THE **SMART REVOLUTION**

SMART INTEGRATED INFRASTRUCTURE WHITE PAPER

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The Smart Revolution

Introduction

The rapid development of innovative software applications, decentralized information networks and advanced communication and sensor technologies are revolutionizing the way we live. Black & Veatch is at the forefront of this revolution. The following whitepaper presents the framework for what we call *Smart Integrated Infrastructure*. From advancements through the Smart Evolution Cycle to the role of Smart Analytics in planning for a smarter future, it will address why the world as we know it is getting smarter and more integrated, the value and implications that brings society and how utilities and municipalities can prepare for it.

Why Get Smarter Now?

Without doubt the world is getting smarter. In the past two decades we've seen tremendous advances in technology. Whether you're talking about Big Data, Big Math, the Cloud, M2M communications, the near ubiquitous availability of high speed data coverage in developed regions, or advancements in personal and mobile computing, the way we interact with the world has changed significantly. The pace of change will only accelerate as we head further into the 21st Century.

Back in the 1990's, who could have imagined the magnitude of these changes and the impact they would have on our lives and communities. There have been several false starts regarding the implementation of smart technologies, as evidenced by the bursting of the dot-com bubble, but now many are achieving the level of maturity necessary to make solutions successful, indeed transformative. This convergence of applications, communications and technology is enabling the rapid development of services and capabilities in an unprecedented manner. According to the authors of *The Second Machine Age* (Brynjolfsson), we are at "an inflection point in the history of our economies and societies because of digitization" and this is creating many new opportunities and challenges for businesses and communities.

In parallel with these technology advances, the global economic and social landscape is rapidly shifting:

- Resources are getting scarcer;
- Commodities and energy are becoming more expensive;
- The world is undergoing the largest wave of urban growth in its history;
- Slow economic growth in areas like the United States is creating funding shortages at the Federal, State and city levels, which is in turn stressing the support of basic services;
- Society's expectations around quality of life and social responsibility are evolving;
- Climate change is increasing the focus on environmental sustainability;
- Changing regulations are driving the need for infrastructure upgrades and new business models;
- City finances are strained, driving a stronger focus on cost and waste minimization.

The focus on environmental sustainability is becoming more significant as critical resources are becoming more stressed, leading us to ask questions such as:

- How can we improve our water systems to prevent significant water losses and better manage energy use?
- How will we successfully transition to a cleaner, more diverse and distributed energy system without sacrificing service reliability?
- How do we intelligently invest in transportation systems to make them more efficient and address increasing levels of traffic congestion?
- How do we reduce food waste and crop vulnerability while balancing competing uses such as biofuels?
- How can we both mitigate and adapt to global climate change to ensure the safety and resiliency of our communities?

Meanwhile the global population is growing and becoming more concentrated in cities. How will we accommodate 700 million additional people in urban population centers over the next 10 years?[1] The United Nations projects that the world's cities will need to accommodate an additional three billion residents by the middle of this century, and a recent UN report suggests that 40,000 new cities will be needed worldwide[2].

In addition to accommodating this population influx with essential services, cities must also address evolving consumer expectations. In today's world of social media, online services, interactive phone and vehicle assistants, self-generated energy, medical diagnostics systems, and much more, there is a need and opportunity for cities to redesign their approach to what services are delivered, how and by whom.

The convergence of these trends – rapidly -evolving technology and changing economic and social landscapes – puts us on the pathway of a revolution that will change the way we live: a revolution that will set development trends for the next fifty years and propel us into the 22nd Century. This revolution in technology has been referred to in many different ways, picking up rally banners like Smart City, M2M, The Internet of Things and The Internet of Everything to name a few. As early as 2001 the California Institute of Smart Communities stated, "A Smart Community is a community that has made a conscious effort to use information technology to transform life and work within its region in significant and fundamental, rather than incremental, ways."[3] These are the type of changes that are starting to manifest themselves today.

Transformational Technologies

The scale of technology and computing power now available provides the catalyst and engine needed to address changes of this magnitude. Based on their latest research, Brynjolfsson and McAffee (Brynjolfsson) believe that we have reached a critical tipping point:

[1] Smart Cities Council (2013). *Smart Cities Readiness Guide*, Chapter 1, page 6
[2] Smart Cities Readiness Guide, Chapter 1, page 6
[3] California Institute for Smart Communities, 2001

"The full force of these technologies has recently been achieved ... Although computers will continue to improve and do new and unprecedented things, the key building blocks are already in place for digital technologies to be as important and transformational to society and the economy as the steam engine was to the Industrial Revolution."

