Global Sustainable Cities Network

Country-Level Snapshots:

Waste-to-Energy and Cities: Demand-Side Management

CLEAN ENERGY MINISTERIAL

Accelerating the Transition to Clean Energy Technologies

August 2013

Introduction:

The Global Sustainable Cities Network (GSCN) is an initiative of the Clean Energy Ministerial, a high-level global forum to promote policies and programs that advance clean energy technology, to share lessons learned and best practices, and to encourage the transition to a global clean energy economy. The aim of the GSCN is to provide an open platform for groundbreaking sustainable city initiatives throughout the world to share knowledge that can be utilized and incorporated throughout the initiatives' respective development life cycles.

The countries participating in the GSCN are the United Arab Emirates (UAE), the People's Republic of China, Sweden, Finland, and Denmark.

The GSCN is initially focused on two crosscutting and integrative technology domains identified as areas of common interest among participants:

- Waste-to-Energy (e.g., waste-waste, water-biogas, biofuel-based district heating and cooling in an integrated urban development setting)
- Cities – Demand-Side Management (e.g., smart grid, buildings – thermal management, green lighting, cool roofs, district heating and cooling infrastructure)

Participant countries have produced the following country-level snapshots to summarize their activities, challenges, and successes in the two technology domains (potentially including commercial-scale projects, pilot studies, and pipeline inventories; national market size and investment estimates; R&D status; best practices; policy mechanisms in place that support each domain; etc.), as well as identified areas of greatest interest to their respective constituents.

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Participant Snapshot	
Crosscutting and Integrative Technology Domain	**Waste-to-Energy (e.g., waste-waste, water-biogas, biofuel-based district heating and cooling in an integrated urban development setting)**
Country Participant	**United Arab Emirates**
Network Constituents	**Masdar, Abu Dhabi National Energy Company (TAQA), Bee'ah**

PROFILE OF NETWORK CONSTITUENTS

1. **Masdar:**

The Masdar initiative is designed to advance renewable energy and sustainable technologies through education, research and development, and commercialisation in order to drive UAE energy leadership and economic diversification as a pillar of the Abu Dhabi Economic Vision 2030. Announced in 2006 by HH Sheikh Mohammed bin Zayed Al Nahyan, the Crown Prince of Abu Dhabi, the company is now achieving its vision of sustainability through four integrated units: the Masdar Institute of Science and Technology, an independent, research-driven graduate university developed in partnership with the Massachusetts Institute of Technology (MIT); Masdar Capital, which invests in clean energy projects; Masdar Clean Energy, which develops and operates renewable power generation projects such as solar and wind farms, as well as carbon mitigation projects; and Masdar City, a clean technology cluster that is emerging as a sustainable urban development. Masdar City is also a special economic zone that provides incentives to businesses that encourage sustainable living.

2. **Abu Dhabi National Energy Company (TAQA):**

TAQA is the Abu Dhabi National Energy Company and has taken the initiative for delivery of the first waste-to-energy plant in the Emirate, in partnership with the Center of Waste Management. TAQA is a multi-platform company operating oil and gas and power and water facilities globally. TAQA has recently become a member of the Abu Dhabi Sustainability Group and established Energy Solutions as a third vertical, specializing in alternative energy.

3. **Bee'ah:**

Bee'ah is a public-private partnership initiated by the Municipality of the emirate of Sharjah and the first fully integrated waste management company in the UAE, focusing on cradle-to-cradle solutions and the 4 Rs – reduce, re-use, recycle, and recover. It provides municipal waste collection (the first two-stream

collection in the Gulf), medical waste collection and treatment, and the highest-rated waste facility in the Middle East at Al Saj'ah (including material recovery, tire recycling, car shredding and recycling, construction and demolition waste recycling, a composting plant, and a fully lined landfill, among other initiatives). It is geared to achieve the 100% landfill diversion target set for the Emirate of Sharjah by the end of the first quarter of 2015, and it also runs educational programmes in schools and a specialized visitor centre.

HISTORICAL CONTEXT AND EXPERIENCE RELATED TO DOMAIN (PER CONSTITUENT):

1. **Masdar:**

   Masdar developed a solid waste management strategy to achieve the zero-waste target (98% diversion of materials from landfill) that was originally set for the Masdar City development. The strategy incorporated waste-to-energy forms of treatment for the residual waste stream; i.e., after recycling and composting.

   An indoor zero-waste solution was also devised for the first buildings (Masdar Institute 1A) in the City development, incorporating micro-/small-scale advanced thermal treatment technology.

2. **Abu Dhabi National Energy Company (TAQA):**

   TAQA was founded in 2005, has a workforce of 2,800 that is drawn from 41 nationalities, and is working in 13 markets. TAQA is 51% owned by the Abu Dhabi Water and Electricity Authority. TAQA is incorporated as a private joint stock company and is listed on the Abu Dhabi Stock Exchange with a combined asset base of more than $32 billion with revenues of $6 billion annually.

3. **Bee'ah:**

   Bee'ah was founded by Emiri decree in 2007 to pioneer world-class waste management in the Emirate of Sharjah. As part of the portfolio of waste management solutions, Bee'ah began to consider waste-to-energy and in October 2011 signed an MOU with the Government of the Netherlands (NL Environment Agency), covering support from Dutch experts in the field of waste management in general and in waste-to-energy in specific. Feasibility studies for waste-to-energy in Sharjah are currently underway, with a potential start-up date in 2015.

CURRENT ACTIVITIES RELATED TO DOMAIN (PER CONSTITUENT):

1. **Masdar:**

The amount of waste that is currently generated in the City development is very small and uneconomical for the development of a waste-to-energy plant. Masdar's current activities are thus limited to keeping abreast of new technology developments in the domain.

Masdar Venture Capital is an investor in one of the world's first utility-scale municipal solid waste plasma gasification plants, which is being constructed in Morcenx, France, by CHO Power Europlasma.

2. **Abu Dhabi National Energy Company (TAQA):**

TAQA is now in the process of providing a bankable feasibility study for the Abu Dhabi Waste to Energy Project that includes the Waste Characteristic study, site selection, planning, permitting, financing, and technical concept design, followed by the EPC RFP and subsequent build and commissioning.

3. **Bee'ah:**

Bee'ah continues to meet different investors and technology providers, including those for incineration, gasification, and anaerobic digestion, with consideration given to the route that will have the lowest emissions.

CURRENT CHALLENGES RELATED TO DOMAIN (PER CONSTITUENT):

1. **Masdar:**

Masdar's current challenges related to waste-to-energy are:

- Lack of conducive environmental and financial regulatory regimes
- High capital costs compared to other energy forms
- Lack of enabling policies; e.g., feed-in-tariffs

2. **Abu Dhabi National Energy Company (TAQA):**

The challenges that exist today are mainly due to a historical lack of strategy and a lack of current coordination between Abu Dhabi stakeholders that would bring waste-to-energy in Abu Dhabi in line with best international practice. This is, however, being addressed.

3. **Bee'ah:**

Technology costs are the primary challenge Bee'ah is facing, as the cost of waste-to-energy is high compared to the cost of normal local practices in waste management, such as landfilling. Similarly, the cost of energy/electricity production from waste-to-energy is higher than that of the UAE natural gas average, requiring subsidization or another form of government information.

On the policy side, there are no frameworks for waste-to-energy on either the emirate or federal level.

SUCCESSES RELATED TO DOMAIN (PER CONSTITUENT):

1. **Masdar:**

   Masdar developed a compelling business case and roadmap for a regional/Abu Dhabi waste-to-energy plant that resulted in the inclusion of this route in the Renewable Energy Road Map for Abu Dhabi—target 7% energy from renewable sources by 2020.

2. **Abu Dhabi National Energy Company (TAQA):**

   Abu Dhabi National Energy Company (TAQA) and the Center of Waste Management have signed an agreement to develop an initial 1 million tonne per annum plant in Abu Dhabi. A bankable feasibility study in underway and a state-of-the-art waste-to-energy facility should be commissioned in the fourth quarter of 2016.

3. **Bee'ah:**

   While not specific to waste-to-energy, Bee'ah surpassed 40% waste diversion in late 2011—up from around 0% before its founding—and has the recycling capacity in place to front-end waste-to-energy processes.

AREAS OF GREATEST INTEREST RELATED TO DOMAIN (PER CONSTITUENT)

1. **Masdar:**

   Masdar's greatest interests related to waste-to-energy are:

   - National policies and other enabling instruments and mechanisms (e.g., classification of waste-to-energy as renewable energy, thus allowing access to government financial support systems)
   - Feed-in-tariff structures; premium payments for green energy
   - Project development and implementation costs (capex, opex, and life cycle costs - $/kwh)
   - Advanced waste-to-energy technologies and small-scale and large-scale facilities

2. **Additional general:**
   - Tipping fee structures and benchmarking
   - Regulatory models for cross-municipal/border waste collection and disposal
   - Environmental performance metrics and record of "proof"

Participant Snapshot	
Crosscutting and Integrative Technology Domain	**Cities – Demand-Side Management (e.g., smart grid, buildings – thermal management, green lighting, cool roofs, and district heating and cooling infrastructure)**
Country Participant	**United Arab Emirates**
Network Constituents	**Masdar, Executive Affairs Authority (EAA), Dubai Carbon Centre of Excellence (DCCE)**

PROFILE OF NETWORK CONSTITUENTS

1. Masdar:

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2. Executive Affairs Authority (EAA):

The Executive Affairs Authority provides high-level economic policy advice to the Chairman of the Executive Council and oversees strategic research into economic policy issues that require further study and clarification prior to entering a decision-making phase. The Economic and Energy Affairs unit has been playing a central coordinating and facilitation role to bring together all key stakeholders in order to develop a comprehensive and integrated Demand Side Management Strategy for the emirate of Abu Dhabi. Here are some of the main key demand-side management stakeholders:

2.1 Abu Dhabi Water and Electricity Authority (ADWEA):

ADWEA consists of a corporate entity that represents a group of operationally separate utility companies that together have responsibility for the generation, transmission, distribution, and retailing of electricity and water and overall expansion planning for the Abu Dhabi power and water sector. ADWEA's responsibility to promote energy efficiency is enshrined within Law number 2 of 1998, and combining this responsibility with its access to the customer metering systems owned and operated by the two distribution companies that serve the Emirate give it the potential to play a leading role in the

development of a system that can be used to measure and quantify the effectiveness of energy and water efficiency measures and associated programs of work on behalf of the sector.

2.2 Abu Dhabi Urban Planning Council (UPC):

Abu Dhabi's Plan 2030 establishes a clear vision for sustainability as the foundation of any new development occurring in the Emirate and capital city of Abu Dhabi. This commitment is a reflection of the values and ideals of the UAE. The tenets of sustainable living in the Middle East are the guiding force behind Estidama. More than just a sustainability program, Estidama is the symbol of an inspired vision for governance and community development.

It promotes a new mindset for building a forward-thinking global capital. To establish a distinctive overarching framework for measuring sustainability performance beyond the usual planning and construction phases, UPC has worked with the team guiding Estidama to ensure that sustainability is continually addressed through four predefined angles: environmental, economic, social, and cultural.

The purpose of Estidama is to create a new sustainability framework that will direct the current course while allowing adaptation as new understanding evolves.

By promoting a new sense of responsibility with Estidama, UPC is going beyond other sustainable development initiatives around the world by creating new tools, resources, and procedures crucial to the 2030 vision.

2.3 Department of Municipal Affairs (DMA):

Officially established in 2007 and located in Abu Dhabi city, the Department of Municipal Affairs (DMA) was created to oversee all municipal planning and public works projects in the Abu Dhabi Emirate. As a regulatory body, the DMA comprises three regional municipal administrations – Abu Dhabi Municipality, Al Ain Municipality, and Western Region Municipality.

With the municipal system acting as a foundation to implement the Abu Dhabi Vision 2030 at a city-wide level, the Department of Municipal Affairs along with the Municipalities, is tasked with ensuring the creation of sustainable cities that are great places to live, work, and visit. The municipal system has a great responsibility to ensure environmental sustainability; social sustainability; premium infrastructure provision; and strong, transparent governance, all of which will support the Emirate's vision of building a sustainable, knowledge-based economy through the Abu Dhabi Vision 2030. By working closely with its stakeholders, the municipal system aims to ensure a high quality of life among citizens and visitors of Abu Dhabi, comparable to the best cities in the world.

