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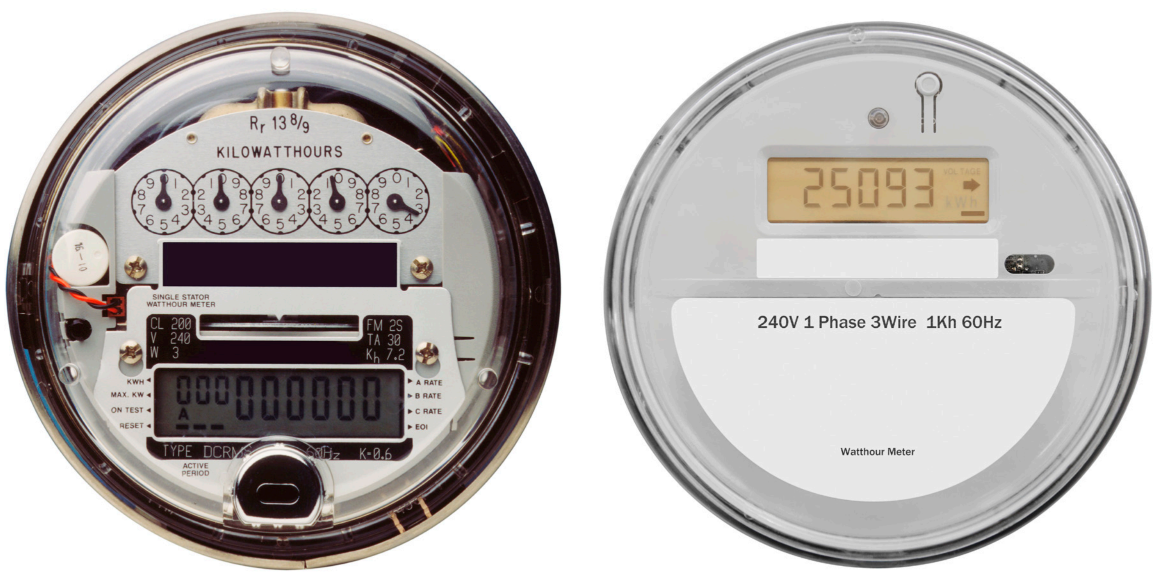
Implementing dynamic pricing
Meter configuration trade-offs



Deloitte Center for Energy Solutions

This paper explores the technical and financial impacts utilities may face as a result of selecting single-register (index) versus multi-register (load profile) meter configurations to support planned time-of-use and demand management programs.

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Hypothesis

Utilities choosing to implement Smart Grid solutions have many business and technical options which can lead to improved operational and asset efficiencies and enablement of demand management programs. This paper explores the technical and financial impacts a utility may need to address when considering meter hardware selection to support Advanced Metering Infrastructure (AMI), demand management, and dynamic pricing offerings. These meter configurations are defined below, and will be further explored from both technical and financial impact perspectives.

- **Single-register (index) meter:** Meter that records index values at configured intervals (i.e. every hour, half hour, 15 minutes, etc.). Direct measurement of interval data is not configurable. It is assumed that there is two-way communication capability to the AMI network and into the home, where possible.
- **Multi-register (load profile) meter:** Meter that can directly measure interval consumption at configured intervals. It is assumed that there is two-way communication capability to the AMI network and into the home, where possible.

The technical perspectives in this paper are focused mainly on configuration at the meter level. Although technical and financial impacts to other systems based on these meter configurations are discussed, it should be assumed that the AMI network capabilities (i.e. communication frequency with the meters), ability to store historical reads in the meter, and ability to store reads in the Meter Data Management System (MDMS) are the same in both approaches.

The financial impact analysis is based on high-level business case scenarios, where the impact analysis of the meter configuration options reveals that the utility's investment may significantly increase if the utility does not take the long-term perspective into consideration concerning business drivers, the regulatory horizon, cost recovery, scalability, and future performance capabilities that may require the implementation of advanced Time-of-Use (TOU) billing at a later date.

This paper explores the technical and financial impacts a utility may need to address when considering meter hardware selection to support AMI, demand management, and dynamic pricing offerings.

