B. Liner and A. M. Farid, "Extending the utility analysis and integration model at the energy water nexus," in First IEEE International Smart Cities Conference, (Guadalajara, Mexico), pp. 1–4, 2015.

Extending the Utility Analysis and Integration Model at the Energy Water Nexus

Barry Liner, Ph.D., P.E.
Water Science & Engineering Center
Water Environment Federation
Alexandria, USA
bliner@wef.org

Amro M. Farid, Ph.D.
Mechanical Engineering, MIT
Engineering Systems & Management, Masdar Institute
Abu Dhabi, UAE
amfarid@mit.edu

***Abstract*— In the coming decades, water utilities will be exposed to greater pressures. Some of these, like ageing infrastructure, and decreasing availability of public funds are old but set to intensify. And yet others like energy efficiency, climate change, and resilience in smart cities are emerging drivers. A conceptual reference business model (Utility Analysis and Integration Model, or UAIM) that defines the essential aspects of utility performance and provides a structure that allows utilities to accelerate and sustain overall performance improvement was introduced to provide tools for improving the overall utility performance prompting reliance on the individual talents and extensive experience of utility managers in the industry. The UAIM seeks to leverage the significant improvements in local performance, aided by diverse technologies and automation (e.g. software, IT systems) that target specific user groups and business processes within a utility. The UAIM concepts of People, Process, and Technology overlaid with Strategic, Technical and Operational dimensions can provide powerful insight into operations of an infrastructure enterprise at a micro-level or intra-utility perspective. As we seek to solve increasingly complex infrastructure challenges which span multiple sectors (water, wastewater, energy, solid waste, etc.), the UAIM can be extended to a cross-sector perspective**

Keywords—Water energy nexus, Enterprise reference model

I. INTRODUCTION

Water utilities are undergoing a sector-wide transformation from the traditional role of water treatment to one of resource recovery and management. The 2011 Water Environment Federation (WEF) Renewable Energy Position Statement states:

"Wastewater treatment plants are not waste disposal facilities but are water resource recovery facilities that produce clean water, recover nutrients (such as phosphorus and nitrogen), and have the potential to reduce the nation's dependence on fossil fuels through the production and use of renewable energy and the implementation of energy conservation." [1]

It clearly calls attention to the changing role of the water sector to ensure sustainable resources management. In 2013, WEF, the Water Environment Research Foundation (WERF), and National Association of Clean Water Agencies (NACWA) reiterated this view in the form of a seminal thought piece that called to action: "The Water Resources Utility of the Future: A Blueprint for Action."[2] The blueprint defines evolving environmental, economic, and social roles that clean water utilities are playing in their communities, with the intent that utilities will use the blueprint to transform the way traditional wastewater utilities view themselves and manage their operations. It explores how traditional publicly owned treatment works have mastered their core wastewater treatment function and now are redefining themselves as resource recovery agencies and vital community enterprises. This integrated and multi-functional role will require an equally integrated enterprise of the utility. The new sustainable multi-functional water utility must also look outwards beyond the boundaries of its organization. For example, water and electric utilities must cooperate on energy efficiency issues.

As part of The Johnson Foundation's Charting New Waters program, experts at their meetings called out this shortfall, particularly in the convening report, "Building Resilient Utilities: How Water and Electric Utilities Can Co-Create Their Futures." [3] One of the identified key challenges to a more sustainable water sector is the lack of systems thinking:

"At a fundamental level, there is a lack of understanding between sectors about their respective operational needs and constraints, as well as a lack of broad systems thinking about the interdependencies between them."

This statement is equally true at the within the water utility enterprise. Therefore, the transformation of the water opportunity will provide opportunities for water professionals to embrace industrial engineering, systems analysis, and change management techniques to enhance the sustainability of our critical civil infrastructure.

Vitasovic et. al. [4] explored the idea that improvements in overall performance can also be gained if different domains of the enterprise are better coordinated through a Utility Analysis and Integration Model (UAIM). This effort focuses on

developing an implementable model for developing a holistic approach to utility management that considers interactions between different components and improves overall system performance through integration.

II. Concept

With the aspirational goals of transforming water and wastewater utilities to Water Resources Utilities of the Future or even Integrated Utilities of the Future, leaders and decision makers require the means to move on the pathway from the current state towards these visions of "utilities of the future."

The water sector presents unique characteristics. It is heavily regulated in many areas. The environment acts as a "non-paying customers". And many view water as a fundamental human right rather than a for-profit commodity for sale. Nevertheless, enterprise integration and its underlying methods in model-based systems engineering have a universal characteristic in much the same way that all business have the traditional management functions e.g. (strategy, accounting, and human resources.) Many of the same principles may be applied with some modification to this unique context.