Some examples have already started to establish themselves. In the power industry smart grid technologies such as advanced metering infrastructure (AMI), renewable energy sources, microgrids, advanced grid control and demand response systems are becoming mainstream. Within cities, we are seeing the first implementations of green transit options, intelligent street lighting and dynamic traffic management systems. In water systems around the world, advanced leak detection, innovative predictive maintenance and asset management solutions are taking hold as utilities strive to reduce costs and make the most of a resource under pressure. As pointed out in a recent Metropolis Magazine article[4], "we should also bear in mind that the smart revolution will be so broad and so deep that it's impossible to list all the present and future ways these technologies can - and will - reshape how and what cities, and their inhabitants, do."

Even though the implementation levels for these technologies are currently low compared to the size of the opportunity, they serve as critical building blocks for the smart city or community. The maturity of what are now commonplace artifacts of this digital revolution can provide the seeds of further innovation on a grand scale. As asserted in The Next Machine Age (Brynjolfsson p.80), "digital innovation is recombinant innovation in its purest form. Each development becomes a building block for future innovations; progress doesn't run out, it accumulates." Each building block increases the opportunities for new innovative combinations, thus the power to innovate and the opportunity to accelerate smart city capabilities lies in the speed in which the critical pieces are recombined into transformative solutions.

So just how big is the smart revolution? Anthony Townsend in the book *Smart Cities*[5] estimates that the software, sensors and communications elements for smart projects will represent between 1 to 3% of the overall worldwide construction budget[6]. Since it is anticipated that global infrastructure spending will be of the order of $40 trillion through 2030, this component of the smart market alone represents hundreds of billions of dollars[7].

Elements of a Smart Solution

The basic concept of a smart solution is the measurement of key system parameters, moving this data to a place(s) where it can be processed and the interpretation of this and other related data to provide improved insights and enable more informed actions and decisions toward the attainment of system

[4] Metropolis Magazine (Feb. 2014) "Big Data, Big Questions". Retrieved at: http://www.metropolismag.com/February-2014/Big-Data-Big-Questions/

[5] Townsend, A. (2013). *Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia*. New York: WW Norton & Company.

[6] Mathis, S. (Jan13, 2014). *The Rise and Fall and Eventual Rise Again of the 'Smart City'.* The Atlantic CityLab online. Retrieved at: http://www.citylab.com/tech/2014/01/rise-and-fall-and-eventual-rise-again-smart-city/8081/

[7] Mathis, S. (Jan13, 2014). *The Rise and Fall and Eventual Rise Again of the 'Smart City'.* The Atlantic CityLab online. Retrieved at: http://www.citylab.com/tech/2014/01/rise-and-fall-and-eventual-rise-again-smart-city/8081/

goals. In many cases, measurement of the required parameters generates huge volumes of data (Big Data) that are processed at the edge (Edge Processing) and/or centrally (often in the Cloud using Big Math).

It is the combination of sensors, analytics and the Cloud's limitless processing ability that enables the identification and understanding of complex relationships. Data from sensors or other systems can be repurposed to increase the knowledge or veracity of a particular solution. For instance, applying analytics to relate meter data to weather data to other situational data can dramatically increase our understanding of how energy is flowing and enable advanced energy management solutions. Advanced analytics can be used to "predict" what might happen in the future to further enrich data content and enable even smarter systems. Application of analytics in this way can be thought of, in simple terms, as a vehicle to create additional, powerful synthetic sensor data. This is an example of recombinant innovation at the most fundamental level.