Technical configuration impacts and considerations

Demand management and dynamic pricing overview

Demand management has long established its usefulness in managing peaks and has been used quite effectively to mitigate capacity, regulation, and other reserve requirements. It has also proven to be useful in mitigating the need to engage in spot market energy procurement, and has been used as a tool to ensure system reliability. Demand response (enabled through direct/indirect load control), and dynamic pricing structures are common techniques used to address peak load capacity restrictions.

It is postulated that better alignment of the cost of electricity supply with demand, using dynamic pricing tariffs, can potentially yield multiple benefits to both the utility and their customers. Benefits include the potential to avoid or defer capital investments using load shaping, load shifting, peak load reduction, and transmission capacity optimization techniques. These in turn support reduced carbon emissions, increased asset utilization, and reduced operational costs—in theory, benefitting consumers with lower commodity charges.

It is postulated that better alignment of the cost of electricity supply with demand, using dynamic pricing tariffs, can potentially yield multiple benefits to both the utility and their customers.

Interval data has been touted for its ability to provide keen insight into demand and consumption profiles unlike what was available in the past. The same data is often referenced for its potential to provide end consumers with insight into their specific consumption patterns, providing the ability to modify their consumption behavior, and shift their demand to periods of cheaper supply. But is interval data truly required to implement demand management and dynamic pricing programs? Meter configurations will be evaluated in the context of dynamic pricing offerings. Consumers who can and do shift their load profiles from on-peak to off-peak periods based on pricing structures and/or signals thus support demand management programs.

Meter configuration

Smart meters are capable of measuring various parameters including interval data, index reads, voltage, outage conditions, and consumed and delivered energy. There is a difference in the method of determining consumption depending on meter configuration. Meter channels or registers define the measurement parameters, and can range from basic to complex, resulting in a broad range of costs and capabilities, which also impact integrations and back-office configuration.

Depending on the specific business drivers for a utility, there are multiple meter configuration options. Less costly, single-register configurations measure and store index reads. Index reads are subtracted from previous reads (in the MDMS or other system) to provide an aggregate view of consumption across that period (i.e. across the billing cycle or interval.) The subtraction process itself defines the fact that consumption was calculated. Smart meters with single-register configurations are programmed to measure and record index reads at the end of each interval, perhaps at the top of each hour, thus producing 24 values per day. Even with this configuration, the utility and/or the customer will only have an understanding of the average and total consumption across that time slice which may span multiple intervals. Insight into the consumption profile within the interval is not obvious. Although a single-register configuration can support TOU billing, the configuration will not support the implementation of more discrete and flexible tariffs enabling tactical demand response. Without the provision of register configurations capable of measuring interval data, advanced TOU tariffs and demand response strategies may not be possible without further investment.

Conversely, increasingly complex and comprehensive channel configurations typically lead to increased costs including meter assets, infrastructure, integration, and Head End/ MDMS/Customer Information System (CIS) system configuration. Most definitions of smart metering assume the inclusion of registers that measure detailed interval data, which is enabled through the multi-register meter configuration. In contrast to the single-register configuration, the multi-register configuration that allows pure interval measurement does not rely upon calculation algorithms—it is measured directly and can be aggregated directly. Both calculated and aggregated consumption data support basic TOU tariffs; however, many demand response solutions and dynamic pricing tariffs may not be possible without the use of true interval data.

Technical impacts of meter register configuration

Smart meters can be configured to measure multiple parameters at multiple frequencies. Dynamic pricing tariffs such as Real Time Pricing (RTP), Critical Peak Pricing (CPP), Peak Time Rebate (PTR), and basic TOU each require certain parameter and frequency combinations to ensure the data and capabilities in the meter support the implementation of the dynamic pricing tariff. To enable these tariffs and achieve the desired benefits, multiple applications need to be aware of meter register configurations. In addition to the meter, core applications that need to know the meter's configuration include the AMI Head End, MDMS, and CIS applications.

There are specific reasons that each system needs to understand the meter configuration. The AMI Head End requires awareness of the configuration to understand what information to request and expect from the meter. The MDMS requires awareness of the configuration to understand what data it will receive from the Head End as well as the type of VEE and billing determinant calculations the MDMS is required to perform. The CIS system requires awareness of the configuration to know what specific data to request from the MDMS to support billing. All of these systems require awareness of the capabilities configured in the meter to understand whether real-time event signals can be sent to specific meters. Enabling these systems to communicate and transfer accurate information requires a significant amount of application configuration and system integration efforts to enable an efficient, reliable, and secure infrastructure. This system integration is technically enabled using an Enterprise Service Bus (ESB) or other form of middleware to facilitate communication between these systems.

