Institutional Challenges and Opportunities: Decentralized and Integrated Water Resource Infrastructure

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ABSTRACT

Small-scale water, stormwater and wastewater are more sustainable in the environment than traditional centralized infrastructure. The failure to adopt these decentralized technologies is increasingly attributed to institutional and market barriers. The framework of institutions needs to be altered and expanded in the following key respects: integrated planning, funding, regulations, and design across water, stormwater, and wastewater; collaborative design processes to assess multiple community benefits and engage stakeholders; expanded private sector role in technology development, systems management, and finance; stimulus of continuous innovation and reform; development of robust patterns and models of installation, maintenance, financing, regulatory oversight, and customer acceptance.

***Keywords*:** water, wastewater, decentralized, private, infrastructure

1 A NEW PARADIGM OF DECENTRALIZED WATER RESOURCE INFRASTRUCTURE

In the mid-1800's, a fateful decision was made by American and European cities to begin installing miles of underground pipes to bring potable water to residents and then dispose of the wastewater and stormwater in nearby rivers, lakes or oceans. This "hard path" engineering has brought substantial public health benefits. But, there is growing evidence of how disruptive centralized distribution and collection is to regional water hydrologies and of how expensive it is to build and maintain. Recently, from a variety of quarters, there has been a flickering of interest in reopening earlier arguments that "soft path" approaches that treat and reuse water and wastewater at or near the site of use might be a more sustainable approach for the nation after all.

A key change from the 1800's is that technologies, such as membranes and remote telemetry controls, have advanced to the point where public health can be protected at the individual site, and the need for piping in clean water and piping out pollutants for disposal miles away is no longer the decisive factor. Soft path approaches have a lighter footprint in the environment, which has been heavily disrupted and stressed by the accumulation of hard path infrastructure. Localized capture of water, and treatment, reuse, and disposal of wastewater can restore streams, aquifers, wetlands and habitat. And, since about 70% of costs of the hard path solutions are in the underground piping system, this treatment and reuse at the site could turn out to bring substantial cost-savings as well. In the long-run, the nutrients in wastewater may be of value in agriculture, and synergies with distributed energy production and other infrastructure may also be important.

2 OBSTACLES TO DECENTRALIZATION

Advocates of decentralization have argued that small-scale, integrated technologies work and are more sustainable in the environment. The failure of mainstream institutions to adopt these technologies is increasingly attributed to institutional and market barriers.[1] Decentralized systems are generally on private property, and utilities have a great concern and skepticism for managing dispersed treatment units, many of which involve natural soil-based systems, and for dealing with unpredictable and uneducated customers, who may even turn off units.

Substantial experimentation in decentralized institutions needs to be supported by public, private, and non-profit sectors, lest mainstream professionals be asked to take on responsibilities they don't want, or block initiatives of private markets and other stakeholders because they are skeptical they will work or be integrated into practice. The benefits of decentralized infrastructure also have to be seen in a much broader framework, lest facilities planning continue to be dominated by economies of scale of centralization of siloed pieces of the infrastructure.

3 INSTITUTIONAL CHALLENGES AND OPPORTUNITIES

The framework of institutions around water resource infrastructure needs to be altered and expanded in the following key respects if decentralized and closed-loop systems are to be adopted over time.

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3.1 Integrated Water Resource Management

Management and regulations need to be integrated across the water "chain". Much of the demand for "closed loop" reuse of treated effluent, for example, will stem from reducing demand for new water supplies.

An integrated water resource management perspective starts with the goals of:

- Minimizing waste
- Lightening the environmental footprint
- Maximizing community benefits of the infrastructure

Figuring out what this new integrated system would look like is not obvious. The following five scales and perspectives of integration are a start:

1. At the "appliance" or technology level, the trio of decentralized water-efficiency, stormwater retention, and wastewater treatment and reuse should be blended into common programs at EPA and in the states;
2. At the site or neighborhood level, the Green Building movement should take an integrated approach to water conservation, reuse, and resource recovery;
3. At the municipal level, asset management and facilities plans should be based on full benefit and cost comparisons of the centralized and decentralized options;
4. At the watershed level, assessment and planning should be integrated across the water cycle and with energy, transportation, and land use planning;
5. At the federal and state levels, policy, funding, and regulatory structures need to be integrated across the water cycle. This would include greater cooperation among EPA, USDA, HUD, DOE, DOD, Interior, and Commerce.

3.2 Multiple Community Benefits and Stakeholders

Many of the benefits of decentralized systems are outside the water field, and include recapture of energy from wastewater, recapture of nutrients for agriculture, creation of parks and green space, and regeneration of neighborhoods and local jobs. Engineers and communities need to develop "systems engineering" approaches to "triple bottom line" planning, capital budgeting needs to be integrated across all municipal infrastructure, and multiple constituencies need to be involved in decisions.

1. The trio of decentralized technologies can reduce overall water usage and be used to: restore and maintain ecosystem services, save energy, produce energy and nutrients, create green spaces, improve air quality, restore urban streams and ecosystems, create green companies and green collar jobs.

2. Significantly more diverse constituencies, professions, and bureaucracies will be required to make decisions about water infrastructure, particularly during phases of invention and experimentation. The role of the voluntary nonprofit sector, in particular, needs to be enhanced. NGO's need to broaden their understanding of centralized and decentralized water infrastructure and their long-term sustainability, impacts on ecosystems, and community benefits.

3. The Green Building movement, based on the alignment of interests of builders, manufacturers, environmental NGO's and public agencies, is another example of the synergies of expanding the conversation.