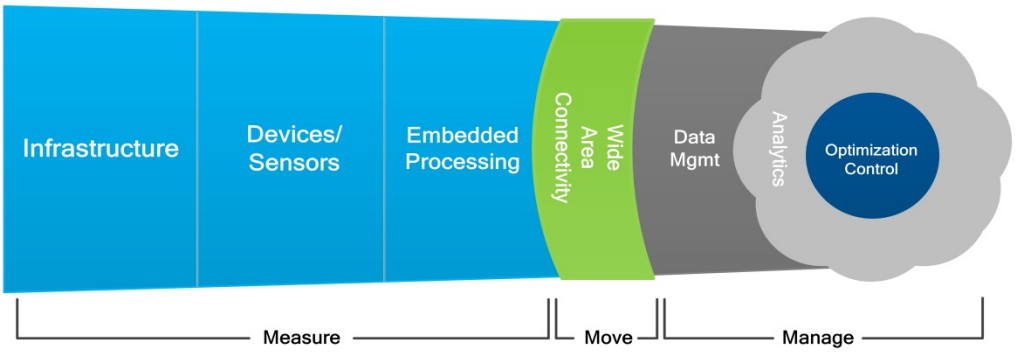

Figure 1 - A Simple Smart Solution Framework

While these systems can be highly complex, the majority of solutions can be distilled down to a relatively small number of fundamental elements. This simplistic view is not meant to minimize the range of technology options, the many ways they can be assembled, and the complexities of how they interact to deliver a solution, but rather to provide a framework that can be easily understood by a wide variety of stakeholders. This is important since it is stakeholders such as city managers, politicians, utility staff and regulators that ultimately prioritize these efforts and control the flow of money that will fund smart solution implementation. They will need such framework(s) to be able to develop or understand the business models needed to justify expenditures for such systems. It should be noted that not all potential smart solutions will have strong stand-alone business cases from the outset. But, they might in the future as the economics of doing business change or the solutions being considered are brought together to work in concert with each other (see Holistic Solutions Bring the Greatest Value).

Simplified Smart Solution Framework

Based on the observation regarding the distillation of a smart solution into a relatively small number of fundamental elements, a simplified smart solution framework is presented in **Figure 1**. This does not represent the complete picture but reflects the underlying components of the smart solution. This framework is based on the concept of, "measuring, moving and managing" data.

This simple smart solution framework consists of the following elements:

- **Hardware** – working in concert with infrastructure, a combination of devices, sensors, microprocessors and communications technology allow things to become aware of their environment:
    - **Infrastructure:** This is the foundation of the smart solution and includes things like water and wastewater treatment facilities, energy infrastructure, transportation systems, street lighting and waste management systems, just to name a few.
    - **Devices and Sensors:** These units are responsible for measuring key performance parameters relating to the infrastructure. Measurements can range from a few to many hundreds or thousands of parameters. Examples include measurements of temperature, power, volume, vibration, fluid flow, light levels, proximity and stress. The sensors may be part of the deployed infrastructure or retrofitted in the case of upgrading existing infrastructure.
    - **Embedded Processing:** With the processing power available today from relatively simple modem chipsets, data processing and even analytics can be undertaken at the edge. This data processing might consist of data aggregation, data parsing, local process control, etc. The advantage of undertaking edge processing is that it optimizes data and control flows by ensuring only the required information is passed to the central core.
    - **Wide Area Connectivity:** This describes the often complex web of connectivity path(s) required to transport data between the infrastructure under consideration to the central place(s) where it will be stored, processed and acted upon. These connective paths may include wired and wireless technologies including but not limited to fiber, mesh networks, local area networks and cellular networks. In many ways you can think of communications, or more generally ICT (Information and Communications Technology), as the glue that holds the smart solution together.

- **The Smart Software** – Smart Software complements and leverages the data coming from physical hardware and acts as the heart of any smart solution.
    - **Data Management:** Data must be aggregated and stored to be available for further processing into valuable information. Although utilities have traditionally favored firewalled and isolated standalone data storage located within their own network, Cloud-sponsored capabilities are quickly growing. The degree of data in the Cloud is often dependent on the size of the IT organization. In fact the capabilities of the Cloud allow smaller utilities or businesses to take advantage of the same tools that their bigger brethren use, further increasing the reach of the technology revolution.

- **Analytics:** Analytics applications are the brains of the smart solution and involve the discovery and communication of meaningful patterns in data to drive improved performance and identify future opportunities and risks. Analytics include the application of statistics, first-principle models, simulation and data aggregation techniques using data from a wide array of system-based or cloud-based sources. In addition to directing control functions, analytics are used to perform complex assessments of things like maintenance, operations or compliance strategies. Although centralized analytics are important for complex, multi-system challenges, the sheer volume of data is also driving some analytics to move closer to where the data is produced to enable faster action and require less processing.
- **Optimization and Control:** The final, critical step in this end-to-end model is to take appropriate actions. Realizing the value from data and analytics requires taking actions that positively impact performance. Analytics help control and manage "local" optimization systems by evaluating performance against system or "global" goals and helping to find the right recipe for improvements. Optimization and control closes the loop within the smart solution.