Creating and maintaining register configurations is typically a manual process within the MDMS, AMI Head End, and CIS systems—with the initial configuration normally created at some point during the procurement process. It is critical that this process is looked at from a holistic perspective so that the data that originates in the meter effectively travels through all systems. In order for each system to understand the data being transferred and to process the data correctly, there is usually a unique identifier used or a translation table to consistently map the meter's measurement channels and capabilities across these systems.

Smart meters can be configured to measure multiple parameters at multiple frequencies.

Assigning devices to meter configurations is commonly an automated process and utilizes the meter configurations created in advance. Since this is typically an automated process, a significant amount of system integration is required to assign the device in each system to the correct meter configuration. This process is usually triggered in the CIS system when a meter is assigned to a meter configuration, commonly during the back-office completion of the meter installation process or the meter maintenance process. Interfaces then notify the MDMS and Head End system that a new device has been created or an existing device has been changed to a different configuration. The order in which each system is notified is critical and often depends on the specific solution implemented. The integration process needs to be capable of handling sequencing so each meter in each system is configured in the correct order—resulting in the avoidance of data loss. For example, it may be required that the MDMS becomes aware of the configuration prior to the AMI Head End to ensure the MDMS is ready to receive reads once they begin to be transmitted and received. When an existing device is updated to a new configuration, an added level of complexity is introduced to ensure the MDMS and AMI Head End are in sync concerning when to expect data from the old configuration and when to expect data from the new configuration. The ability to keep these configurations in sync across the CIS, MDMS, AMI Head End, and meter is a core requirement that is consistent across both single-register configuration and multi-register scenarios. However, there are specific technical impacts and challenges for each configuration option.

The table below highlights some of the technical impacts and important points to consider when evaluating the implementation of a single-register configuration versus multi-register configuration. When evaluating the options, it is important to consider that single-register meters will not enable true dynamic pricing tariffs nor will the single-register meters support event-based demand response programs due to their inability to measure interval consumption on a near real-time basis.

Technical impacts and points to consider for single-register vs. multi-register configurations			
Category	Scope	Single-register configuration	Multi-register configuration
Demand response and energy efficiency objectives	• Load reduction measurement and verification	• Not designed for dispatchable peak load reduction • Supports aggregate load shifting to cheaper periods of supply • Less customer involvement; the customer could see more detailed usage information	• Supports dispatchable peak load reduction • Certain tariffs like CPP and PTR require baseline calculations (5 day average) to compare this to the actual hourly usage • Significant customer involvement. The customer will receive event signals as well as price signals and has to react to these signals in order to reduce their bill
Communication	• Reliable and secure transmission • Dependent on topography • Multiple standards	• A single-register configuration supports basic TOU tariff needs; collected and bucketed data once a month, at the time of billing	• Two-way communication of events to the customer, in addition to meter reads communicated at least every hour (24 hours x 30 days = 720 meter reads for a monthly bill), and prices every hour from a third party
Metrology/meter capabilities	• Many options of meter capabilities out in the market • No clear understanding where responsibilities for the new smart meters are (e.g., where is the system of record for specific data such as firmware version, meter soft switches, etc.?)	• Only one data stream (KWH) from the meter to the bill print is needed • To register total KWH is considered the basic for all available smart meters	• More costly meters • Multiple meter configurations (interval recording channel registers) have to be mapped all the way through the infrastructure architecture • Supports complex billing purposes (all DR Tariffs)
Data quality	• Solutions will only be as good as the underlying data • Processes for validation, editing, and estimating (VEE) of measurements have to be in place to improve data quality and billing accuracy	• Bills will be more accurate than the bills with consumption derived by a meter reader • The bill will still be basic to understand • Existing VEE rules in a current CIS system can be used	• Bills are more complex to understand for CSR and customer • VEE rules have to be defined in the MDMS
Integration	• MDMS has to integrate and translate hourly data, prices, events and meta data for different meter/ infrastructure vendors	• MDMS will need to be in place to store meter reads and potentially perform billing determinant calculations for TOU buckets	• MDMS serves multiple purposes to store and validate hourly data, prices, events and meta data for different meters
Meter replacement/meter deployment	• Utility needs a strategy and workforce to exchange conventional meters for smart meters	• The basic meter configuration will be similar to the conventional meter setting • Meter replacement is a “like for like” in regards to meter configuration and yields a significant advantage with planning	• Complex planning and replacement processes have to be in place in order to allocate the new meter configuration through all systems