3. Dubai Carbon Centre of Excellence (DCCE):

The Dubai Carbon Centre of Excellence (DCCE) specializes in the design and incubation of greenhouse gas reduction measures and works towards Dubai's transition to a low-carbon economy.

It is dedicated to serving both public and private companies on carbon management and revenue strategies, as well as pre-empt future legislation by reducing their carbon footprint and overall environmental impact.

DCCE offers "Total Energy and Carbon Solutions" that promise a return of investment in the form of cost savings and available market mechanisms, including carbon credits. It is DCCE's philosophy to approach projects in a manner that considers the financial outcome as much as the environmental impact, as all investment in green technologies must be economically viable.

From this perspective, DCCE does not differ from any other management consultancy; it aims to maximize the return of investment in the field of environmental upgrades.

HISTORICAL CONTEXT AND EXPERIENCE RELATED TO DOMAIN (PER CONSTITUENT):

1. **Masdar:**

Masdar City is an emerging global hub for renewable energy and clean technology that puts companies and residents inside the heart of a fast-evolving industry.

Created by the Abu Dhabi Government in 2008, the low-carbon development, which lies 17 kilometers outside Abu Dhabi's city centre, relies almost entirely on solar and other renewable energy sources. Its sustainable elements include narrow streets that encourage walking, unique shading created by buildings that are constructed next to each other, and solar panels extending from rooftops that both block sunlight from the ground and capture it for power. Streets and buildings are aligned along a northeast-southwest axis, guaranteeing shade all day and capturing cooling breezes.

Educational spaces are mixed with recreational, residential housing, retail, manufacturing, and office spaces, dramatically reducing the strain on transport systems. Commuters and residents can find everything they need, close at hand.

Buildings are energy efficient, low-rise, and densely populated. This reduces the energy required for building usage and internal transportation.

Underscoring its leadership position in sustainable development, Masdar City will host the headquarters of the International Renewable Energy Agency (IRENA) and is home to the Masdar Institute of Science and Technology, a graduate-level research university that is dedicated to innovation in clean energy.

Residential units at Masdar Institute are monitored for minute-by-minute electricity consumption as well as cold-water and hot-water use, and residents are regularly reminded of their exact usage of resources, encouraging them to use less.

Smart grids at buildings make it possible for power to be distributed in two directions. Electricity can be fed into the grid from multiple points, and consumers can be suppliers if they have enough power to spare from solar panels. This allows them to generate more electricity than they use.

Masdar Institute seeks to be a leading renewable energy and clean technology player by providing a test bed for the world to develop commercially viable, sustainable energy solutions, providing applied research for the four corporate arms of its allied Masdar group and the UAE as a whole.

2. Executive Affairs Authority (EAA):

Demand Side Management (DSM) programs have the potential to substantially reduce future government subsidies by reducing consumption during the peak (highest cost of production) periods. A 2009 DSM study sponsored by the Executive Affairs Authority (EAA) identified significant technical potential for reducing electricity consumption by implementing international best practices and high-efficiency products, which prompted the EAA and other stakeholders to study the area in greater depth.

The EAA in 2010 conducted a pilot project to analyze the potential energy savings that could result through the implementation of a proactive air-conditioning (A/C) maintenance program. Improving the efficiency of A/C systems was identified as the most promising opportunity for energy savings because it represented almost 60% of the summer peak demand, thus providing it with the greatest technical potential for short-term savings in energy and government costs. Based on the outcome of that pilot study, energy consumption was decreased by 27% in A/C units that were maintained, which equates to an annual savings of 668 gigawatt hours (GWh) in the residential and commercial sector if implemented across the entire Emirate.

Encouraged by the outcome of the pilot study, the EAA in 2011 was mandated to form a taskforce consisting of all relevant Abu Dhabi entities that would provide a comprehensive analysis of the cooling sector within the Emirate and to develop a strategy to reduce energy consumption resulting from cooling, and thus reduce government expenditures in the form of electricity subsidies.

The taskforce developed a comprehensive strategy for reducing A/C-related energy consumption and government subsidies associated with it. The taskforce, which included ADWEA, DMA, EAA, EAD, RSB, UPC, MIST, QCC and others, developed an optimized strategy called the Comprehensive Cooling Plan (CCP).

The measures and programs within the CCP have the technical potential to reduce cooling load and electricity demand by 29% and 13%, respectively, over a 10-year period and given current demand projections.

3. Abu Dhabi Water and Electricity Authority (ADWEA):

The Government of Abu Dhabi has ambitious plans for ongoing growth and development across all sectors of the economy. The rapid increase in population combined with concurrent growth in industrial and commercial sectors has led to an average peak electricity demand growth of 7.5% per annum since 1998, which has accelerated to 11.4% since 2008. Double-digit growth is expected to continue beyond

2020 if the government maintains its current development strategy, with peak Abu Dhabi system demand rising from 3,304 MW in 2000 to 6,885 MW in 2010 and forecasted to reach 17,293 MW by 2020.

The cost of providing new-generation capacity however is high—typically averaging around USD $1 million for every new megawatt of conventional fossil-fuel-powered capacity. Ongoing production costs are also high and guaranteeing the availability of the fuel needed to ensure the security of the supply will also remain an area of critical importance. In 2010 direct subsidy costs paid by the Abu Dhabi government on behalf of consumers totaled AED 13.3 billion (AED 5.9 billion for power and AED 7.4 billion for water). With demand forecasted to more than triple between 2010 and 2020, the parallel increase in required subsidy levels will place an increasing burden on the country's finances. In parallel with the unprecedented growth in demand, per-capita electricity consumption in the Emirate of Abu Dhabi is amongst the 10 highest in the world, and the UAE has the second highest per capita carbon dioxide emissions of any country. The primary drivers for this situation are a combination of a hot, arid, and humid climate; a heavily subsidized tariff regime that discourages energy efficiency measures; and historically a lack of building and appliance standards mandating defined minimum levels of performance.

Whilst the ultimate decision to raise tariffs is political rather than purely economic, there are a range of other interventions that can be implemented to improve energy efficiency and drive down energy intensity. A sector-wide working group was established in the summer of 2011 to develop a number of strategy options that could form the basis of phase 1 of a Comprehensive Energy Efficiency Program for Abu Dhabi. These options were presented to Abu Dhabi's leadership during the summer of 2012 and focused on measures that could be taken to reduce the load associated with cooling. Cooling was selected from the range of energy consumption drivers because it represents 60%–70% of the summer peak load and offers the greatest technical potential for short-term savings. Generically these include the following classes of interventions:

a) Cooling system maintenance of large chiller units
b) Cooling system maintenance of central, split, & window A/C systems
c) Rebalancing & commissioning of A/C systems
d) Isolation & decommissioning of excess capacity of A/C system in facilities
e) Temperature set point control, cycling of chillers, and other dynamic demand response measures
f) Building envelope enhancements

A series of pilot projects aimed at validating the anticipated savings from the full-scale implementation of each of these above measures has now been approved as the next step. The impact of all interventions must however be measured and quantified. The development of an accurate energy modeling system will be an essential component in this; however, it depends heavily on the availability of historical energy consumption data that is combined with building and weather data in order to create a predictive energy consumption capability.

4. Abu Dhabi Urban Planning Council (UPC):

The Abu Dhabi Urban Planning Council (UPC) is recognized internationally for large-scale sustainable urban planning and for rapid growth. *Plan Abu Dhabi 2030* urban master plan addresses sustainability as a core principle. Estidama, which is the Arabic word for sustainability, is an initiative developed and promoted by the UPC. Estidama is the intellectual legacy of the late Sheikh Zayed bin Sultan Al Nahyan and a manifestation of visionary governance promoting thoughtful and responsible development. The leadership of Abu Dhabi is progressing the principles and imperatives for sustainable development, through Estidama, while recognizing that the unique cultural, climatic, and economic development needs of the region require a more localized definition of sustainability.

5. Department of Municipal Affairs (DMA):

a) Abu Dhabi International Energy Conservation Code:

In 2009, the DMA began development and adoption of new building codes that are in compliance with International Codes (I-Codes). The 2012 International Energy Conservation Code can be found among the six individual building codes under the I-Codes being adopted by the Emirate. The I-Codes have been developed in collaboration with entities in the United States of America. The Code sets in place minimum standards for energy conservation for both commercial and residential buildings, and it is expected to meet all United Nations Green Building targets for extremely hot areas; other geographical locations comparable to Abu Dhabi's extremely hot climate include Calcutta, Riyadh, Kuwait, and Hong Kong. The energy targets per year that are expected to be met under the new code include 132 kWh per square meter in a residence and 96 kWh per square meter in an office. These codes are considered global best practice and are necessary to fulfill the Emirate's 2030 Vision of a low-carbon future.

b) Energy Efficient LED Street Lighting Regulations:

The DMA is also working to install more energy-efficient street lighting in the Emirate by passing a policy in the Emirate requiring all new street lighting to use light-emitting diode (LED) lighting technology.

c) Water Conservation (from energy-intensive desalination):

Despite being in one of the most water-scarce regions in the world, Abu Dhabi is among the highest in the world for potable water consumption per capita. But Abu Dhabi is improving: in 2009, Abu Dhabi residents consumed 450 liters per day, a 10% improvement from 2008's 500 liters per day per capita. According to the DSM research commissioned in 2009, residential water use accounts for approximately 42% of total metered water in the Emirate. Experts are suggesting the Emirate focus on initiatives that will reduce demand, rather than focusing on creating additional desalination plants, which require large amounts of energy in order to meet current demand. The DMA and the municipalities are committed to water conservations and have a number of initiatives underway to improve water conservation performance.

6. Dubai Carbon Centre of Excellence (DCCE):

DCCE is an independent, public-private private joint stock company with government-owned shareholders, founded to assist the public and private sectors in carbon matters by an agreement between the Dubai Supreme Council of Energy and the United Nations Development Programme, signed in the presence of H.H. Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE and Ruler of Dubai; H.H. Sheikh Hamdan bin Mohammed bin Rashid Al Maktoum, Crown Prince of Dubai; and UN Secretary-General Ban Ki-Moon. DCCE is a young carbon aggregator established as a result of strong commitments from its shareholder base. DCCE is registered in the UAE with the following equal shareholders: Dubai Aluminum (Dubal), Dubai Energy and Water Authority (DEWA), Emirates National Oil Company (ENOC), and Istidama Carbon Consulting (Istidama).

Headquartered in the United Arab Emirates, DCCE is established to extend the knowledge of decades of United Nations' operations to the private-sector community. Its core team provides more than a century of cumulative years of experience in socio-development programmes and operates through a network of international organizations and service providers throughout the GCC and Europe.

DCCE's partners and stakeholders have been actively involved over the last few years in providing support and services through their institutional roles in the UAE—working in boardrooms, project development, strategy and planning, and think-tanks in numerous UAE and international firms to achieve results that go beyond traditional business outcomes.

CURRENT ACTIVITIES RELATED TO DOMAIN (PER CONSTITUENT):

1. Masdar:

a) <u>Demand-side energy management programme in existing buildings:</u>

On behalf of Abu Dhabi Municipality (ADM), Masdar has partnered with Schneider Electric to offer a distinctive energy management programme for 70 buildings of different types and uses in Abu Dhabi.

The programme has been mandated to deliver a detailed energy audit, a comprehensive residential survey, a high-level study on regulatory framework, and full electromechanical implementation specifications.

The programme will deliver on this mandate through a strategy that incorporates analysis, implementation, monitoring, and management. It will be customised for the region and will utilise international standards and guidelines.

It is currently in its final stages and will be fully completed by the end of 2012.

b) <u>High-performance buildings:</u>

Several buildings are currently under construction at Masdar City. State-of-the-art energy efficiency strategies, both active and passive, are being applied in these buildings, drastically reducing their energy consumption in a cost-effective way.

Here are two examples:

1- Siemens headquarters building (currently under construction):

This building will provide the headquarters for Siemens LLC. The site for the building forms part of the Masdar City master plan development and will conform to the design guidelines, sustainability objectives, and commercial requirements of Masdar.

The design process goal is to maximise sustainable and commercial benefits. Various passive and active design options were analysed throughout the design stages. The best solutions were carried forward. This measurable and empirical process of selecting the fittest solutions avoids unnecessary inefficiencies in the building.

The building is seeking a LEED Platinum certificate and has successfully achieved an energy reduction of 46% below the ASHRAE 90.1 2007 baseline, which is the benchmark adopted in LEED and Estidama, Abu Dhabi's green building system.