Supporting this framework, there are also a number of common elements that are critical to the success of the smart solution:

- **End-to-end security:** Security is a major consideration within any smart solution. This is particularly true for critical infrastructure such as electricity or water systems and for processes that require the transport of personal and financial information.
- **Power provision:** Smart systems cannot function without power. At the device/sensor level typically only low power is required but deployments can be in the hundreds or thousands of units and making power available at all locations can be a challenge. For centrally-based elements, like Cloud-based analytics and control systems, there are just a few physical installations but their power requirements are more onerous. Where new infrastructure is being deployed, power provisioning through the local utility is often required.
- **Local communication paths:** In addition to wide area connectivity, the majority of smart solutions will incorporate many localized connectivity paths. These paths make use of a variety of wired and wireless communications technologies. With so many and such diverse potential for communication paths, it is important to manage how data is routed and which end-users it reaches. Further, different data types require differing levels of Quality of Service (QoS), often entailing the prioritization of different traffic flows.
- **Data Quality and Veracity.** It is critical that data quality and veracity is adequate for the job at hand; it is often necessary to employ specialized analytics to cleanse and/or augment the raw data streams.

Holistic Solutions Bring the Greatest Value

From early project successes, we know that some smart solution business models will stand on their own from day one. For instance many utilities were able to show that Advanced Metering Infrastructure (AMI) investments would result in an attractive payback period as the result of meter reading and billing efficiencies and a greater awareness of energy usage by consumers which led to reduced energy consumption. Combine these with the potential benefits of load shifting brought about by time-of-use based electricity tariffing structures, and data analytics that leverage meter data for conservation voltage reduction (CVR) and asset management programs, and it is no surprise that many smart metering systems have already been deployed.

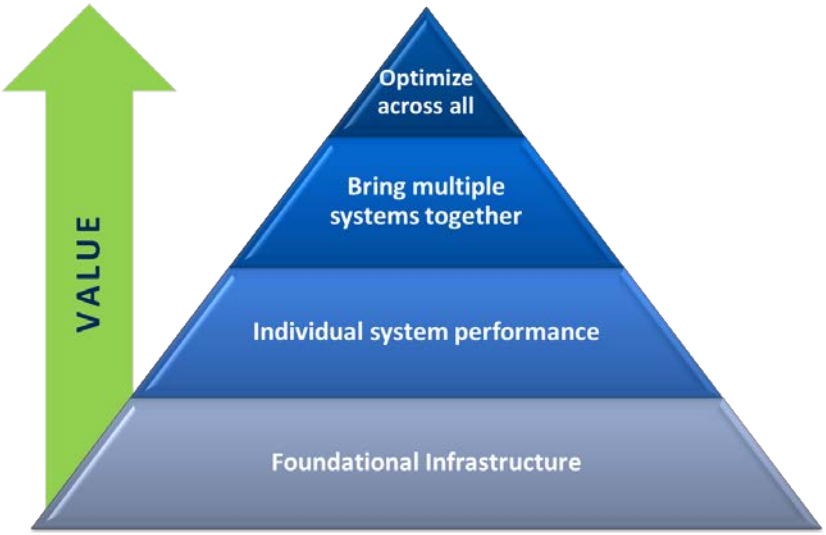

Figure 2 - The Smart Evolution Cycle: Building toward Smart Integrated Infrastructure (SII)

However, for many smart solutions things get most interesting when multiple systems are aggregated together within their own verticals or across industries. Now the greatest synergistic value can be realized in terms of cost savings, reduced environmental impact and other benefits. It makes no difference whether you are considering solutions implemented at the building, campus, regional or even national level - the greatest return on investment will typically be achieved when systems work in concert in a holistic fashion. **Figure 2** illustrates the concept of what can be referred to as the Smart Evolution Cycle.