Technical impacts of single-register configuration to support non-interval TOU billing

To support non-interval TOU billing utilizing a single-register configuration, there are certain application configuration, system integration, and other technical requirements and impacts. The CIS, MDMS, AMI Head End, and smart meter are all required to have an awareness of the single-register meter configuration and devices that need to be assigned to this single-register configuration. Keeping configuration in sync across systems is fairly straightforward for this type of configuration. Since the meter only records basic index data and the data is typically aligned with what the CIS uses to bill, the single-register configuration is similar in all of the aforementioned systems. This aids in simplifying the use of a translation table or other mapping scheme to ensure accurate data exchange between all systems.

In a single-register configuration, the meters record traditional index reads at the end of each interval. Consumption needs to be calculated for each interval by subtracting recorded index reads. The calculation can be performed in different systems, which means that there may be an impact on the solution depending on when and where the calculation is performed, as well as how the data is stored. The utility will need to choose whether they want to store the calculated consumption values in the MDMS or only store the index read at the end of each interval. In the event that the utility elects to store the calculated consumption values, a decision will need to be made as to whether this calculation is performed in the AMI Head End (if it is an option for the AMI Head End being used) or the MDMS. Consideration should be taken for customer web portal requirements, MDMS and CIS TOU calculation capabilities, and any other subscribers to the data. Certain customer web portals and TOU rate engines may require pre-calculated consumption values whereas others may be able to handle the calculation on the fly. Therefore, it is very important to understand the utility's particular requirements for storing consumption data due to the various impacts.

If the decision is to store the calculated consumption interval values in the MDMS, the result may prove to be more complex for the meter configuration synchronization process than storing in the AMI Head End. The reasoning behind the added complexity is that the physical meter would reflect a configuration in which the meter is only recording single index reads, while the MDMS would contain an interval "channel" that is storing the calculated consumption values per interval (this type of channel is commonly referred to as a "logical" channel). If the MDMS stores the calculated consumption interval values, the CIS would likely contain a configuration reflecting that of the physical meter and requires an awareness of what data to expect for billing. Purchasing meters where "logical" channels require calculations may increase the complexity of maintaining configurations across systems.

> Keeping configuration in sync across systems is fairly straightforward for {single-register} configuration.

Although certain configurations require a more complex set-up in the MDMS and AMI Head End, the impacts of the single-register meter are fairly minimal in the CIS itself. Since this configuration closely mirrors that of basic meters prior to the introduction of smart meters, the CIS should only see moderate change. Similar meter configurations and TOU rate calculations will likely be utilized. The most significant change would be ensuring that the back-office configuration of the device indicates that the device has the capability to communicate through the AMI Infrastructure rather than the meter reader's mobile solution. There are several attributes that need to be configured to support communication throughout the AMI Infrastructure. New meter attributes such as "meter communication type," "network type," and "meter capabilities" (e.g., remote read) will need to be configured. In addition, there is typically a status that indicates when the meter is actively communicating with the Smart Grid infrastructure that may require back-office configuration for monitoring purposes. Additionally, new meter characteristics such as "In-Home Display (IHD) capability" and "external battery types" may need to be configured.

Subsequent to the set-up, system integration is required to enable end-to-end communications. This will involve interfaces to create and assign devices to configurations in all systems, enable meter reading data transfer between systems, and enable billing determinant data transfer between systems.

It is possible to purchase multi-register smart meters that record interval data and still implement basic non-interval TOU billing.