The main design strategies used to achieve the high-energy performance are:

- Window-to-wall ratio below 40%, maximising views and natural daylight, and minimising cooling and artificial lighting demand
- Well-insulated walls and roof
- High-performance glass (low U value, high VLT/SHGC)
- External shading elements on windows
- High albedo roof coating
- Low lighting power density
- Advanced lighting control
- Variable-frequency drive fan coil units, with low specific fan power
- High-effectiveness energy recovery from exhaust air
- Free reheat on air-handling units
- Demand-controlled ventilation
- Solar collectors provide 75% of hot-water demand
- Advanced energy management system

2- Masdar Institute phase 1B building (currently under construction):

Phase B of the Masdar Institute of Science and Technology (MI), currently under construction, covers an area of 18,958m², comprising 219 apartments, three laboratories, a multipurpose hall, gym, 25 m swimming pool, a learner's pool, a student affairs facility, cafe, and retail outlets on the podium level, as well as offices and meeting rooms.

The main energy performance measures applied in this building are:

- High-performance skin (façade and roof) and MEP systems
- Daylighting to reduce internal loads and reliance on artificial lighting
- Orientation for optimum shade
- Natural ventilation via atrium and manually operable windows
- Microclimate temperature of streets reduced
- Streets and communal space comfort enhanced by shade and courtyards
- Glazing-to-wall ratio below 40%
- 100-year structural design life

c) Masdar City energy and water monitoring:

Masdar City is using C3 Energy & Emissions Software to manage its energy consumption. The C3 energy management software enables Masdar to monitor and reduce its energy and associated greenhouse gas (GHG) emissions by enabling building and asset-level monitoring, benchmarking, and cost assessment of energy-reduction initiatives. Masdar is also utilising the C3 energy software to provide data and validation of its Annual Sustainability Report, which will be released in January 2013.

d) Masdar City smart grid:

Masdar has installed smart grid functionality in order to enable the development of demand-response technologies. This includes bidirectional switches and closed-loop distribution loops.

The smart grid-smart building integration is managed by a specialised Distribution Management System (DMS) with a monitoring station allocated for Masdar City.

e) Smart grid and smart building research collaboration between Siemens and Masdar Institute:

Masdar Institute, in collaboration with Siemens, is developing a multidisciplinary building technology research programme to support the coming of age of the high-performance building. The building will combine a low-energy envelope with efficient HVAC/lighting, on-site energy generation/storage devices, smart appliances/thermostats, and advanced building management systems. These systems will be able to interact with the smart grid, participate in demand-response programmes, provide ancillary services, and achieve energy and cost savings with improved technical and environmental performance.

Masdar Institute has identified two key thrust areas that will form the core of building technology research:

1- On-site energy storage/generation to enable a building's full participation in demand-response programmes. Three projects were identified in this area:
   a- Automated, Comfort-Constrained Demand Response Using Alternating Roots Property of Transient Thermal Response
   b- Advanced Load Forecasting for Smart Buildings
   c- Demand Response and Adaptive Generation (DRAG) for Smart Grids

2- Engagement of the end-user in energy efficiency and demand response. Two projects were identified in this area:
   a- Managing Real-time Interventions in Smart Buildings: Learning to Influence People's Behaviour
   b- Experimental Demand Response Incentive Scheme Evaluation at Masdar Institute Residences

f) Building technology research centre:

The building technology centre will provide for Masdar Institute the following areas of research:

- Modeling and numerical simulation of buildings and cities
- Advanced forecasting and predictive control/optimization algorithms
- Automated control/monitoring/diagnostic tool
- Decision-support tools to predict the impact of DSM/DR programmes
- Engaging and incorporating the end-user

g) Optimal chiller plant control for district cooling:

Masdar Institute is a member of Abu-Dhabi Government's CCP (Comprehensive Cooling Plan) demand-side management initiative. The optimal chiller plant control for the district cooling research project, in collaboration with Tabreed, aims to develop an optimal control strategy for one of Tabreed's district cooling plants. This will provide net energy savings of 20% or more compared to business as usual.

2. Abu Dhabi Water and Electricity Authority (ADWEA):

a) Development of an Energy Modeling Capability:

Regardless of what interventions are implemented, the measurement and quantification of their effectiveness and the ability to monetize these savings will be essential to the long-term viability of energy efficiency measures. Without the ability to measure how much has been saved, it will be impossible to validate the return on investment made or manage and administer any financial rebate program.

Abu Dhabi Water and Electricity Authority is therefore seeking to develop the capability to monitor consumption data at the level of the individual consumer and build a robust energy modeling capability that will enable the impact of specific efficiency interventions to be measured starting at the building level but with the ability to aggregate upwards as required to the sector and ultimately the whole Abu Dhabi network. The system should enable, for example, the disaggregation of all consumption data and its allocation to a range of customer types including building typologies, sector types, and demographics to support the development of a detailed understanding of how much, where, under what conditions, and by whom energy is consumed.

A typical accuracy of better than +/- 3% is targeted, with better than +/- 5% regarded as essential at the level of each consumer if real confidence in the model is to be achieved. This necessarily implies that the model developed must be sufficiently robust that it can compensate for the effect of key non-intervention-related variables, which might include temperature, humidity, DNI, GHI (and other weather variables), occupancy levels, holidays, and so forth.

The key is for the model to be able to accurately and reliably forecast consumption. Initial proof-of-concept work undertaken by three different companies, each utilizing limited sample data sets, has demonstrated typical accuracies of around +/-5% utilizing daily consumption data. Subsequent phases aim to confirm how much more accuracy can be obtained from increasing the sample data.

3. Dubai Carbon Centre of Excellence (DCCE):

DCCE is a leading advisor on carbon matters in the region. The close link to decision makers and government authorities is its strategic advantage. This provides a valuable source of expertise and networking and ensures that DCCE's services comply with both the national strategy and international standards.

a) Carbon Credit Portfolios:

The creation of a portfolio of carbon credits through structuring, investing, and advising emission reduction projects will help to meet the needs of Dubai and regional institutions and support achievement of "carbon neutrality." The portfolio is composed of individual projects as well as Programmes of Activities (PoA) that will allow small-scale projects to be developed cost effectively under one umbrella. This will ensure that projects are eligible for CERs even after 2012. At this stage, DCCE offers this for Green Building and Solar Power projects.

b) Climate Change Capital Fund:

DCCE is working on establishing a Climate Change Venture Capital Fund to provide capital and incentives and to attract global leading technology companies to Dubai.

Carbon Expertise:

DCCE's experience and activities will form a leading knowledge repository on carbon matters in the region, which will be accessible to all concerned parties. This will contribute to the creation of Dubai's knowledge economy, enabling the transfer of green technologies, jobs, and investments.

c) Carbon Framework:

DCCE proactively responds to Dubai's global responsibilities in the fight against climate change and therefore hopes to contribute to the Emirate's progressive reputation throughout the region and the world. The DCCE, jointly with the United Nations Development Programme (UNDP) and investors from the private sector, will establish a formal framework to address carbon emissions in the Emirate/UAE.

The UNDP is an integral partner to the initiative and provides access to its immense network of expertise. Its aim is to facilitate the transition to a low-carbon economy and building local capacity. The establishment of this PPP is seen as a significant step forward towards a participative approach, assisting in combating climate change challenges where the business community can hold a proactive role and support the much-required change.

d) Carbon credit certification:

At the moment, DCCE has consolidated a pipeline of 1.7 million tons of CO_2 emission reductions in 12 projects equal to an annual turnover of USD $25 million at current market rates. Of these projects, the following are being submitted for registration under the Clean Development Mechanism, whilst others are either eligible under European Trading Scheme compliance (equivalent measures) or voluntary markets.

Dubai Carbon's "Clean Development Mechanism" projects in the pipeline:

- Dubai CFL Project Free distribution of energy efficiency light bulbs to 720,000 households, fully funded from carbon revenue
- DEWA Solar Farm 10 MW Solar Farm to be established on the Dubai - Al Ain road
- DEWA Inlet Chillers – Use of inlet chillers to improve turbine efficiency in power generation
- UCC Waste Heat Recovery – Use of waste heat from kilns to generate 15 MW of renewable power
- UCC Alternative Fuels – Use of refuse-derived fuel for the furnace instead of coal, with methane avoidance and efficiency in the emissions
- DUBAL Desalination Pumps – Upgrade desalination pumps with more efficient ones
- DUBAL D18+ – New smelter technology fully developed by DUBAL in house with substantive saving of PFCs
- DUBAL GTX Steam management – optimization through a fully centralized steam management system
- DUBAL Absorption Chillers – Use of heat and heat pumps for cooling requirements of Dubal site
- DUBAL Regenerative Burners – Use of available burners heat to provide additional heat to the furnaces

CURRENT CHALLENGES RELATED TO DOMAIN (PER CONSTITUENT):

1. Masdar:

a) Market structure:

The building market is diverse and complex. The commercial relationships between the many specialists involved are intricate and critical in sparking action on energy efficiency. The sector is characterised by the fragmentation within sections of the value chain and non-integration among them. Even the largest players are small and relatively local by international business standards, with the exception of materials

and equipment suppliers. The complexity of interaction among these participants is one of the greatest barriers to energy-efficient buildings. Incentives to reduce energy use are usually split between different players and are not matched to those who can save the most through energy efficiency. Local authorities influence the value chain by enacting building policies for their areas. These rules are often a compromise between high levels of energy performance and cost considerations.

b) Energy subsidies:

Electricity is highly subsidised by the Government of Abu Dhabi. Lowering end-use electricity prices leads to increased levels of consumption and waste. It also reduces incentives to conserve or use energy more efficiently due to longer paybacks. These factors exacerbate the harmful effects of energy use on the environment. End users in Abu Dhabi pay 0.15 AED/kWh for electricity, while unsubsidised electricity costs about 0.32 AED/kWh.

c) Lack of regulatory framework:

There is a pressing need for an enabling regulatory framework for energy efficiency in Abu Dhabi. While the Estidama pearl rating system—which enhances the energy performance of new buildings—is now mandatory for new construction in Abu Dhabi, existing buildings are still exempted from such frameworks.

d) Building ownership:

For owner-occupied buildings, the utility and capital expenses are ultimately included in one corporate budget. Thus, decision processes become a justification for any additional expense for higher-performing equipment relative to the expected returns via lower energy costs.

For buildings that are not owner occupied, two separate entities must be considered: the owner and the tenant. This situation becomes a dilemma when neither party has a strong incentive to make the investment in higher-efficiency equipment. If the owner purchases or builds with the intent to sell or lease, alternatives that increase the attractiveness of the building to future owners or tenants (in property values or potential leasing prices) warrant further consideration.

e) Knowledge barriers:

There is a pervasive lack of knowledge about energy efficiency in the public and private sectors; this remains a significant barrier. Best practices are often unknown by homeowners and contractors. Homeowners are responsible for decision making, but they are often ill-informed, unable to adequately evaluate different options, and instead are forced to rely on the suggestions of contractors. Use of life-cycle costing or other long-term, decision-making tools is rare in this sector and the true costs of measures and energy use often remain unknown. Uncertainties and a gap between the perceived energy savings of particular measures and actual savings causes homeowners both to have unrealistic expectations about individual measures and to underestimate the potential for savings with comprehensive measures. Energy use is invisible, and the consequences of it are not obvious.

f) Lack of economic and financial instruments:

At present, there are no economical or financial instruments in Abu Dhabi to facilitate decisions or transactions involving energy efficiency. Inadequate legal and business environments hinder deployment of efficient building technologies by, for example, preventing energy service companies from operating successfully. Financial instruments such as tax incentives or price subsidies can offer substantial short-term benefits, appealing to users. Other instruments could be preferential interest rates for financing energy efficiency investments, and tariff subsidies for reduced energy use.

g) Climate Conditions:

The UAE climate is characterised by high temperatures, humidity, occasional sand storms, and extremely low precipitation levels. In the summer (May–October), average temperatures fluctuate around 40°C, whereas during winter they average around 23°C.

These climate characteristics impose a reliance on mechanical means for cooling, which constitutes the biggest portion of building energy consumption.