Smart solutions are built on a foundation of infrastructure - either through a retrofit or the deployment of new equipment. We start the Smart Evolution Cycle by optimizing the performance of an individual process or system through the use of sensors, analytics and control. Only, however, when multiple related systems are brought together through the use of overarching software and services does the real potential for *Smart Integrated Infrastructure (SII)* get realized. Processing cross-functional data sets provides greater control and predictive precision and further allows for the computation of solution sets not previously possible. Ultimately, by leveraging many data sets that span diverse facilities, systems and purposes, we can optimize the functions of interrelated infrastructure systems – bringing the greatest potential for transformational change. Of course, none of this is possible without the proper people and processes in place to use these solutions to deliver benefit – but that is a topic for another day. In addition to those factors driving the smart evolution cycle, we're also able to realize the following more fundamental benefits:

- Automating traditional manual processes or activities to reduce time and complexity and eliminate error;
- More rapidly and effectively presenting information to users and decision makers to allow action to be taken;
- Reducing the duplication of effort - when efforts are confined to departmental/solution silos, functions are needlessly repeated ;
- Reducing costs through infrastructure sharing - we can reuse items like geographical information systems (GIS), communications networks, cyber security designs and implementations, database management systems and enterprise service buses;
- Reducing costs by reusing software modules – elements include such software as data historians, analytics platforms and content management systems;
- Looking at problems collaboratively makes it easier to share code modules between different applications, minimizing programming time;
- Adopting common best practices - such as a universal security framework across many solutions, standard integration protocols and API's.

This allows us to take the Simple Smart Solution Framework shown in **Figure 1** and develop this to represent a Holistic SII Solution Framework – see **Figure 3**.

While the individual foundational infrastructure requires a dedicated set of devices, sensors, edge processing and analytics elements, once data is brought back through to the central core, it can be stored, accessed, processed and acted upon by common element(s). These can take full advantage of seeing the complete data landscape rather than that viewed when looking only at one solution. Of course this graphical representation is much more linear and simplistic than the real world, where there are interconnections and information sharing at many levels and in many different ways.

The Role of Smart Analytics

If infrastructure is the foundation of the smart solution, and ICT is the glue that holds the system together, then analytics are the brains. Smart Analytics provide context to problems and enable a much clearer view into what is an increasingly complex and muddy world.

Addressing large, complex and dynamic optimization challenges requires an understanding of where we are, where we want to go, and how to get there, while navigating around constraints. It requires influencing a wide range of actions from real-time control to asset management to the deployment of new infrastructure. It means adapting to the massive scale of change happening within a community system. We need to be able to plot an optimum course and then adapt as the situation warrants.