3.3 Enhanced Role of the Private Sector

While private wells and septic systems in rural areas have generally been managed by homeowners, the "permanent" water and sewer lines and treatment plants built in urban and suburban areas have been the responsibility of public utilities. "Privatization" of these large utilities has been relatively rare in the US, in contrast to Europe and Australia, in particular. Integrating decentralized systems into this mainstream public infrastructure will largely be through private sector activity, but municipalities will have to oversee this process and ensure that the public is well served.

The likely private sector dominance of the decentralized water field is a challenge to conventional thinking and practice, but it can be a tremendous opportunity for leveraging the creativity and dynamism of entrepreneurs and inventors and for shifting some of the financial burden of infrastructure installation and maintenance onto private transactions. The EPA has taken a strong stance for utility management, and even outright public ownership, of decentralized wastewater systems, in particular, but that approach needs to be reconsidered. In spite of EPA advocacy, few public utility management models for decentralized systems have emerged, and that is largely explained by the unsuitability of market conditions for this role.

The basic reason for an enhanced role of the private sector, and conversely, a minimized role of the public sector, is that decentralized infrastructure is usually on private property, and services are customized for each buyer, whether at an individual home, subdivision development, or commercial property. Generally, neither the customer nor the municipality is interested in direct utility management of this work. Homeowners and builders are used to hiring their own contractors and subcontractors, such as electricians and plumbers, and they prefer being able to choose their own contractor in water, stormwater, and wastewater as well. Additionally, municipal utilities are used to managing large treatment plants and pipes, and are quite nervous about trying to work with and control

thousands of quirky and demanding homeowners and businesses.

Therefore, it is not surprising that most water-efficient appliances, green roofs, and advanced onsite treatment units are being purchased, installed, and managed by private customers and contractors. The cluster system that mimics the conventional sewer, but on a smaller scale, is a more market-friendly fit with conventional utility management, because management of the advanced treatment unit is controlled by individual homeowners. Case studies show that cluster system management is being more readily adopted by both existing municipal and new private utilities.

Part of the advantage of a private sector model is the creativity and innovation that entrepreneurs can bring to the field. The decentralized private sector model offers a number of opportunities:

- Private sector companies install and manage decentralized technologies
- Private companies invent and manufacture decentralized equipment
- Green Building adoption of decentralized systems
- Private capital investments in sustainable infrastructure

The key to an appropriate and successful role of the private sector in decentralized systems will be in aligning the private and public interests. Case studies have shown that new private companies are doing important work in establishing models for installation and management of small-scale treatment units. But, the larger and longer-term interests of the public are not yet being protected. Over time, the following issues were identified that will need to be addressed:

- Accountability and control—Private companies have not always advocated the intensity of maintenance and repair needed for systems to function properly. Public agencies will need to develop effective inspection and oversight programs, certification systems, and fines so that this maintenance is assured
- Equity—Many of the new installations are in up-scale new subdivisions. Public agencies will need to provide subsidies, and eventually, mandates for decentralized treatment installations regardless customer income
- Land use—Developers are discovering that cluster wastewater systems and low impact development practices can lower the price of water services in new subdivisions, but these developments are not always consistent with broader community or watershed land use needs

Municipal utilities will need to explore and ultimately feel more comfortable with a set of new tools to manage decentralized infrastructure. Instead of directly installing, maintaining, and owning the infrastructure, they will need to provide incentives and oversight of the infrastructure. Like the transition energy utilities made to encouraging solar panels on private property, utilities will need to institute:

- Financial incentives to the homeowner or business, including tax incentives, rate incentives, or rebates
- Social marketing programs to encourage the purchase of decentralized units
- Possible ordinances or mandates for decentralized systems, if voluntary use is not high enough
- Inspection programs to assure compliance
- Planning procedures for understanding the role of decentralization in the broader infrastructure mix, patterns of siting the infrastructure appropriately, and others

Federal and state governments will also need to adapt to, and provide incentives for, an enhanced role of the private sector.

- Grants and loans made available to communities should be flexible, so that communities can use the funds to set up homeowner revolving loan funds or grants
- Tax incentives directly for the customer should be considered
- Efforts should be made to establish national standards in management, technology performance, certification and training of installers, and green building ratings

Federal research and development investments can be made in partnerships with the private sector to pilot test new inventions and to commercialize and disseminate their use. Finally, federal "champions" can provide signals to the private sector that decentralization is a key to future sustainability in the infrastructure, and Cleantech investors and others will likely follow.

3.4 Continuous Innovation

As in all transitions to a new paradigm, the precise technologies and applications are still evolving and often higher in price than they can eventually be. All parties need to incorporate greater experimentation and innovation in their practice, including government funding of demonstration projects, municipal funding of pilot programs as part of responsible asset management, and early adoption by "green" customers of technologies that are new and more expensive.

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3.5 Streamlined Institutional Tools

New, robust models need to be developed, where a package of installation, maintenance, financing, regulatory oversight, and customer acceptance have been shown to work for a given technology. For example, green roofs can be installed, managed, and financed by the private developer, and the municipality can provide financial incentives, "social marketing", and oversight inspections. Cluster wastewater systems can be managed by private utilities. Water-efficiency appliances can be sold directly to homeowners, and developed and marketed by large corporations. These demonstrated "packages" then need to be broadly disseminated in the field.

REFERENCE

[1] Nelson, V. 2008. "New Approaches in Decentralized Water Infrastructure" Project 04-DEC-5SG. Prepared for the National Decentralized Water Resources Capacity Development Project by the Coalition for Alternative Wastewater Treatment. Gloucester, MA.