One potential constraint related to single-register configuration is introduced when a utility decides to change meter configurations. In the ever-evolving Smart Grid industry, it is likely that a utility may want to change the data that is being recorded or expand the measurement capabilities to enable new programs.   Depending on the specific meter purchased, some meters can be re-configured manually or "over-the-air" to implement new register configurations. With a single-register meter configuration, it is likely that the meter will not have the capability to be re-configured "over-the-air" to record interval data. It is more than likely that the utility would be required to invest in new smart meters with multi-register read capabilities and perform physical meter exchanges to enable new data capture, measurement, and management capabilities. In addition, this change would require the technical infrastructure to handle larger volumes of meter data.

Optimization of the AMI network and the scheduling of meter read requests may be dependent on the type and amount of data that the meters are recording. If the AMI network and read schedules are optimized for a single-register meter, there may be impacts to the AMI network when switching to a smart meter where larger amounts of data are being captured. This could result in software configuration changes in the AMI Head End and MDMS as well as a potential need for additional network infrastructure and network optimization activities to ensure efficient and reliable communication continues with the increased volume of data.

Another key technology component that may help to increase consumer engagement in demand response programs is the In Home Display (IHD.) Depending on the IHD utilized and the capabilities of the meter, a single-register configuration may not provide adequate, granular information in order to make the IHD usable. If the meter can only provide the IHD register reads at the end of the interval and the IHD does not have the capability to calculate consumption based on the registers, constraints will be prevalent on the information the IHD is capable of displaying to the consumer.

Overall, while the single-register configuration can simplify application configuration and system integration, it can limit the ability to support more advanced TOU billing such as Critical Peak Pricing (CPP) and Peak-time Rebate (PTR) in the future. The advantage of this configuration option is that there are minimal impacts to the business processes in the back-office. The bill that the customer receives will look similar and back-office systems will treat the new smart meter like a conventional meter since it will have the same single-register configuration.

Technical impacts of multi-register configurations to support non-interval TOU billing

To support more advanced TOU billing scenarios such as CPP and PTR, the meter is required to record interval consumption values directly. However, it is possible to purchase multi-register smart meters that record interval data and still implement basic non-interval TOU billing. The most significant technical impacts to this approach result from the additional data volumes present throughout the systems. The utility may choose to have the meter record more advanced data, but not propagate this data to other upstream systems such as the AMI Head End or MDMS. If the investment is made in these multi-register smart meters, but the utility decides to implement basic TOU billing, the data required to produce billing determinants would be identical to the data for single-register meters. Similarly, the configuration effort for device management and back-office solutions will be very similar to the configuration effort described for the single-register configuration. The utility may choose to store the additional data in upstream systems, but there may be cost implications to infrastructure sizing. The additional data would likely require additional storage capacity in the MDMS, potentially increased bandwidth requirements in the AMI Network, and potentially increased throughput in the ESB.

Undoubtedly this solution requires a larger upfront investment throughout all the solution components including more expensive meters, larger storage, increased server performance for the MDMS, and increased bandwidth requirements. However, the multi-register meter may provide an advantage over the lower cost single-register configuration in its ability to support advanced TOU billing capabilities.

Since the smart meter is already recording the interval data required to implement CPP and PTR programs, and the option exists to store this data in the MDMS, achieving a smoother transition to more advanced billing scenarios is facilitated. Rather than having to purchase new meters and additional infrastructure, the changes would include incremental configuration and system integration changes to move from basic TOU billing to supporting CPP and PTR functionality.

The most significant configuration impacts would be related to billing determinant calculations in the MDMS (to handle the more advanced rates) and the CIS (to make the appropriate billing determinant requests, issue the corresponding peak event notifications when necessary, and perform rate configuration changes.) As a result, additional system integration would be required to provide the additional interfaces needed for these events and billing determinant requests. If the CPP or RTP programs support IHDs, there would be additional system integration work required as well. However, if a multi-register configuration was purchased up front, it is likely that the meter will already have the capability to measure and provide data needed to integrate with the IHD.

Additional costs for application configuration and system integration efforts to transition from basic TOU billing to advanced TOU billing would be required even if RTP and CPP were implemented immediately.

Overall, a multi-register meter configuration provides the utility with the flexibility to initially roll-out basic TOU billing and transition to advanced TOU billing with minimal technical impacts. The impact on the business processes for non-interval TOU billing will be minimal as described in the single-register approach, but will increase incrementally when the utility moves towards advanced TOU billing.