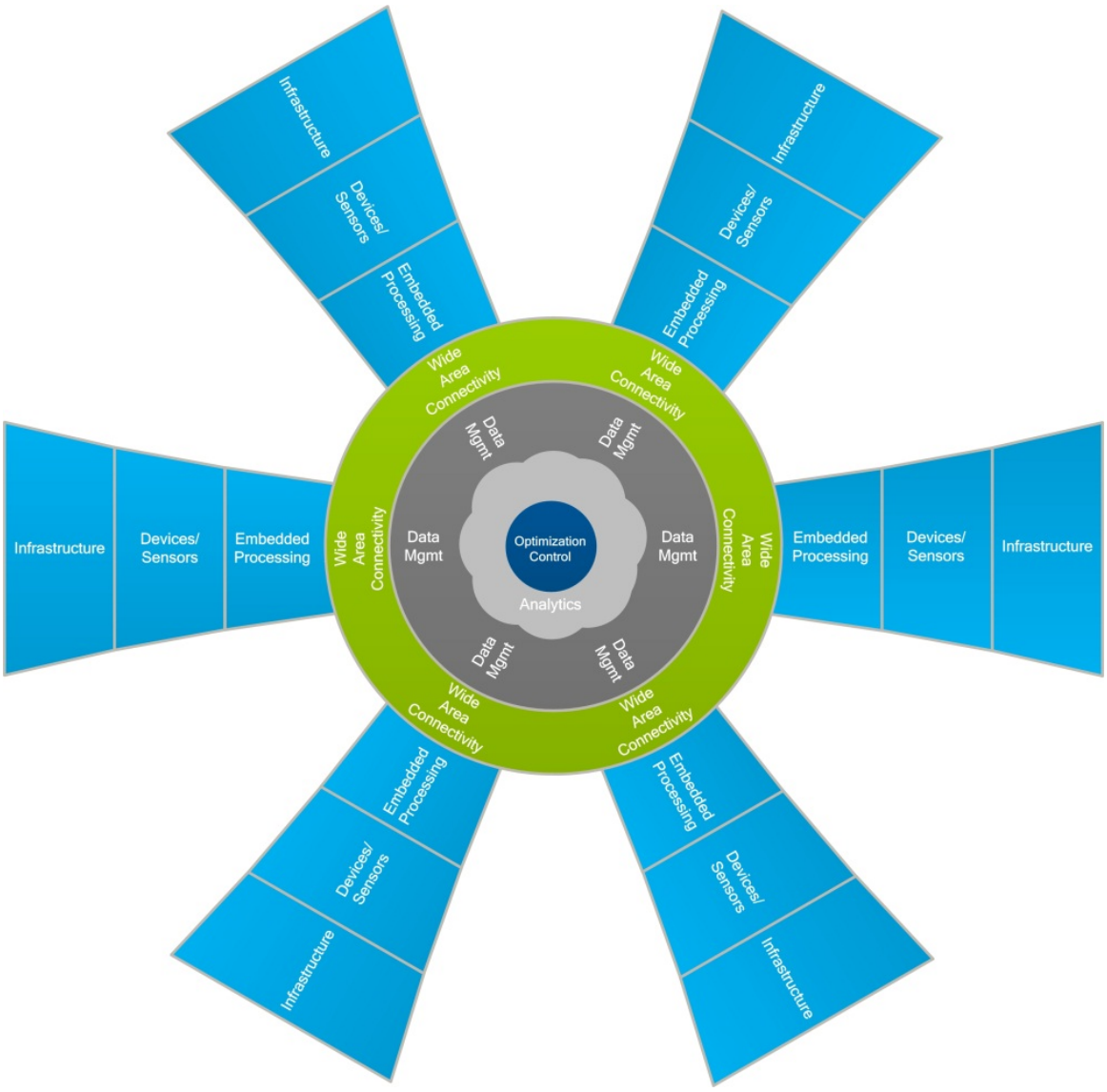

Figure 3 - A Holistic Smart Integrated Infrastructure Solution Framework

To successfully implement such a solution takes an enterprise data management and analytics approach that can integrate, structure and manage data from many systems, formats and time scales. Further, the application of advanced analytics using past and current data to address current needs as well as predictive/simulation techniques, facilitates understanding of the optimal path forward.

Example: 360-degree Asset Analytics

Figure 4 illustrates Black & Veatch's analytic platform structure, ***ASSET360™***. It is designed to provide a holistic 360-degree understanding (past-present-future) of infrastructure-based systems from a common "lens" – providing a single point of truth for short-term and longer-term decisions and actions. It improves asset performance and mitigates long-term risk through the use of two inter-connected components:

- **Operational Intelligence:** Improves and sustains performance and operations through asset monitoring, anomaly detection and diagnostics, smart management of identified issues, system performance tracking, and specialized modelling and analytics of individual processes.

- **Adaptive Planning:** Focuses on optimizing operational, strategic, and asset planning processes to provide a better understanding of options, risks and impacts of alternative scenarios, an understanding of planning interdependencies, and the ability to adapt plans to evolving market and operating conditions.

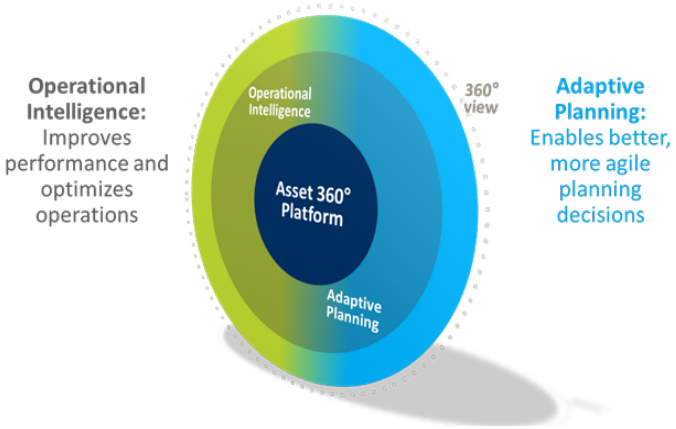

Figure 4 - Smart Analytics Enable a 360-Degree System Perspective

In addition to using performance data coming directly from the infrastructure under consideration, valuable data also comes from other diverse external data sources, such as:

- **Weather data**: For things like system modeling, predicting renewable energy commitment and dispatch, predicting asset wear-and-tear, and wet weather planning;
- **Geographic data:** With geographically distributed assets new uses of geospatial information continue to emerge - one example is the optimization of energy storage usage across multiple feeders based on predictive supply and demand;
- **Pricing data:** Coming from the suppliers of resources used by the smart solution. An obvious example is market pricing signals for electrical energy.

