. However, in an effort to model other scenarios, the operation of some assets were not prioritized with utility value applications. The three control methodologies of DUC, third-party aggregator and autonomous were successfully demonstrated respectively:

- The two large grid-scale energy storage systems (KB ESS and MU ESS) were utility owned, and under direct utility control. The five utility value applications tested were congestion management, voltage support, energy arbitrage, real-time price dispatch, and utility peak load reduction. Also under DUC were the 12 Utility-Controlled Residential Solar PV via Smart Inverters, which were controlled for the utility value application of voltage support.
- The six residential energy storage systems as well as the electric vehicle were operated under aggregated control and were called upon for the utility value applications of congestion management, voltage support, energy arbitrage, real-time price dispatch, and utility peak load reduction. The three commercial sites were also operated under aggregated control, and although they were also utility owned, the demand charge reduction application was given precedence over the three utility value applications of utility peak load reduction, energy arbitrage, and real-time price dispatch.
- Six additional residential solar PV systems with smart inverters were enabled to run under autonomous control, providing voltage support.

3.2 Optimal System Performance

Optimizing the performance of a fleet of DER assets is determining the appropriate methodology from the options above based on the specifics of each application. The optimal solution will look different for each utility based on the several factors mentioned in this report, along with the goals of the utility and its customers. Rather than a one size fits all, successful DER programs will include a variety of these methodologies coordinated to operate in a holistic manner. All methodologies presented in this report come with costs borne by different entities. Final Deliverable 5 (FD-5) delves into the details of these costs, and how they contribute to the calculation of the System Levelized Cost of Energy (LCOE) as well as the impact of value applications in optimizing this cost metric.