Ultimately, one key advantage of enterprise integration is that it is an incremental process that does not require full integration at once. Instead certain process of the utility become modeled as priorities and resources allow. Over time, and as part of a maturity model, the full enterprise integration model is developed. Of course, as more of the enterprise integration occurs the more that synergies become apparent and the utility can begin to leverage true economies of integration.

Developing a practical and accurate overall model of how a utility actually works is considerably more difficult than developing a model for a physical, chemical, or biological process. It is in fact so difficult that most people have so far considered this to be impossible: this is why we do not have different models of "how a utility works" available to us. There are a number of enterprise control models (such as ISA 95, GERAM, PERA), but they focus on the enterprise and operational integration in for-profit industries and are primarily IT-centric. [5] There are also a number of maturity models, such as Smart Grid Maturity Model (SGMM) and Capability Maturity Model Integration (CMMI), to address organizational maturity and performance.[6] The application of either (or both) the existing enterprise control systems and maturity models is difficult in the water sector. Water resources utilities performance is not principally tied directly to profit measures, but also include a substantial contribution to supporting the provision of ecosystem services. Utilities have "non-paying customers" in the environment.

The Utility Analysis and Integration Model (UAIM) proposed to use integration to enhance performance and efficiency in the water sector.[4] This UAIM is applicable at the enterprise level in both the micro level (intra-enterprise within the water utility) and the macro level (inter-enterprise with related natural resource or infrastructure sectors including electricity, Stormwater, natural gas, and solid waste. The graphic below shows the UAIM as applied at the micro level at the water enterprise.

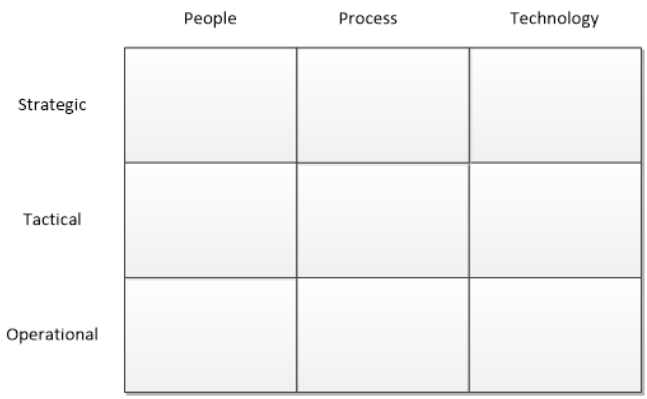

Fig. 1. Conceptual Representation of the Utility Analysis and Integration Model (UAIM)

According to the thought leaders participating in the Charting New Waters initiative, we will need systems approaches to the provision of infrastructure services across related sectors. This idea extends the UAIM across sectors in accordance with the Principles for the Integrated Utility of the Future identified by Charting New Waters.[3]

The utility of the future will provide water delivery, wastewater treatment, energy generation and solid waste management services in an integrated way that optimizes the use of all resources and eliminates waste. Key principles include the following:

- Apply systems thinking and triple-bottom line analysis to all management decisions, including design, construction, operations and maintenance.
- Do no harm, and go beyond compliance.
- Measure success based on environmental, climate and other nonfinancial performance criteria.
- Right-size facilities and operations for the customer base, and allow for future flexibility.
- Leverage diverse sources of financing.
- Engage customers as resource management partners.[2]

The graphic below shows the UAIM as applied at the macro level across related infrastructure utilities or natural resources management stakeholders.

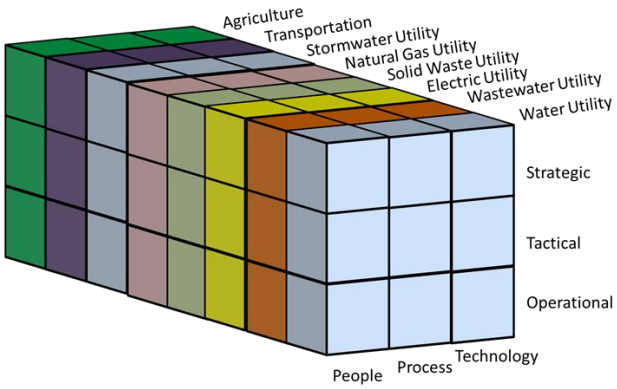

Fig. 2. Conceptual Representation of the extension of UAIM across interrelated infrastructure sectors

The cross-infrastructure sector approach can already be seen in emerging frameworks, especially between water and energy. The application of these concepts is exemplified by research and the living laboratory at the Masdar Institute in Abu Dhabi.[7] From a managerial level standpoint, this integration is highlighted in frameworks which complement the UAIM such as the WEF Energy Roadmap.[8]

Water industry leaders identified the need for an energy roadmap to guide utilities of all sizes down the road to overall sustainable energy management through increased renewable energy production and energy conservation. This roadmap leverages a framework developed by the electric power sector's Smart Grid Maturity Model (SGMM). The basis of the Energy Roadmap was developed by water and power industry leaders who analyzed successful utilities in Austria, Holland, Australia, and the United States. High level, strategic best practices were identified and organized into topic areas, which define the level of progression towards achieving energy sustainability.