Analytics Next Steps: Adaptability and Continuous Improvement

Traditionally, the storage and evaluation of data has created visibility into what has happened within many utility and community processes. Today, communications systems and analytics possess the horsepower and bandwidth to allow presentation and analysis of real-time asset data to show what is happening now. But as we look to really take advantage of analytics we need to turn our attention to predicting and influencing actions. The better we understand what will happen under certain conditions,

the better we can address risks and issues and identify how to alter performance targets to optimize a wide array of assets to meet higher-level goals.

The final frontier, the infusion of cognitive capabilities into analytic systems, would offer an unprecedented step forward. This will be detailed more in future whitepapers but in simple terms, this means that data continues to be used by the system to refine its predictions, improve its understanding of dependencies or interdependencies between systems and objectives, and, hence, its ability to continue to refine and optimize performance.

The impact of this final step will become even more critical as the world becomes more complex, the number of participants (man and machine) explodes, and goals get transformed by political and technological forces. Today, we look to infuse agility into operations, asset management, and performance optimization by driving analytics off of an increasingly-rich dataset; in the future, we will look to directly alter and improve algorithms, models, and systems to, in effect, "learn" or evolve capabilities.

If we return to the idea of recombinant innovation, think of the cumulative power in three dimensions:

1. Adaptive, evolving asset models;
2. The application of such capabilities to an increasingly-large population of assets to achieve scale;
3. The ability to apply analytics across a wider range of problem domains, such as resiliency, resource management, sustainability and quality of life.

It is a big idea and a big challenge but we are already seeing examples today in the utility space where scale of data combined with advanced analytics are yielding new insights and new opportunities:

- **Volt/VAR Optimization** - Voltage reduction can be measured and refined on a circuit-by-circuit level by leveraging AMI-collected voltage data in concert with SCADA and power systems equipment and traditional power flow models;
- **Buried infrastructure** - The level of investment or areas of focus can be optimized for rehabilitating buried cable or water supply networks by predicting changes in failure rates and implications as a function of strategy;
- **Optimization Systems** - Advanced inductive math is applied to identify optimal control protocols to improve efficiency while maintaining or enhancing environmental compliance.

Different problems will dictate different levels of complexity and widely-varying needs for advanced analytics. Practically speaking, it is important to think about how to dial in the right amount of analytics needed to address any particular problem and then how to assemble an increasingly-larger and more powerful solution from among the pieces.

Smart Solutions on a City Scale

So what types of transformational change might be seen? Consider the following example set in a medium-sized progressive city where the city utilities (electricity, water and waste water management) are working in harmony with other smart city solutions. In this city, forward thinking telecommunications planning has provided shared, ubiquitous high-speed data coverage leveraging commercial cellular and wireline services, as well as targeted private wireless data network deployments using assets such as newly retrofitted intelligent street lighting solutions. In addition to shared communication pathways, the City ICT Master Plan has been largely implemented to provide city and utility services common access to cloud-based storage, analytics and control applications, protected by the umbrella of a system-wide cyber security architecture.

While covered in the news and featured in many respected trade journals, to the citizens of this city the only obvious manifestations of this smart city implementation are the City Community Service mobile application (with features like energy and water efficiency dashboards, and methods of reporting a multitude of city related service issues) and a number of city-sponsored and third-party mobile applications that allow for the intelligent control of such things as home heating, lighting and security, plus applications that allow residents to reserve parking spaces in the downtown area, pay for public transport and HOV access and provide information on local events and services.