Technical impacts of multi-register configurations to support advanced TOU billing

The single-register configuration approach will not technically support an implementation requiring dispatchable demand response and advanced dynamic pricing tariffs. The implementation of event-based demand response programs such as CPP and PTR require a different approach.

Multi-register meters that record interval data will require a larger upfront investment than prior configuration options discussed. Propagation of interval data to upstream systems will be required to support CPP and PTR scenarios. This is very likely to result in increased costs for AMI network infrastructure, MDMS hardware, and ESB technical infrastructure.

To implement CPP and PTR tariff structures, utilities will be required to develop complex billing determinant calculations (which will need to take place in either the MDMS or the CIS). Since a MDMS typically has the capability to validate, edit, and estimate (VEE) large volumes of interval data, as well as perform billing determinant calculations efficiently, the calculations are typically accomplished in the MDMS. However, a change would be required in the CIS to identify the customers that are enrolled in the CPP or PTR program to ensure they are being billed accurately. Once the rate structure is finalized, the aggregation algorithm will need to be configured and passed through the necessary AMI systems.

Propagation of interval data to upstream systems will be required to support CPP and PTR scenarios.

The CIS system will need to provide the capability to create, edit, and store additional pricing algorithms. Once finalized, data integration to the MDMS must support the transfer of pricing signals and measurement parameters. Certain dynamic pricing programs store baseline consumption as a vehicle to compute usage reduction per customer during peak times. This creates additional system integration impacts because the CIS needs to be configured for the data to be integrated, processed, and displayed on the customer's bill.

In addition to billing determinant calculations, there is a potential need for advanced VEE rules in the MDMS. VEE rules will need to be defined and created in the MDMS to ensure that the CPP and PTR billing determinants are calculated using valid data. Additionally, VEE rules require definition so that invalid data can be identified and corrected prior to bill generation.

Additional technical efforts will be required to support CPP and PTR billing. Interfaces will need to be developed to support more advanced billing determinant requests from the CIS to the MDMS, as well as interfaces to communicate peak events to the MDMS, AMI Head End, smart meter, and potentially IHD.

Utilizing multi-register configurations to support advanced TOU billing has a significant impact on the design of the back-office business processes for device installation, meter reading, and bill display, as illustrated below:

- **Device installation:** Every device replacement may lead to a new, more complex configuration compared to the register configuration in the former device. Therefore, a process needs to be in place to match the old register configuration to the new register configuration. This is required to ensure correct billing, suppress bill data proration, or simply prevent a wrong bill.
- **Meter reading:** A decision must be made regarding which system will be the system of record to store billing-relevant meter reads. Back-office personnel may require training to enter and/or validate and update reads within a MDMS instead of the typical back-office system.
- **Bill display:** More data and complex algorithms are used to calculate the bill for these advanced programs. The data and calculations then need to be displayed and explained to the customer in the bill document.

Due to the substantial back-office impact introduced by advanced TOU billing, training and testing will be a significant undertaking to support interval advanced TOU (CPP and PTR) billing with multi-register configurations.

Utilizing multi-register configurations to support advanced TOU billing has a significant impact on the design of the back-office business processes for device installation, meter reading, and bill display […]

Business case impacts and considerations

Investment decisions and the business case

Utilities are continually faced with making investment decisions related to which meter configuration to deploy and integrate with their infrastructure. Many decision variables come into play including the utility's access to investment capital, business drivers and strategy, regulatory approval requirements for rate cases, and impacts to the utility and its customers.[1] Complicating the investment decision even further is the short-term versus long-term investment perspective; not just from a Return on Investment (ROI) viewpoint, but from a regulatory viewpoint. In the ever-changing Smart Grid ecosystem, unknowns are becoming commonplace. When implementing dynamic pricing programs, utilities face significant challenges concerning which investment path to take concerning technical infrastructure, meter configuration, system integration, and maintenance and training costs. These investments vary significantly because the costs to support advanced TOU billing capabilities are significantly higher than the costs to support non-interval (basic) TOU billing.

Investment scenarios

There are three potential investment scenarios explored based off of the meter configuration options available to utilities, as follows:

Investment scenario 1: single-register configuration to support non-interval TOU billing

Some utilities may choose to invest in meters with the single-register configuration for a number of reasons including compliance mandates to implement basic TOU functionality only or constrained funding to invest in an end-to-end, latest-and-greatest smart meter implementation with advanced TOU billing capabilities. The business case is often positive due to the low capital investment and corollary costs; this assumes that the technology and the customer programs are sufficient per the business drivers.