2. Abu Dhabi Urban Planning Council (UPC):

Estidama will continually evolve to embrace the rapidly changing concepts for sustainability and ground them in the environmental, social, cultural, and economic needs of the GCC region. Estidama sets the path for a bright future for the Emirate, its citizens, its residents, and the generations to follow. Consequently, the success of Estidama will depend on everyone in the Emirate to create a better future for all.

SUCCESSES RELATED TO DOMAIN (PER CONSTITUENT):

1. Masdar:

a) Masdar energy design guideline:

The goal of Masdar City is to provide residents with the highest quality of life, with the lowest environmental footprint. To that end, buildings in the Masdar City community are designed with efficiency measures to reduce their energy consumption and, subsequently, their environmental footprint. Ultimately, Masdar City's goal is to derive 100% of its energy requirements from renewable sources. Therefore, designing buildings that use the minimum amount of energy without sacrificing occupant comfort is paramount.

This Masdar Energy Design Guideline (MEDG) has been developed specifically to serve as a mandatory framework for designing energy-efficient buildings in Masdar City. The MEDG provides minimum requirements for new buildings in Masdar in the following areas:

- Building Envelope
- Heating, Ventilating, and Air Conditioning
- Service Water Heating
- Building Lighting Systems
- Electric Power, Motors, and Energy Management systems

The last version of MEDG (version 3) was developed internally in view of achieving a city-wide energy efficiency KPI of 50% better than the Abu Dhabi baseline in the most cost-effective way.

b) Microclimate and thermal comfort:

Because Masdar City has placed a priority on pedestrians, optimal thermal comfort for people walking in the city is a primary requirement for the city's success. The capture of beneficial winds, the self-shading of buildings, and the reduction of the heat-island effect diminish the felt outside temperature considerably. The city's master plan considered this aspect in the following manner:

- The urban fabric (the Large and Small Square) is compact, with narrow streets that promote the self-shading of buildings and minimise the solar heat gain
- The major linear parks (Green Fingers) are oriented from the northwest to the southeast. This maximises wind movement and facilitates the movement of wind into the narrow streets
- The maximum walking distance is restricted to 150 m to 200 m, representing an outdoor walking time of 2.5–3 minutes
- The building heights are optimised to reduce the canyon effect within the urban fabric and narrow streets
- Built form guidelines prescribe that the taller buildings are on the southwest and southeast sides of the street to facilitate wind flow downward into the streets
- The plot guidelines prescribe that the buildings are be built to line for 75% of the plot line, with a columnade along the street edge to facilitate a shaded environment for pedestrian movement

c) Siemens HQ building:

The new Siemens headquarters building under construction in Masdar City aims for LEED Platinum certification. It has achieved an energy reduction of 46% compared to ASHRAE 90.1 2007 baseline (which equates to about 65% better than Abu Dhabi standard buildings). The building achieved this high-energy performance by complying with Masdar Energy design Guidelines 3.0. This project has been named winner of the coveted MIPIM Architectural Review Future Projects Awards 2012 in the Offices category.

d) The Future Build:

The first portal of its kind to originate in the Arab world, The Future Build assists architects, engineers, and contractors in identifying and sourcing building products and materials. These materials have been independently assessed to ensure they deliver the environmental benefits that they claim. The Future

Build also provides the latest green building news, as well as sustainable procurement and supply chain consulting and training services.

The Future Build offers an unrivalled platform for suppliers of green building products to bring their products and materials to the attention of all elements of the construction industry. This is particularly true in the United Arab Emirates and the wider Arab world that is concerned with sustainable construction.

e) Innovation with commercial partners:

The Siemens partnership covers the entire value chain of clean energy. This includes SME investment, on-site LEED Platinum HQ, funded research at the Masdar Institute for demand-response technologies, engineering collaboration for carbon capture, and ongoing collaboration for development of global renewable power production and energy efficiency.

The partnership enables development of demand-response technology ahead of the market. In this manner, the developments at Masdar will create new ways to address energy efficiency, which is intended to create and drive commercial value.

f) International Renewable Energy Agency (IRENA) headquarters to be based in Masdar City:

Abu Dhabi has been selected to house the secretariat of the International Renewable Energy Agency (IRENA), the first time an international organisation has chosen a Middle Eastern city for its headquarters. IRENA will be located in Masdar City.

g) Introduction of energy efficiency technologies and fuel switching in new buildings to CDM:

Masdar has developed a methodology to calculate carbon reduction by applying energy efficiency measures and/or fuel switching in new building units (residential, commercial, and/or institutional units). Examples include efficient appliances; efficient thermal envelope; efficient lighting systems; efficient heating, ventilation, and air conditioning (HVAC) systems; passive solar design; optimal shading; building energy management systems (BEMS); and intelligent energy metering.

This methodology was submitted and finally approved by the United Nations Framework Convention on Climate Change (UNFCCC) in June 2011 (AM0091: Energy Efficiency technologies and fuel switching). This is the first methodology that looks into the emission-reduction calculation of new buildings under the UNFCCC scheme. It is also the first time that a methodology has been approved that applies a set of measures to buildings without directly quantifying a specific emission reduction to a specific measure.

h) Pilot projects:

Masdar City has engaged in multiple pilot projects since its inception that have contributed to the development's knowledge base and have enhanced the credibility of its sustainability story. Pilot projects enable Masdar City to test technology with limited capital investment and risk. Pilot project highlights include:

- Geothermal Cooling Pilot: Geothermal cooling is an alternative to traditional electric chillers. Masdar City has demonstrated that geothermal shows significant potential for providing low-cost renewable cooling and hot-water applications to Abu Dhabi
- Solar Cooling pilot: Masdar City is testing a series of single, double, and triple effect absorption chillers powered by different technologies of solar panels. The pilot demonstrated successfully that solar cooling is possible in the UAE climate
- Transportation pilot: In its search for appropriate and sustainable transportation solutions, Masdar City is piloting a Personal Rapid Transit (PRT) and Freight Rapid Transit (FRT) system of electric-powered, automated, single-cabin vehicles that offer the privacy, comfort, and non-stop travel of a taxi service, and the reliability and sustainability of a public transport system. Masdar City also has initiated an electric car pilot with Mitsubishi Heavy Industries to test a point-to-point transportation solution that uses Mitsubishi Motor's i-MiEV, five-door hatchbacks
- The solar panel test field that gives Masdar performance data on more than 35 different solar panels

2. Executive Affairs Authority (EAA):

As mentioned earlier, the project's first phase will consist of the pilots that would verify the commerciality of each of the measures being proposed. Success will be determined on the ultimate savings that are yielded from each measure. Once the pilots are completed, a business case for each measure and/or program will be submitted to the government for Emirate-wide implementation to reduce energy demand.

3. Abu Dhabi Water and Electricity Authority (ADWEA):

a) Model Implementation and Data Availability:

All customers within Abu Dhabi Emirate are supplied with water and electricity by either Abu Dhabi Distribution Company (ADDC) or Al Ain Distribution Company (AADC). Following a recent program to replace analogue meters with solid-state, potentially "smart" digital meters, 506,000 digital water and electricity meters have been installed in ADDC's area of operations covering Abu Dhabi Island and the Western Region and c. 180,000 meters have been installed in Al Ain and the Eastern region served by AADC. This represents about 90% of the total meter points in the Emirate, with the remaining 10% of analogue meters located in older buildings that are expected to be pulled down soon or buildings that were difficult to install meters in. This figure is therefore expected to fall naturally over the next few years.

In effect from March 2012, 128,000 meters are collecting hourly electricity and daily water consumption data, with daily data from both being sent to an Oracle-based meter data management system (MDMS) that is currently undergoing user acceptance trials (June 2012). A little more than half of these are electricity meters. The majority of these meters are on Abu Dhabi Island and most are in medium- and high-rise buildings of more than five floors.

The contracted rollout for bringing the remaining meters online anticipates that by the end of October 2012, 320,000 meters in Abu Dhabi and 80,000 meters in the Al Ain regions will be linked and automatically downloading daily electricity and water consumption data into the Meter Data Management System, representing 58% of the total meter stock.

The meters themselves are of various types manufactured by Elster, Itron, and Iskra. They have been specified to have a memory capacity capable of holding a minimum of 6 months of 15-minute data before the full memories start to be overwritten. The electricity meters are recording hourly consumption data; however, as this data is not required for billing purposes, its capture and download to the "head-end" Meter Data Management System (MDMS), an Oracle database, was not stipulated as a requirement of commissioning and the MDMS is currently capturing only daily data rather than hourly data.

Any further implementation of an automatic meter reading capability will require a new contract that could be put in place if the business case for doing so is clear. The technology, capability, and price of meters have all changed markedly since the first batch was installed in 2007. There may also be additional requirements from an extension to the current smart meter installation program (e.g., the ability to feed real-time information to in-house displays or to communicate directly with household appliances to enable consumers to take advantage of variable pricing) that were not part of the original specification.

AMR coverage on Abu Dhabi Island is good via a dedicated wireless mesh that has been installed specifically to facilitate data capture. Coverage is almost non-existent in the Western region, good in Al Ain, and fair/good in the Eastern region. More than 3,000 SIM cards are being used to transmit data via GPRS outside of the coverage area of the wireless mesh grid on Abu Dhabi Island. These are forwarding data from between 1 and ~25 meters, typically from villas and low-rise buildings.

There will inevitably be much more complete AMR data sets for certain building typologies in some areas; for example, virtually 100% for medium- and high-rise towers on Abu Dhabi Island.

In order to gain an understanding of typical energy consumption across 20 different standardized building typologies, a statistically based minimum sample size for each building typology has been developed. The aggregate total number of buildings for all typologies is c. 1,500; however, it is recognized that it will not be possible to sample every building identified for various reasons (e.g., access difficulties). A larger sample of 2,000 buildings has thus been identified from which the minimum number of 1,500 will be drawn. This sample has been developed with the objective of ensuring that the resulting consumption data will enable the average energy intensity for each typology to be calculated with a precision certainty of +/- 20 KWh/m^2.

4. Abu Dhabi Urban Planning Council (UPC):

The Estidama Pearl Rating System has now been in force for two years and has proven to be a successful sustainability program for the Emirate. With all new villas, buildings, and community developments required to meet minimum quality and sustainability standards, we are creating a

better built environment in Abu Dhabi. To date, the UPC Estidama team has awarded Design Ratings to more than 187 projects, representing approximately 4.4 million square meters of gross floor area (GFA). Of these, 74 are currently under construction with 2 already completed. These projects represent approximately 1.3 million square meters, or 30% of the awarded GFA.

AREAS OF GREATEST INTEREST RELATED TO DOMAIN (PER CONSTITUENT)

1. Masdar:

a) Policy development and enforcement mechanisms:

Enforcement mechanisms are the regulatory or statutory parts of an implementation framework, involving government participation. Statutory instruments seek to bring the entire market to a minimum performance standard. A good enforcement mechanism provides the very foundation on which a broader demand-side management programme is developed. Examples of such mechanisms are:

- Government can make demand-side management projects more attractive by providing legal, technical, and financial support
- Directive/decree for energy efficiency in existing buildings
- Building retrofit code
- Municipal and federal-level programmes to promote and commercialise energy efficiency and renewable alternatives
- Periodic energy audit requirements
- Minimum building maintenance specifications/certifications
- Mandatory compliance for building owners
- Tariff incentive policy

b) Framework for prioritisation, categorisation and validation of actions:

The importance of a methodical framework for prioritisation, validation, and categorisation of actions or measures to be implemented at a city-wide scale cannot be emphasised enough. Having a robust framework in place will ensure that energy efficiency enhancements are carried out in the most cost-effective manner, and that opportunities with the deepest potential impact are seized.

c) Building energy performance certificates:

Energy performance certificates along with a mandatory requirement for valid certificates to be produced for any real estate transaction (buying, selling, leasing) will put building-energy performance into the consciousness of the general public. As this information becomes readily available by making energy performance visible, this will gradually lead to increased awareness and eventually generate a demand for better-performing buildings.

d) Energy service companies (ESCO) business model:

Increasing the energy efficiency of buildings in a sustainable manner requires a market for energy efficiency. This market is currently weak and perceived as too risky. It will require strengthening and increased certainty before private actors are willing to engage further. Private actors are pivotal to the market's development. This circular dynamic underlies the role between public and private actors in market transformation. The UAE should aim to trigger such market transformation through policies that combine regulations. It should also seek both voluntary agreements with manufacturers and regulations to improve the EE standards of equipment and appliances.

e) Energy-efficient water desalination and treatment cycles:

Desalination demand is projected to expand rapidly in the UAE. As desalination requires a considerable amount of energy, water production will contribute significantly to increased energy use. Therefore, energy-efficient water desalination systems are of greatest interest to the country.

f) Energy-efficient cooling technologies:

There are substantial challenges posed by the high electricity needs of traditional air conditioning, which consumes approximately 70% of a total building's energy as well as approximately 70% of the peak electricity demand in the UAE. Masdar Institute's research focus has traditionally been on efficient cooling technologies. The projects cover a wide range of relevant topics such as efficient buildings, advanced cooling technologies, district cooling, GCC-specific A/C equipment, and tools for the design and assessment of demand-side management programmes. These projects are all funded by external entities (Siemens, Tabreed and Executive Affairs Authority of Abu Dhabi).