For instance, picture a sunny summer day and a mother and child who are on their way to see an afternoon movie screening in the downtown area. As they drive through their neighborhood the mother realizes she has left on the iron but rather than turning around and heading back she simply pulls over to the curb. Safely parked she uses one of these applications to switch off the plug feeding the iron; something she can do with every electric socket in her house. While this is activity going on behind the meter, the electricity coming into her house is now being managed by a whole host of smart grid technologies that have shaved the utilities peaking plant capacity requirement by 4% in the last year alone. Demand-side and behind-the-meter advanced energy storage systems and advanced analytics interpreting real-time grid conditions and utilizing both weather and instantaneous cloud cover measurements have made these savings possible. This same weather information, would if it had been raining have caused the smart traffic monitoring system to redirect some portion of afternoon traffic onto surface streets (avoiding areas where flash flooding is predicted to occur) in order to maximize traffic flow. Today, however, it is bright and sunny and thus the in-car navigation system only adjusts routing directions based on current traffic conditions and the availability of parking spaces close to the mother's destination. Parking availability, both current and at the mother's estimated time of arrival is predicted by interpreting occupancy data coming from embedded sensors in the parking infrastructure, knowing parking behavior patterns for that area of town, and of course accounting for local events and weather information.

Now that the house is empty, motion and proximity sensors realize that no one is home and the thermostats automatically adjust a few degrees upwards reducing electric air conditioning consumption. This reduction in power draw tips the operating point of the installed residential solar/battery storage system so that the house is now producing more power than it is using and this allows energy to flow

back into the grid – the aggregated effect across thousands of unoccupied homes further reduces peak demand for the city utility.

By the time the mother and child leave the theatre, darkness starts to blanket the city and the intelligent street lights they walk under adjust their output illumination to light their way safely back to their parked car. This same street-lighting infrastructure, which has reduced the city energy bill by 43% annually, is used to host many other sensors (including cloud cover, security, proximity, traffic-flow and urban noise) as well as forming the backbone of a private data communications network. At the same time, CCTV monitors the area the mother and child are walking through. While these images are monitored manually in a central operations area, face-matching computer algorithms rapidly scan all within sight of the security cameras and alert police officers to known persons of interest. These are just a few of the many interconnected systems and applications that are running twenty-four hours a day within this smart city of the not-too-distant future.

Building a World of Difference

As a leader in Critical Human Infrastructure™, Black & Veatch recognizes the strong economic, environmental and social drivers for smarter, more integrated infrastructure systems as well as the new technology-enabled opportunities to deliver on the promise. We have created a dedicated business to help explore and develop smart solutions for communities, utilities, campuses, private enterprises and others.

The Smart Integrated Infrastructure™ (SII) Group takes a system-wide perspective to architect end-to-end smart solutions that consider such things as:

- The interrelationships between different aspects of planning and operations to optimize against diverse objectives and constraints;
- Leveraging data from increasingly intelligent and inter-connected assets to deliver new sources of knowledge, efficiency and value;
- The Implementation of communications networks and sensors that enable the creation and flow of information across systems;
- Managing and leveraging data to improve individual system performance;
- Optimizing interconnected processes across the organization;
- Helping you to become a participant in a larger “smart community” ecosystem to reflect broader environmental, societal and economic dependencies.

In addition to this integrator perspective, Black & Veatch brings particular expertise to bear in the areas of Management Consulting, Smart Analytics and Engineering, Procurement and Construction. Black & Veatch works with world renowned partners to bring the overall smart solution together. For more information about how Black & Veatch solutions can help you with your smart infrastructure needs, please contact Gary Hawkins (HawkinsG@bv.com) or Jennifer James (JamesJA@bv.com). White Paper *Lead Author: Gary Hawkins, Smart Technologies Solution Lead*, Black & Veatch.

Works Cited

Brynjolfsson, Erik & McAffee, Andrew. *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*. New York: W.W. Norton & Company, Ltd., 2014.

Mathis, S. (Jan13, 2014). The Rise and Fall and Eventual Rise Again of the 'Smart City'. The Atlantic CityLab online. Retrieved at: http://www.citylab.com/tech/2014/01/rise-and-fall-and-eventual-rise-again-smart-city/8081/

Metropolis Magazine (Feb. 2014) "Big Data, Big Questions". Retrieved at: http://www.metropolismag.com/February-2014/Big-Data-Big-Questions/

Smart Cities Council (2013). *Smart Cities Readiness Guide*.

Townsend, A. (2013). *Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia*. New York: WW Norton & Company.

California Institute for Smart Communities (2001). *Ten Steps to Becoming a Smart Community.* Retrieved at: *http://www.smartcommunities.org/library_10steps.htm*