Using a management systems framework, WEF's Energy Roadmap [9] is a series of steps to help water/wastewater utilities plan and implement an energy program. Steps are arranged under various topics, from technical needs to managerial aspects and are applicable to small, medium, and large facilities. The steps are arranged under six topics. Under which, the steps are organized into levels of progression. The first set of steps enables the organization. The second set integrates energy efficiency and generation into the organization's structure, culture, communications strategy, and technology. The last set of steps involves optimizing current processes and procedures. The topics are as follows:

- Strategic Management: High-level management policies and practices that lay the foundation for sustainable energy management
- Organizational Culture: Implementation of an energy vision to create an organizational culture that values energy efficiency at all levels and supports an energy champion and cross-functional energy team
- Communication and Outreach: Tools for effective two-way communication with key stakeholders around energy management
- Demand Side Management: Methods to assess and reduce energy use and energy costs
- Energy Generation: Tools for utilities to evaluate whether and how to increase onsite renewable energy production and/or investments
- Innovating for the Future: Guidance for utilities of all sizes to leverage existing research, further in-house innovation and manage risk associated with these ventures

The Strategic Management topic area specifically calls out both integration of strategy, tactical and operational levels within the utility (UAIM concepts applied at a micro level) and collaborative partnerships between water, wastewater, electricity, natural gas, and solid waste utilities (UAIM concepts at a macro level).

III. Setting the Stage for Implementation

Developing the UAIM and fleshing out key components can be done with the help of the community of leading edge innovative utilities, academics, consulting engineers, research foundations, associations, and organizations that support the sector. The critical point in the development of this UAIM is to have an implementable framework. The water sector has been plagued by inconsistent adoption and ineffective use of management models or benchmarking efforts such as Qualserve, Effective Utility Management (EUM) [10], and The Partnership for Safe Water. All of these were good ideas, but implementation has been uneven, often through no fault of the leaders who championed them. The transition to a resource recovery paradigm espoused in the Utility of the Future will continue to drive the water sector towards more integrative management. This transition provides opportunities for integration across the water energy nexus.

References

[1] Renewable Energy Generation From Wastewater (2011). Water Environment Federation Position Statement, Updated October 14, 2011

[2] The Water Resources Utility of the Future: A Blueprint for Action. (2013). Water Environment Federation, National Association of Clean Water Agencies, Water Environment Research Foundation, http://www.nacwa.org/images/stories/public/2013-01-31waterresourcesutilityofthefuture-final.pdf

[3] Building Resilient Utilities: How Water and Electric Utilities Can Co-Create Their Futures. (2013). The Johnson Foundation at Wingspread. Convening Report for August 21-23 meeting. November 2013

[4] Vitasovic, Z., Olsson, G., Liner, B., Sweeney, M., & Abkian, V. (2015). Utility Analysis and Integration Model. Journal - American Water Works Association 107(8) · August 2015

[5] Chen, D., Doumeingts, G., & Vernadat, F. (2008). Architectures for enterprise integration and interoperability: Past, present and future. Computers in industry, 59(7), 647-659.

[6] Van Looy, A., De Backer, M., Poels, G., & Snoeck, M. (2013). Choosing the right business process maturity model. Information & Management, 50(7), 466-488.

[7] Lubega, W. N., & Farid, A. M. (2014). Quantitative engineering systems modeling and analysis of the energy–water nexus. Applied Energy, 135, 142-157.

[8] Liner, B. (2014). A management system to drive energy sustainability in the water sector. Proceedings of the Institute for Industrial Engineers Annual Conference – Applied Solutions, Montreal, June 2, 2014

[9] The WEF Energy Roadmap: Driving Water And Wastewater Utilities To More Sustainable Energy Management (2013) Water Environment Federation, Alexandria, VA

[10] Effective Utility Management: A Primer for Water and Wastewater Utilities (2008). USEPA, APWA, AWWA, AMWA, NACWA, NAWC, and WEF. June 2008