When properly designed and managed, district cooling is inherently more energy efficient than decentralised cooling. In that sense, it can be part of a larger demand-side management portfolio. The same is true for cooling systems that use renewable energies. Such systems can effectively shave a portion of the grid's peak load by resorting to either solar or geothermal energy.

g) Smart grid and associated technologies:

Finally, smart grid and associated technologies are usually recognised as enablers of energy efficiency. For example, smart meters make it possible to influence the peak load via information feedback and dynamic pricing. Smart thermostats can interpret grid signals to offset temperature setpoint, relieving cooling load. Similarly, smart appliances incorporate control logic that sheds domestic appliance load from the grid when requested by the grid operator.

2. Executive Affairs Authority (EAA):

The EAA's primary area of interest within Demand Side Management is to reduce overall government expenditure towards the sector and improve the efficiency of the government's balance sheet. This reduction in energy demand and improvement in energy efficiency will also help allocate the government's resources—for example, natural gas—in a more efficient manner.

3. Abu Dhabi Water and Electricity Authority (ADWEA):

ADWEA's primary area of interest is the development of the capability to accurately measure and validate energy efficiency savings from the level of the individual building up to the level of the whole city and whole Emirate. This process includes building and implementing the models and algorithms; the capture, handling, storage, and analysis of required data; and, in parallel, the development of the staffing capability to undertake these tasks given the right tools and manage a multimillion-dollar-per-year energy efficiency program. This will in turn lead to ADWEA being able to play the role of the DSM Program Manager and Contract Administrator for all energy saving interventions across the Emirate.

4. Abu Dhabi Urban Planning Council (UPC):

Demand side management in energy, water and waste.

The People's Republic of China

Participant Snapshot	
Crosscutting and Integrative Technology Domain	**Waste-to-Energy (e.g., waste-waste, water-biogas, biofuel-based district heating and cooling in an integrated urban development setting)**
Country Participant	**The People's Republic of China**
Network Constituents	**The People's Government of Chongming County; The People's Government of Zixing City**

PROFILE OF NETWORK CONSTITUENTS

1. **The People's Government of Chongming County:**

   Chongming County, including Chongming Island, Changxing Island, and Hengsha Island, covers an area of 1,411 square kilometers (km^2) and has a registered population of 680,000. Chongming Island, reputed as "the door of Changjiang" and "Yingzhou in the East China Sea," is the third-largest island in China after Taiwan Island and Hainan Island, with a land area of 1,267 km^2. Chongming County has committed to building an ecological island since 1999.

2. **The People's Government of Zixing City:**

   Zixing is situated at 113 degrees east longitude and 25 degrees north latitude in the southeast of Hunan Province. The city governs 20 administrative units. It covers an area of 2,747 km^2 with a population of 370,000, of which about 250,000 are farmers. It is a new industrial and tourist city, with mining areas, forests, reservoirs, and tourism areas.

HISTORICAL CONTEXT AND EXPERIENCE RELATED TO DOMAIN (PER CONSTITUENT):

1. **The People's Government of Chongming County:**

   Chongming is the largest agricultural county in Shanghai area. It produces a great deal of agricultural waste each year, including livestock and poultry manure and crop straws. The traditional processing methods have not been able to adapt to waste disposal. Therefore, ecological methods were used to solve the problem, and these efforts are helping in the eco-island construction of Chongming.

2. The People's Government of Zixing City:

Agricultural population accounts for the majority of Zixing City. The territory is rich in crops, including paddy rice, maize, and sorghum. These crops will produce a large quantity of biological waste when they are ripped. Farmers usually feed animals with this biological waste or burn it in field to improve the soil.

CURRENT ACTIVITIES RELATED TO DOMAIN (PER CONSTITUENT):

1. The People's Government of Chongming County:

First, to strengthen our cooperation with international organizations and to broaden our vision, we held the international forum of Chongming eco-island. This helped us increase our international experience. Second, we expanded the cultivated area of green manure by adopting the rotation of grain crops and green manure. This decreased our fertilizer input. Third, we increased our educational propaganda to encourage the full involvement of all citizens in environmentally friendly efforts. Through this propaganda, we have reduced the burning of crop straws and encouraged citizens to put out rural household garbage for collection. Finally, we have introduced vaporization technology for crop straws to increase recycling.

2. The People's Government of Zixing City:

First, we cooperated with various enterprises to develop crop-waste utilization technology. Second, we strengthened our exchange of information and cooperation with international organizations to broaden our vision. Third, we introduced technology that could vaporize crop straws to increase the use of recycling. Finally, we developed technology to manage animal waste.

CURRENT CHALLENGES RELATED TO DOMAIN (PER CONSTITUENT):

1. The People's Government of Chongming County:

Focusing on the target of eco-island construction in Chongming, we face serious challenges in decreasing the input of chemical fertilizer and pesticides, reducing agricultural pollution, and promoting the comprehensive resource utilization of agricultural wastes.

2. The People's Government of Zixing City:

Zixing is a resource-exhausted city. Currently, we are facing serious challenges in industry transformation and environmental deterioration. By firing the straw, we have achieved an energy utilization rate that is not high, and it is hard to concentrate processing because famers live in scattered locations. The excretion of animal waste damages the environment.

SUCCESSES RELATED TO DOMAIN (PER CONSTITUENT):

1. **The People's Government of Chongming County:**

   First, there is mechanization of crop straws returning to fields. Second, efficient and low-toxic pesticides and biotechnology are used to eliminate the ill effects of pests and plant diseases on crops. Third, a portion of the animal dung is used to produce methane with fermentation technology.

2. **The People's Government of Zixing City:**

   First, we recycle biomass. Some of the animal dung is used to produce methane with fermentation technology. Second, we take efficient and low-toxic pesticides and biotechnology to eliminate the ill effects of pests and plant diseases on crops. By these means, we are helping to improve the environment.

AREAS OF GREATEST INTEREST RELATED TO DOMAIN (PER CONSTITUENT)

1. **The People's Government of Chongming County:**

   Focusing on the development of highly efficient eco-agriculture, we are interested in recycling agricultural wastes, pollution abatement, and risk assessment of the agricultural eco-environment. We are also interested in mechanization of agriculture, standardization and cleaning of agricultural production, tridimensional multiplication planting, and breeding in woods. Finally, we want to apply technology research and integration to enhance the sustainable development of eco-agriculture in Chongming.

2. **The People's Government of Zixing City:**

   We produce and utilize biodiesel. We have the technology to generate power from kitchen waste.

Participant Snapshot	
Crosscutting and Integrative Technology Domain	**Cities – Demand-side Management (e.g., smart grid, buildings – thermal management, green lighting, cool roofs, district heating and cooling infrastructure)**
Country Participant	**The People's Republic of China**
Network Constituents	**The People's Government of Longyan City; The People's Government of Shijingshan District**

PROFILE OF NETWORK CONSTITUENTS

1. **The People's Government of Longyan City:**

Longyan, with a population of 2.951 million, covers an area of 1,900 km^2. It is located in the west of Fujian province. Longyan has abundant resources of forest and mining, and it has the headstream of the three major rivers in Fujian: Minjiang River, Jiulongjiang River, and Tingjiang River. The forest coverage rate of Longyan is 78%, ranking first in Fujian. National 5A Meihua Mountain Nature Reserve is honored as "the Green Emerald of the tropical desert zones." Longyan is the newly rising tourism area in the West Taiwan Strait Economic Zone, and the world nature heritage Hakka Tulou has been honored as "the exotic flower in world architectural history."

2. **The People's Government of Shijingshan District:**

Shijingshan District is located in the west of Beijing. The region's total area is 84.38 km^2. The resident population is 634,000. In 2012, the whole year's million-yuan GDP energy consumption was about 1.04 tons of standard coal.

HISTORICAL CONTEXT AND EXPERIENCE RELATED TO DOMAIN (PER CONSTITUENT):

1. **The People's Government of Longyan City:**

Historically, population growth and poverty have led to heavy deforestation. Longyan was one of the areas most severely affected by soil and water loss. According to a remote sensing survey in 1985, the area of the soil and water loss was 3.747 million acres, taking up 13.13% of total land area, in which moderate or above loss area took up 32.93%. Since 2000, 10 million provincial financial allocations of funds have been used for controlling soil and water loss in Changting County. In recent years, on the basis of strategy development by the Fujian Provincial Party Committee, the Fujian Provincial Government, the Longyan Municipal Party Committee, and the Longyan Municipal Government—and after unremitting efforts—Longyan's soil and water loss management and ecological protection have achieved remarkable success.

2. The People's Government of Shijingshan District:

Shijingshan has a large amount of heavy industry, and the energy consumption is high. High energy consumption has led to air pollution. In order to clean the air, saving energy and clean energy are necessary. The district began to accelerate the transformation of the energy pattern in the 2000s.

CURRENT ACTIVITIES RELATED TO DOMAIN (PER CONSTITUENT):

1. The People's Government of Longyan City:

Energy demand is one important origin of forest deforestation. In order to satisfy the energy demand of local farmers and restrain deforestation, we have undertaken the following activities:

a) Encouraged farmers to use clean energies and give them subsidies:

Farmers in high soil and water loss areas are encouraged to use natural gas, solar energy, and biogas. Subsidies are provided to people who use electricity to seal off mountainous areas where soil and water loss are high. Since 2000, municipal and county governments have raised 9 million yuan to improve soil and water loss management.

b) Introduced conservation policy and established a protection system:

Through auction and leasing and by contract, the government has established a system of forest rights, introduced a number of preferential policies for infrastructure construction, and given full play to the main role of organizations at the grassroots level and main body. The government has also established village rules in soil and water loss areas to forbid mountain logging, pulling weeds and grazing animals, and forming the forest management mechanism of "village autonomy, people supervision."

c) Developed the economy and improved the standard of living in the soil and water loss area:

The government has combined soil and water loss management, developed a characteristic industry, popularized economic fruits that are suitable to grow in southern red soil, and developed the forest economy. It has also increased the income of people who work in managing soil and water loss so that there will be a win-win in ecological benefit, economic benefit, and social benefit.

2. The People's Government of Shijingshan District:

First, Shijingshan District implements the green lighting project. The project includes a program allowing people to purchase energy-saving lamps for only one yuan, free implementation of heating and lighting, the promotion of efficient lighting products, and the construction of new LED lamps. Second, we started the cleaning energy project. The northwest heating power center has begun using gas instead of coal. The region's heating and cooling infrastructure is being updated, and the old heating pipe network is being improved to highlight energy transportation efficiency.

CURRENT CHALLENGES RELATED TO DOMAIN (PER CONSTITUENT):

1. **The People's Government of Longyan City:**

   The challenges include how to correctly handle the relationship between economic construction and ecological protection, as well as adhering to the unification of economic and social development while protecting the natural ecological environment. Other challenges are combining development and management, realizing both economic and social development, improving people's living standards while at the same time protecting the environment, and realizing the harmony between human beings and nature.

2. **The People's Government of Shijingshan District:**

   The need for power has increased because the standard of living has improved. It is difficult to construct new buildings that meet the updated energy standards.

SUCCESSES RELATED TO DOMAIN (PER CONSTITUENT):

1. **The People's Government of Longyan City:**

   Effective soil and water loss management has led to improvement in the ecological environment as well as rural economic development. According to statistics from 2000–2012, the forest coverage rate in a managed area of the city that is known for soil and water loss rose from 15%–35% to 65%–91%. Soil erosion decreased from 8,580 tons per square kilometer per year to 438−606 tons.