> {The} investments vary significantly because the costs to support advanced TOU billing capabilities are significantly higher than the costs to support non-interval (basic) TOU billing.

Although this option may seem frugal based on a utility's business drivers and/or capital constraints, there is a chance that the utility may want to implement a more robust solution in the long-term to enable advanced dynamic pricing programs. This is a risk concerning scalability for future releases.

Some single-register configurations are upgradeable and may be an economical option to turn on additional registers that measure interval data. Some meter manufacturers offer "pay-as-you-go" programs where the meter manufacturer provides a key to increase the number of registers in the meter. If the utility selects one of the meter vendors that provide this option, the utility would simply modify each meter by adding additional registers; a much lower cost than procuring new multi-register meters (and replacing existing meters.) However, all other costs to convert the dynamic pricing program to advanced TOU billing remain due to the requirements for the advanced functionality.

In the event that the utility cannot modify the single-register smart meters by adding registers, the utility will need to re-invest in multi-register assets. This approach creates duplicative and higher costs associated with

[1] Alcatel-Lucent Australia at EEA Conference & Exhibition "Smart Choices: Establishing a Solid Foundation for an Effective, Future-Ready Smart Metering System" <enterprise.alcatel-lucent.com/docs/?id=12458> 2009

meter acquisition, meter deployment, and supporting infrastructure. The utility may face stranded asset costs because the meters and infrastructure may not have fully depreciated and cannot be utilized for the new dynamic pricing program. These costs may be overlooked when the utility is initially making its investment decision. The re-investment and re-deployment approach will likely result in a negative overall business case. Therefore, utilities should approach these investment decisions with a long-term view in mind, and consider all configuration options in a holistic manner.

The following table illustrates the high-level cost impacts from a sample business case for Investment Scenario 1 (Note: all numbers are illustrative in nature, and pilot numbers are used for simplicity.) Please note that this example contains assumptions that some of the assets from the initial investment apply towards the re-investment.

Investment Scenario 1			
Initial investment in single-register smart meters & assets for basic TOU billing			
	Cost ($)	Quantity	Cost impacts ($000)
Electric single-register smart meter unit cost – residential	$100	10,000	$(1,000)
Electric single-register smart meter unit cost – commercial	$150	2,000	$(300)
Infrastructure			$(1,000)
Meter deployment	$50	12,000	$(600)
System integration			$(1,000)
Corollary (training and maintenance)			$(10)
Estimated initial investment for single-register smart meter pilot for basic TOU billing			$(3,910)
Re-investment in multi-register smart meters & assets for advanced TOU billing			
Electric multi-register smart meter unit cost – residential *(Single-register smart meters are stranded assets)*	$150	10,000	$(1,500)
Electric multi-register smart meter unit cost – commercial *(Single-register smart meters are stranded assets)*	$300	2,000	$(600)
Infrastructure *(Assumes additional investment of $500k to accommodate advanced TOU billing)*			$(500)
Meter deployment	$50	12,000	$(600)
System integration *(Assumes additional investment of $500k to accommodate advanced TOU billing)*			$(500)
Corollary (training and maintenance)			$(5)
Estimated re-investment for multi-register smart meter pilot for advanced TOU billing			$(3,705)
Estimated cost impacts for investment scenario 1			**$(7,615)**

Although {Investment Scenario 1} may seem frugal based on a utility's business drivers and/or capital constraints, there is a chance that the utility may want to implement a more robust solution in the long-term to enable advanced dynamic pricing programs, {leading to increased and duplicative costs.}

Investment scenario 2: multi-register configurations to support non-interval TOU billing

Many utilities will prepare for the future, but not necessarily invest aggressively up front. In this situation, a utility may elect to invest in meters with multi-register configurations that are capable of advanced TOU billing, but only implement non-interval (basic) TOU billing to save on the other costs and follow a prescribed deployment strategy. This strategy enables the utility to implement advanced TOU billing when necessary, with less financial strain. This typically results in a positive business case up front; however, the utility will experience a longer timeframe to break even on the investment since advanced TOU billing is not implemented initially.