   The combination of soil and water loss management coupled with development has driven industrial growth. Presently, several 10,000-acre base areas have been established in many soil and water loss areas. These areas include red bayberry, Guanxi Sweet pomelo, tee, bamboo, tea-oil tree, Chinese chestnut, Gingko, and other trees. The forestry not only controls the soil and water loss but also allows the rural economy to develop and increases farmers' incomes. Longyan has been honored as "a flag of soil and water loss area management in southern red land."

2. **The People's Government of Shijingshan District:**

   About 32,000 tons of coal have been saved by using the Energy Performance Contracting method. The people's awareness of the need to save energy has increased.

AREAS OF GREATEST INTEREST RELATED TO DOMAIN (PER CONSTITUENT)

1. **The People's Government of Longyan City:**

   Of greatest interest are the domestic and international preferential policies and subsidies for energy management and clean energy. The application of these policies and procedures has certainly enhanced industrial development. This is mainly due to financial support from the government and related preferential policies. Presently, however, most of these preferential policies and fiscal subsidies are unlikely to continue. Many clean technology enterprises face the risk of bankruptcy, being sold, or being acquired without the support of this timely and objective policy.

2. **The People's Government of Shijingshan District:**

   Areas of greatest interest include strengthening energy conservation management at the source and the construction of buildings integrated with solar photovoltaic technology. Other areas of interest include the use of sewage source heat pumps and energy-saving monitoring technology.

Sweden

Participant Snapshot	
Crosscutting and Integrative Technology Domain	**Waste-to-Energy (e.g., waste-waste, water-biogas, biofuel-based district heating and cooling in an integrated urban development setting)**
Country Participant	**Sweden**
Network Constituents	**City of Umeå, City of Linköping, City of Gothenburg, City of Borås, Avfall Sverige (The Swedish Waste Management Association)**

PROFILE OF NETWORK CONSTITUENTS

1. **City of Umeå:**

The city of Umeå (117,000 inhabitants) is the center of growth in the north of Sweden. The city has the ambition to become the northern hub for sustainable urban development. It is actively cooperating with the business and research sector to pursue this objective. One particular area of strength in Umeå in this regard is in the field of Waste to Energy (WtE).

Key stakeholders in Umeå actively working with Waste to Energy are Kompetensspridning i Umeå AB, Umeva, and Umeå energi AB; all three are owned by the municipality.

Kompetensspridning i Umeå AB is a company aimed at marketing and selling municipal competence and municipal innovations, in close cooperation with the municipality's administration, companies, and trade, as well as industry in the Umeå region.

Umeva is responsible for waste management in the municipality of Umeå. Umeå energi treats and recycles energy each year, amounting to 160,000 tons of household and industrial waste from the region.

The companies work in close cooperation with Umeå University, Swedish Agricultural University (SLU), and business clusters such as Processum and the Biofuel Region. In addition, Kompetensspridning i Umeå AB is working in close cooperation with private businesses such as Mittel AB and Vitec AB. These are private companies that are interested in exporting knowledge and material in the sector.

2. **City of Linköping:**

The overall climate goal of Linköping municipality is to become carbon neutral by 2025. The starting point for achieving this goal is that all actions be based on a holistic view of all the waste and energy systems. The Tekniska Verken group, a multi-utility company owned by the city of Linköping, has more than 50 years of experience in developing and operating state-of-the-art waste-to-energy facilities as well as waste management solutions and district heating and cooling networks. With regard to energy efficiency and environmental performance, the waste-to-energy facilities show some of the best achievements in Europe, which is the result of continuous development and improvement. Today, four plants are in operation with a total capacity to treat more than 15% of the Swedish municipal solid waste, and to provide more than 90% of the population of the city of Linköping with low-priced renewable heat and electricity. A key factor in achieving this goal is to reduce fossil-based fuels and carbon emissions from the transport sector by turning organic waste to biogas as vehicle fuel. Seven percent of today's total fuel consumption in Linköping is biogas produced in two plants. With regard to waste management, only 1% of the city's municipal solid waste goes to landfills, while 50% is being recovered and 49% recycled.

3. City of Gothenburg:

The City of Gothenburg is Sweden's second-largest city, with a population of half a million. Gothenburg has a highly diverse industrial structure and is the heart of a large and growing business region. The city of Gothenburg has waste-to-energy-related activities in several of its own organizations; the energy company Göteborg Energi, which offers district heating, energy services, cooling, gas, optical fibers, and an electricity supply network. The district heating network provides heating to more than 90% of all apartment blocks in Göteborg, and 86% of the heat is waste heat. The waste company Renova, which is co-owned by Göteborg and 10 other municipalities, covers the waste hierarchy and operates—for example—recycling, biowaste treatment, incineration with electricity and heat production, landfilling, vehicle development, and hazardous waste treatment. The wastewater treatment company Gryaab, which is co-owned by Gothenburg and six other municipalities, operates the wastewater treatment plant Rya, which is one of the largest in Scandinavia. The sludge is used to produce biogas equivalent to 65 GWh. The city administration Kretslopp och Vatten is responsible for the household waste in the city of Gothenburg and procures a collection of waste from various waste entrepreneurs. Incineration and biowaste treatment are performed by Renova. Business Region Göteborg (BRG), owned by the city of Gothenburg, works to strengthen and develop trade and industry in the Gothenburg region. The objective is to contribute to sustainable growth, as well as a high level of employment and diversity in trade and industry in the region. The company represents the 13 municipalities that form the Gothenburg region, and is project manager of Ecoex—West Swedish Environmental Export—which is a collaborative project involving several public bodies in western Sweden. Ecoex coordinates contact between environmental companies and decision makers who require environmental expertise. It also finds people who have environmental expertise, works with establishing and developing business contacts, informs about implemented solutions in West Sweden, and organizes tailor-made study tours for international delegations interested in finding west Swedish cleantech. Green Gothenburg is another project led by BRG. It organizes study visits that highlight Gothenburg's environmental and sustainability initiatives, targeted at companies with an interest in issues regarding housing, housing construction,

waste management, and energy. The Göteborg Region Association of Local Authorities (GR) is a cooperative organization of 13 municipalities. Combined, the population of these municipalities is 927,000, and in 2010 the region decided upon the same integrated waste-management plan (A2020). Since 2010, the city of Gothenburg has been one of the actors in Mistra Urban Futures, a new center for sustainable urban development with the ambition to become a world leader in the field in the near future. Innovative, excellent, effective, and relevant knowledge is developed in close cooperation between practitioners and researchers. Another initiative is the Smart City of Gothenburg. Its projects are based on the EU`s Smart Cities initiative. Gothenburg is the lead partner of CELSIUS, the Combined Efficient Large Scale Integrated Urban Systems, which focuses on district heating and cooling. Waste-to energy is an important aspect of the initiative. Renova and Kretslopp och Vatten are two of the actors in Waste Refinery, which is a Swedish Excellence Centre coordinated by SP Technical Research Institute. The center performs theoretical and practical research, in close collaboration with representatives from the industry, research organizations, and the society. Chalmers University of Technology is a strong research institution with energy as an area it wants to advance.

4. City of Borås:

The waste handling in the City of Borås, a city of approximately 100,000 citizens, is managed by the municipality owned company Borås Energy and Environment. The company has 220 employees and annual sales of SEK 950 million. Waste Recovery – International partnership in Borås is a cooperation consisting of the City of Borås – City office, Borås Energy and Environment, SP- Technical Research Institute of Sweden, and the University of Borås. Through this cooperation, we work together to develop the local waste management as well as international waste-to-energy projects. Included in our network are a number of businesses that fall within the cleantech range of firms.

5. Avfall Sverige (The Swedish Waste Management Association)

Avfall Sverige is the Swedish Waste Management and Recycling association with 400 members from both the public and the private waste management and recycling sectors. Ninety-nine percent of the Swedish population is represented through Avfall Sverige. Avfall Sverige represents its members in dealings with politicians, other decision makers, authorities and media, both in Sweden and internationally. Together with both public and private sectors, Avfall Sverige has developed a framework to provide a strong platform for exports of Swedish waste management knowledge and technology. With in-depth knowledge and a broad company base, the strongest offer can be created for every case, with teams matching specific needs. Cooperative business models designated to create the strongest offer in each specific project are being developed. A joint network of actors in the Swedish public and private waste management sector provides expertise, products and services. All Swedish GSCN network constituent cities are members of the exhort network. The development of the platform is formed as a project running over 2012-2014. As support to the project leader, there is a working group, with members from both the public and private sectors.

HISTORICAL CONTEXT AND EXPERIENCE RELATED TO DOMAIN (PER CONSTITUENT):

1. **City of Umeå:**

Umeva and its predecessors have been gathering household waste in the city of Umeå since it was legislated in Sweden. Umeå is unique in that for the last 20 years there has been labeling and weighing of individual waste containers. This means there is a unique competence regarding citizen/customer impact by tariff alterations, information campaigns, waste plans, and other forms of governance. These experiences have strongly contributed to the fact that today only 1% of household waste in Umeå goes to landfill.

When it comes to collecting hazardous waste, Umeå is also a nationally award-winning role model.

Umeå Energi has pursued energy recovery from waste since 1973. The business has been expanded in stages, and the latest cogeneration plant using waste as fuel was put into operation in 2001. It was considered one of the most energy-efficient plants in the world, with a yield close to 99%. In parallel, district heating has been extended, currently covering almost the entire city.

2. **City of Linköping:**

Linköping municipality and its companies have a long tradition of environmental and climate work. In 1998, the City Council adopted a local Agenda 21 plan, including visions, goals, and a plan of action for how to work with municipal energy and waste. The expansion of district heating in Linköping started about 60 years ago and over the years has grown to include almost 95% of all households in the urban area of Linköping. The first modern waste-to-energy plant was inaugurated in 1982, and production of biogas as a vehicle fuel began in the mid-‘90s.

Linköping municipality faced a strategic choice as to how the environmental effect of public transport should be reduced, specifically air pollution in the form of nitrogen oxides, particulates, and VOCs, as well as noise. Tekniska Verken, in cooperation with the municipally owned bus company, began a collaborative project on biogas-powered urban buses. This project resulted in the responsible municipal committee deciding that municipal buses would be powered by biogas. Today, all urban and rural buses are running on biogas.

3. **City of Gothenburg:**

The City of Gothenburg has a long history of using waste as an energy resource. Sävenäs waste incineration plant was built in 1972, and the city has since been strongly involved in developing techniques and a system for waste treatment; i.e., flue gas cleaning. Today, Sävenäs is one of the world’s most efficient plants, maximizing the energy produced/ton waste, and minimizing the emissions. Waste heat is used for district heating and electricity production. Today, the waste incineration contributes 30% of the district heating need and 5% of the electricity need for the city. Construction of the district heating system started in the fifties and today it´s more than 1,000 km long. Gothenburg was

also an early implementer of source separation of household waste and has had separate collection of biowaste since 1997. Lately, an increased focus is on collection of biowaste for biogas production, and 32% of the household biowaste in Gothenburg is source-separated and used for biogas production. Sludge from waste water treatment has been used for biogas production since 1991 and produces 65 GWh of biogas, which is upgraded to vehicle fuel. When the Gasendal plant opened in 2007, it was the world's largest biogas upgrading facility. The waste collection fleet in Gothenburg use different new techniques. For example, the electric hybrid technology with refuse compactors runs on electricity and gas. These vehicles are used in central Gothenburg, where the need to reduce both greenhouse gas emissions and noise is most acute. Successful in waste planning, the Gothenburg Region and its 13 municipalities developed the first common integrated waste management plan, A2020, which was decided upon in 2010.

4. City of Borås:

For more than 20 years, we have been focused on using energy from sorted waste. Twenty years ago, we had 100,000 tons of unsorted household waste on community landfill. Today, that number is close to zero. We have a dream of becoming a fossil-fuel free city by converting the city's fossil energy sources to renewable sources, and to generate sufficient energy to meet the city's needs from renewables. We will achieve this by using our unique recycling model, which enables us to take care of communal resources such as waste and sewage sludge and transforming it into district heating, district cooling, biogas, and electricity.

5. Avfall Sverige (The Swedish Waste Management Association)

The development of waste management systems in Sweden has been very successful and yielded unique results from an international point of view. The European Commission ranks Sweden among the top countries in waste management performance in Europe.[1]

Today, less than one percent of Swedish household waste is landfilled. The waste is treated in integrated systems and recycled as district heating, electricity, biogas, biofertilizer and other materials. Different treatment methods are used depending on the character of the waste, making it possible to use the waste as a resource.

Many other countries have been aware of this, and want to learn more about the Swedish waste management system and how it has been built up. On a daily basis, contacts are taken from different countries with different requests on knowledge transfer from Sweden. However, standing alone, the municipalities and companies have had limited resources and possibilities to success in spreading knowledge about Swedish waste management in the world.

[1] Source: Screening of waste management performance of EU member states, EC, Brussels, 2 July 2002

CURRENT ACTIVITIES RELATED TO DOMAIN (PER CONSTITUENT):

1. **City of Umeå:**

Umeva is continuously working in national pilot projects, the latest being a system for the collection of electronic waste, which has received national acclaim. There is also a long-standing regional cooperation on procurement with 14 other municipalities.

The Chinese city of Xi'an has a long-standing cooperating with Umeva in waste-to-energy. Umeva has also been active in national research and development projects in cooperation with several universities.

Umeå Energi supports research and development in a number of areas. One Ph.D. project will investigate how thermal methods can clean ashes from chlorinated organic compounds, such as dioxins and furans. Designed for research, Umeå Energy has funded a road built from bottom ash to assess bottom-ash mechanical properties and environmental impacts together with Luleå University of Technology, VTI, and SGI. Another project in collaboration with SLU and Umeva is producing microalgae in municipal waste water by adding carbon dioxide from flue gases at the city CHP (Combined Heat and Power) plant. The aim is to produce biomass, which can then be processed into biodiesel or other biofuels.

District energy is one of the main building blocks in creating a sustainable city. The city of Umeå plans to have district energy as a main source of energy for many years to come. Umeå Energy is therefore working in close cooperation with city planners. One current national pilot project is Sustainable Ålidhem, in which Umeå Energi is a partner in a refurbishing project aiming to reduce the climate impact of an entire city district. The project underlines the importance of planning, implementing, and monitoring with a holistic approach, and addresses citizen behavior, eco-financial matters of cost-effective energy efficiency measures, and local power production together with large-scale cogeneration of CHP.

Kompetensspridning i Umeå AB is working together with the city, UMEVA, and Umeå Energy to make business of the knowledge regarding district energy and waste-to-energy.

2. **City of Linköping:**

In the spring of 2012 an optical system for sorting waste food from households was introduced. The households sort food waste into a green plastic bag; this bag is then disposed of in the same waste container as other waste. Separating the green bag and its contents from other waste is achieved by optical sorting. A revision of the municipal waste plan will begin in 2013. In 2012, Linköping University was granted partial funding by the Energy Authority to create a national competence center for biogas, Biogas Research Centre (BRC), which has a very broad interdisciplinary approach, bringing together biogas-related expertise from several areas to create interaction on many levels:

- Between industry, academia, and society
- Between various perspectives
- Between disciplines and areas of expertise

The vision of the BRC is: Resource-efficient biogas solutions are implemented in many new applications, contributing to a more sustainable energy supply and an improved environmental situation. It is also a sound business practice.

Currently, the City—through its subsidiary the Tekniska Verken Group—is in the process of developing a model to transfer the knowledge within the field of waste-to-energy on the international market. This will include a training center as well as advanced consultancy services aimed at helping other cities to achieve what Linköping has managed to do.

3. **City of Gothenburg:**

Examples of current activities related to the focus area are GoBiGas, Gothenburg Biomass Gasification, a large investment in biogas production by biofuels and waste from forestry. In 2016, the facility is expected to deliver the biogas equivalent of 1,000 GWh of energy per year. Another example is the increased collection of biowaste, primarily through customer contacts and fees based on the weight of residual waste, in combination with the new pre-treatment facility for biowaste. Several research projects are ongoing within Waste Refinery, both concerning incineration and biological treatment processes. There is also research concerning waste and energy systems. In the waste transport field, Renova has a goal that the vehicle fleet for waste collection shall be fossil-free in 2015.

4. **City of Borås:**

The Stakeholder cooperation Waste Recovery – International Partnership in Borås has a number of ongoing projects, including through the Swedish International Centre for Local Democracy (ICLD). In Indonesia, there is Waste to Value project in Palu, City Clusters in Sleman, and Stakeholder Cooperation in Pontianak. In Vietnam, there is Da Nang. In Moldova, there are Ungheni and Orhei. These projects focus on knowledge transfer for transforming waste to energy. They include commercial projects in Sankta Catarina province in Brazil with 14 municipalities, with education in waste-to-energy. There is also the Demo Environment project on methane gas from landfill in Palu.

5. **Avfall Sverige (The Swedish Waste Management Association)**

Just over five million tons of waste are treated by waste-to-energy in Swedish plants every year. These plants provide heat corresponding to the needs of 810,000 homes, around 20 percent of all the district-heating produced. It also provides electricity corresponding to the needs of almost 250,000 homes. International comparisons show that Sweden is the global leader in recovering energy in waste. Waste-to-energy is a well-established source of energy in Sweden.

The first incineration plant started operation during the latter part of the 1940s. Swedish waste-to-energy today is an environmental, financial, safe and stable contribution to the country's energy supply.

CURRENT CHALLENGES RELATED TO DOMAIN (PER CONSTITUENT):

1. **City of Umeå:**

   One local challenge for Umeva is to implement an ambitious waste plan for the city, in line with the national industry vision "No waste 2020;" Umeva is also striving to be the regional competence resource in WtE in northern Sweden.

   For Umeå energy, one focus right now is on assessing the climate impacts of WtE. Safe management and recycling of waste products is also a focus. The ability to utilize district heating applications other than just heating buildings is being investigated.

   Another challenge is how to make efficient use of energy; i.e., to find best use and technologies to cut losses of energy in supply chains along with our customers.

2. **City of Linköping:**

   Linköping municipality's biggest challenge is to reach its goal of becoming carbon neutral by 2025. To achieve this objective, broad cooperation between the municipality and its companies, the inhabitants, and the local network is necessary. A larger proportion of the vehicle fleet must be powered by renewable fuel. Additionally, an increased production of renewable electricity is needed, and—last but not least—there is a need for increased energy efficiency in both the energy and transport sectors.

3. **City of Gothenburg:**

   Gothenburg has objectives in the integrated waste management plan, in the local environmental objectives, and in the city´s yearly budget, all aiming to decrease the impact that the city has on the climate. Gothenburg has adopted a local environmental objective for 2050 to reduce the carbon footprint of the city, which means the average level of carbon dioxide emissions must be reduced from about 10 tons per person to less than 2 tons for the goal to be reached. There is also an interim target stating that by 2020 the emission levels of carbon dioxide will be reduced by at least 30% compared to the levels in 1990. There are a lot of measures taking place to fulfill the objectives, and a separate environmental action program is being processed at present, to be even more progressive. Translated into the waste hierarchy, the primary goal is to minimize the overall waste amounts, and to reuse and recycle as much of the waste as possible. A big challenge is to decrease the waste amounts generated. Directly focused on waste-to-energy, a big challenge is to increase the collection of source-separated biowaste, and to increase the biogas production from various types of waste, including forestry waste in GoBiGas.

4. **City of Borås:**

   We are constantly trying to identify flows of energy that are not fully exploited in the society. We are in the startup phase of planning a new district heating power plant and a new sewage water treatment plant, which should be ready by 2017. These two facilities are the basis of the city´s future energy and environmental center. The center, located 10 km south of Borås, will also contain reuse and recycling

facilities and greenhouse farming facilities. The challenge is to identify as many re-use and recycling opportunities as possible.

SUCCESSES RELATED TO DOMAIN (PER CONSTITUENT):

1. **City of Umeå:**

Strengths of WtE in Umeå include the fact that it is a modern facility with a highly efficient flue gas cleaning process—a very efficient heat-recovery process that leads to an efficient use of resources. A well-established cooperation with universities and other stakeholders in research and development in the region is a pre-condition for the pilot projects that are currently underway.

Another strength is the ability to communicate with citizens based on the unique competence acquired through the waste collection system (i.e., labeling and weighing of individual waste containers), and thus affecting citizen behavior in line with local and national objectives. The city recycling centers are also in the top echelon in Sweden.

There is also a broad experience in Umeå of taking part in international projects, participation in industry organizations and investigative work, and participation at the national and European level to promote effective utilization of waste.

2. **City of Linköping:**

There are several key success factors in the work Linköping is doing in developing the concept of waste-to-energy. The fact that there has been political consensus on these issues should be specifically highlighted. Another important factor is that the municipally owned company, Tekniska Verken, is active in all branches of the technical supply system, such as electricity, heating and cooling, biogas production, water and wastewater operations, and waste management. In addition, Tekniska Verken is owner of the associated infrastructure. This means the company has had and still maintains a very high level of expertise in all areas of operation. Close cooperation with Linköping University has also been of great importance for the development of the business.

3. **City of Gothenburg:**

Success factors include the combination of efficient techniques and knowledge about waste and energy systems. Renova's waste-to-energy plant is one of the world’s most advanced facilities for the incineration of waste, with highly advanced flue-gas-cleaning equipment. There is the development of a broad range of waste treatment methods. Lately, there has been success in increasing the amount of source-separated biowaste. Transition to a non-fossil waste collection vehicle fleet, efficient waste incineration with low emissions, efficient electricity, and district heat production mark other successes. An efficient regional collaboration aiming at the objectives set in the regional integrated waste management plan, A2020, is another. Another is the GoBiGas project. And there has been increased

political awareness about the connection between consumption and the environmental impact, and the clear and distinct political environmental focus.

4. **City of Borås:**

We have been engaged in international projects since 2008. One of the first was to project-lead the building of a biogas plant at the Gamping fruit market in Sleman, Indonesia. This plant was established with a grand opening ceremony in 2011 and has become a model for a number of similar plants in Indonesia. It has had spin-off effects at the local, regional, national, and international levels. We have also been educating politicians and officials from Indonesia, Brazil, Russia, Vietnam, Thailand, Cambodia, and Laos in basic waste management.

AREAS OF GREATEST INTEREST RELATED TO DOMAIN (PER CONSTITUENT)

1. **City of Umeå:**

The climate issue is a critical one. How can we reduce the carbon footprint of WtE? How can we share best practices? What can be done to reduce the impacts of WtE? What other secondary fuels are available that can be used for energy recovery? How can we further clean ashes in order to reuse them, such as construction materials?

How do we communicate with citizens to safeguard reduced amounts of waste and cleaner waste fractions?

How do we ensure that hazardous waste is collected in the best possible way?

We have come up with efficient methods and technologies of improving yield of CHP hook-ups by different methods, such as fuel quality, incineration, flue gas, and more.

We also see the potential in making a business of our cleantech knowledge and exporting this to countries around the world. We have experience in cooperating with partners in Gothenburg and Linköping on this matter.

2. **City of Linköping:**

- Exporting the knowledge that the city and its companies possess in the field of waste–to-energy. How can this experience be shared and how can profitable business models be created?
- Finding innovative solutions across the energy sector that can support the municipality's efforts to achieve the overall goal of becoming carbon neutral by 2025

3. **City of Gothenburg:**

- How to further promote biogas production
- Developing of business, systems, technique, and competence

- Benchmarking
- Sharing our experiences
- The transition into a fossil-free city
- How to use bio gas and bio energy optimally
- How to further develop the district heating system
- Sustainable transportation

4. City of Borås:

We want to share our experience in the area and share the unique Borås recycling model. We certainly want to take part in the experiences of the other interested parties and recycling models so we can refine our own model and management.

5. Avfall Sverige (The Swedish Waste Management Association)

Without a policy in place on national, regional and local level supporting the development of a sustainable waste management system, a well functioning system cannot be created and work in an optimal manner. GSCN, being a high level global forum, can promote development by providing an opportunity for discussion and the exchange of experiences on successful policy between different countries. In addition, the close city-to-city network that will be created will also be an excellent platform for learning and exchange experiences on different levels that could be a good base for wider knowledge experience and technology transfer between countries.

Participant Snapshot	
Crosscutting and Integrative Technology Domain	**Cities – Demand-side Management (e.g., smart grid, buildings – thermal management, green lighting, cool roofs, district heating and cooling infrastructure)**
Country Participant	**Sweden**
Network Constituents	**City of Malmö**

PROFILE OF NETWORK CONSTITUENTS

1. **City of Malmö:**

The City of Malmö is engaged in a number of public-private partnerships in order to create sustainable neighborhoods in a long-term sustainable city. The major stakeholders in the partnerships are:

- The inhabitants of the city and people working or visiting the city
- Representatives from the city department, and city
- E.ON (the local producer of district heating and owner of the electricity and heating grid)
- VA-Syd, responsible for fresh drinking water, wastewater treatment, and waste management
- Developers
- Researchers, mainly from the universities in Malmö and Lund
- Local, regional, and national governments and agencies in Sweden and Denmark
- Consultancies, NGOs, promoters of cleantech companies and technologies, etc.