Looking at the business case, the utility will invest more up front compared to Investment Scenario 1 – the primary cost differential being the multi-register smart meter itself. Taking this anticipatory approach will not incur the duplicative costs for meter acquisition and meter deployment. However, the utility will still need to re-invest in supporting infrastructure, system integration, and corollary expenses to enable advanced pricing tariffs.

The following table illustrates the high-level cost impacts from a sample business case for Investment Scenario 2 (Note: all numbers are illustrative in nature, and pilot numbers are used for simplicity.) Please note that this example contains assumptions that some of the assets from the initial investment apply towards the re-investment.

Investment Scenario 2			
Initial investment in multi-register smart meters & assets for basic TOU billing			
	Cost ($)	**Quantity**	**Cost impacts ($000)**
Electric multi-register smart meter unit cost – residential	$150	10,000	$(1,500)
Electric multi-register smart meter unit cost – commercial	$300	2,000	$(600)
Infrastructure			$(1,000)
Meter deployment	$50	12,000	$(600)
System integration			$(1,200)
Corollary (training and maintenance)			$(10)
Estimated initial investment for multi-register smart meter pilot for basic TOU billing			**$(4,910)**
Re-investment in assets for advanced TOU billing			
Infrastructure *(Assumes additional investment of $200k to accommodate advanced TOU billing)*			$(200)
System integration *(Assumes additional investment of $500k to accommodate advanced TOU billing)*			$(500)
Corollary (training and maintenance)			$(10)
Estimated re-investment for multi-register smart meter pilot for advanced TOU billing			**$(710)**
Estimated cost impacts for investment scenario 2			**$(5,620)**

[. . .] utilities that implement advanced TOU billing up front have the opportunity to realize benefits more rapidly.

Investment scenario 3: multi-register configurations to support advanced TOU billing

In the event a utility chooses to invest up front in robust smart meters with multi-register capabilities and supporting infrastructure, initial investments are higher than illustrated above in Investment Scenarios 1 and 2. Nevertheless, utilities that implement advanced TOU billing up front have the opportunity to realize benefits more rapidly. Although the investment will be considerably higher compared to the other two investment scenarios presented in the short-term, the business case still has the potential to be positive over the long run due to taking scalability into consideration and mitigating against external drivers that could force re-investments in meter acquisition, meter deployment, infrastructure, system integration, and corollary expenses.

Utilities that acknowledge evolving Smart Grid technologies, regulatory mandates and trends, business drivers, and consumer pricing trends over a longer horizon are likely to make more informed investment decisions that take technology and business scalability into consideration from the beginning, and forecast future drivers that may yield an impact.

The following table illustrates the high-level cost impacts from a sample business case for Investment Scenario 3 (Note: all numbers are illustrative in nature, and pilot numbers are used for simplicity.)

After reviewing the investment scenarios, Investment Scenario 3 appears to yield the lowest overall cost. Not reflected in these business case snapshots are the benefits of the business case and the realization timing thereof. The utility that implements multi-register reads for advanced TOU billing will likely realize benefits very early on, in contrast to the other configuration options, which will take a longer period of time with non-interval TOU billing.

Investment Scenario 3			
Initial investment in multi-register smart meters & assets for advanced TOU billing			
	Cost ($)	**Quantity**	**Cost impacts ($000)**
Electric multi-register smart meter unit cost – residential	$150	10,000	$(1,500)
Electric multi-register smart meter unit cost – commercial	$300	2,000	$(600)
Infrastructure			$(1,200)
Meter deployment	$50	12,000	$(600)
System integration			$(1,500)
Corollary (training and maintenance)			$(15)
Estimated cost impacts for investment scenario 3			**$(5,415)**

Concluding perspectives

While many AMI roadmaps properly and purposefully outline phased implementation strategies to align business processes with investment objectives, we believe it is critical for utility business owners to consider meter hardware impacts early in the selection and design process. While less expensive initial capital costs may be attractive for any reason, there is value in considering the entire roadmap and timeframe a utility has chosen to implement AMI, dynamic pricing, and demand management offerings. Although initial capital costs are more significant for investment scenario 3, they provide a shorter time-to-implementation of advanced pricing and demand management capabilities and help to realize smart grid benefits more quickly than other approaches.

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