HISTORICAL CONTEXT AND EXPERIENCE RELATED TO DOMAIN (PER CONSTITUENT):

1. **City of Malmö:**

The city of Malmö has been engaged in a large number of activities to reduce energy consumption and increase the amount of renewable sources in the energy mix.

The municipality is responsible for education, planning, and infrastructure, as well as protecting consumers and property owners.

The municipality has worked for a number of years with public education in order to promote sustainable development of the city. Energy use has been one of the focus areas for the information campaign. Energy advisors have played an important role in disseminating information about matters connected to energy use.

The municipality has also made a great effort to reduce the energy use in buildings that it owns. As a property owner, the municipality has been working with a number of tools to measure energy use, benchmark energy use in different kinds of buildings, and other efforts, all to make sure that the building stock is energy-efficient and constantly reduces the total energy use.

The municipality has, together with other stakeholders, implemented full-scale actions in the field of energy efficiency in the Western Harbour. The concept of "100% locally produced renewable energy" was developed for the Bo01 area of the Western Harbour. The concept was based on achieving a balance between production and use of energy in the area.

One tool used for increasing energy efficiency in the building stock is Miljöbyggprogram Syd (Environment building program South). It set standards for energy use in buildings erected on land formally owned by the municipality.

CURRENT ACTIVITIES RELATED TO DOMAIN (PER CONSTITUENT):

1. **City of Malmö:**

The City of Malmö has set up targets for energy use in several policy documents. The Energy Strategy and the Environmental program outline the targets for the city as a whole, including municipal operations.

The environmental program for the city of Malmö 2009–2020 documents a variety of goals, including energy efficiency, carbon emissions, and energy efficiency. One goal states that by 2020, energy consumption in Malmö will decrease by at least 20% per person compared to the average consumption during 2001–2005. By 2030, this is to drop another 20%.

The Energy strategy is a complementary tool to the Environmental program and is necessary for the implementation process. The strategy details the action opportunities and targets, including:

For the entire City:

- Energy consumption will be reduced by at least 20% per capita compared to the average use during 2001 to 2005
- Renewable energy sources should be at least 50% of the overall energy mix
- Public transport is to be 100% powered by renewable energy
- GHG emissions must be reduced by at least 40% from 1990

City of Malmö's activities (local government operations):

- Energy consumption will be reduced by at least 30% compared to the average use during 2001 to 2005
- All municipal operation will run on energy from 100% renewable sources
- Energy costs will be reduced

The most structured and far-reaching public-private partnership implemented right now is the work going on in the development area of Hyllie. The city, E.ON, and VA SYD signed an agreement in the beginning of 2011 called a climate contract. In it, they have committed to turn Hyllie into the most climate-smart city district in the region. They also agreed in the contract that the city's energy supply, at the latest in 2020, will consist of renewable or recycled energy entirely.

The objective is that the development of the area will go hand in hand with the implementation of the environmental objectives of the city.

Hyllie will also become somewhat of a larger-scale testing ground for the smart city of the future. Five constructors involved in Hyllie have, for example, received grants from the EU and the Swedish Energy Agency in which climate-smart solutions for ventilation, cooling, and heating are to be tested. One of the visions is that the technology would show the user how he can influence and reduce his own energy consumption.

CURRENT CHALLENGES RELATED TO DOMAIN (PER CONSTITUENT):

1. **City of Malmö:**

A number of ongoing trends constitute the background for the local efforts:

- The share of intermittent renewable energy sources is increasing in the energy system
- The consumers become producers when the number of distributed production units increases
- Electromobility is on the verge of full-scale deployment
- The energy for heating decreases in new buildings

Altogether, this creates a need to steer energy use to moments when there is a good supply of energy. New links and new flows are created between the individual property and the surrounding area, between the area and the city, and ultimately between the city and the regional net.

An obvious challenge is the energy demand in existing buildings. Newly built areas have been in focus for the cutting-edge project. The existing building stock must be integrated. There is a need for assistance and support in developing business models that can support the transition. Splitting the incentives between property owners as the housing companies and tenants makes this difficult.

SUCCESSES RELATED TO DOMAIN (PER CONSTITUENT):

1. **City of Malmö:**

There exists today:

- Clear, long-term objectives
- A consensus among different stakeholders on the objectives
- Channels for stakeholders to cooperate

- A high competence in the area
- A number of earlier projects that have generated valuable insights

AREAS OF GREATEST INTEREST RELATED TO DOMAIN (PER CONSTITUENT)

1. **City of Malmö:**

We would like to learn more about state of the art when it comes to demand-side management. Our main focus is not so much the technical aspects.

The main interest from the city is to gain new insights in how to optimize processes where different stakeholders work together in order to create sustainable energy systems within the city.

We do see that the main future challenges will be in the existing building stock, so that is one of our main interests, especially the development of business models.

The city of Malmö is, of course, also interested in sharing results from the projects and processes in which we have been involved so far.

Finland

Participant Snapshot	
Crosscutting and Integrative Technology Domain	Waste-to-Energy (e.g., waste-waste, water-biogas, biofuel-based district heating and cooling in an integrated urban development setting) Demand-Side Management (e.g., smart grid, buildings – thermal management, green lighting, cool roofs, district heating and cooling infrastructure)
Country Participant	Finland
Network Constituents	Selection underway

INTRODUCTION AND STATUS

This document contains information about the selection process of Finnish cities to the Global Sustainable Cities Network.

The status of selection is that the Ministry of Employment and the Economy of Finland has selected the city of Lahti on Waste-to-Energy activities and the project plan is under preparation. The Ministry is also negotiating with two cities on Demand-Side Management, namely Espoo and Oulu, and is waiting for replies from these cities.

The Ministry of Employment and the Economy of Finland has selected and approached directly the cities of Lahti, Espoo, and Oulu, knowing them to be the leading cities in sustainability in Finland.

- Lahti, Espoo, and Oulu are all among the 10 biggest cities in Finland
- Lahti, Espoo, and Oulu have strong international networks, especially in China, India, and Russia
- Lahti, Espoo, and Oulu are partners of the Finnish Cleantech Cluster (Lahti, Metropolitan area, Oulu, and Kuopio). Together, they cover more than 30% of Finland's cleantech business
- Lahti, Espoo, and Oulu have sustainability as the main priority focus areas in the cities' business plans. They have cutting-edge technologies on waste-to-energy (Lahti) and on demand-side management (Oulu and Espoo)

Participant Snapshot	
Crosscutting and Integrative Technology Domain	**Cities – Demand-Side Management (e.g., smart grid, buildings – thermal management, green lighting, cool roofs, district heating and cooling infrastructure)**
Country Participant	**Finland**
Network Constituents	**Cities of Oulu and Espoo**

PROFILE OF NETWORK CONSTITUENTS

The cities of Espoo and Oulu have strong local cleantech clusters as well ICT clusters. Both cities are developing their own smart cities concepts to combine cleantech and ICT knowledge to develop new solutions (including smart grids) and businesses with strong international market potential for the technologies.

In addition to strong business backgrounds, Espoo and Oulu also have the biggest universities in Finland (Aalto University and University of Oulu). Oulu and Espoo are very active in international collaboration, especially in China and India. Development of smart cities concepts in Oulu and Espoo is supported by the Ministry of Employment and the Economy and TEKES, the Finnish Funding Agency for Technology and Innovation.

Participant Snapshot	
Crosscutting and Integrative Technology Domain	**Waste-to-Energy (e.g., waste-waste, water-biogas, biofuel-based district heating and cooling in an integrated urban development setting)**
Country Participant	**Finland**
Network Constituents	**Lahti region**

PROFILE OF NETWORK CONSTITUENTS

Mass burning of waste was banned in Finland at the beginning of the '90s. Lahti region has formed a unique public-private-people partnership within the fields of waste management and energy production. For years, the Lahti region has been a Finnish pioneer in sorting, recycling, and utilizing waste. **Today, around 90% of the waste produced in the city is recycled or used in energy-production processes.**

- Päijät-Hämeen jätehuolto Oy/Päijät-Häme Waste Disposal Ltd (PHJ) started to develop source separation in the mid-'90s. The waste-management model, based on source separation of various waste fractions, has been in operation from 1998 (bio-waste, energy waste, board, paper and mixed waste). Energy waste has been collected from blockhouses since 1998, and the collection was expanded to all houses in 2000. Other sources such as restaurants, shops, schools, offices, industrial plants, etc. have also been able to separate energy waste.

- Lahti Energia Oy (LE), built in 1998, is the first waste 40 MW gasifier in the Kymijärvi power plant for the utilisation of biomass and (solid recovery fuel) (SRF). The produced fuel gas was utilized in the big coal burner to produce district heat and electricity. Its share of fuel of the old gasifier was small in the beginning, but over the years the utilization grew up to 40%, which was the limit of the environmental permit. This was due to the notification that gasification of SRF worked well and also had a positive effect on exhaust gases. Since then, more than 1 million tons of waste has been gasified, and the gas utilized in the main boiler plant. Waste has substituted for more than 800,000 tons of coal in the main boiler.

- Lahti Science and Business Park (LSBP) has developed as the leading cleantech park in the Nordic Countries, and has specialized also in waste-to-energy technologies and operations.

- Päijät-Hämeen jätehuolto Oy/Päijät-Häme Waste Disposal Ltd (PHJ) processes collected energy waste and recovered wood in a shredding and separation plant to produce SRF. Finnish BMH Technology was the contractor of the plant that started operations in November 2011. The remnant mixed solid waste is delivered to incineration plants in Southern Finland.

- Lahti Energia Oy (LE), built on the basis of good experiences, is a new big boiler plant based on gasification of source-separated combustible waste. The plant started commercially in April 2012. The main contractor was Finnish Metso. The plant uses 250,000 tons of fuel per year. The fuel is collected from shops, industry, construction sites, and homes in the area of Southern Finland. The largest fuel suppliers are private companies Kuusakoski, Stena Recycling, and Suomen Kipa, and municipal waste companies Päijät-Hämeen Jätehuolto and Loimi-Hämeen Jätehuolto. The planned fuel power is 2 x 80 MW. The plant produces 50 MW of electricity and 100 MW of heat. The investment costs were some 160 million €.

The target of the City of Lahti to decrease greenhouse gas production is very high; i.e., to halve it by 2025. Therefore, new development adoptions also in energy and waste management will be studied. The Lahti region produces in forest and agriculture a great amount of biomass, more of which could be utilized locally. Some other matters could be utilization of smaller energy resources and new energy infrastructure; e.g., electric vehicles, biogas buses, etc.

A big shift has been successfully made in the waste-management and energy-production sector in the Lahti region. Today, waste is seen as a valuable resource material for recycling or for energy production.

Denmark

Participant Snapshot	
Crosscutting and Integrative Technology Domain	**Waste-to-Energy (e.g., waste-waste, water-biogas, biofuel-based district heating and cooling in an integrated urban development setting)**
Country Participant	**Denmark**
Network Constituents	**Sonderborg's ProjectZero**

PROFILE OF NETWORK CONSTITUENTS

1. **Sonderborg's ProjectZero:**

ProjectZero is a public-private partnership focused on reducing the carbon emissions of the Municipality of Sonderborg to zero by 2029.

ProjectZero has developed a master plan for 2029 and a roadmap for reducing carbon emissions by 25% by 2015. A roadmap focused on 2020 and achieving another 25% in carbon emissions will be completed by mid-2013. Actual carbon emissions have been reduced by 16.2% as of 2011, compared to the 2007 baseline.

ProjectZero has developed and implemented a large number of participatory platforms enabling citizens, companies, shops, schools, the municipal administration, and utility companies to participate in the transition.

HISTORICAL CONTEXT AND EXPERIENCE RELATED TO DOMAIN (PER CONSTITUENT):

1. **Sonderborg's ProjectZero:**

Sonderborg, like most Danish cities, has strong traditions in utilizing energy from waste. Since 1972, the government has given strong attention to central production of combined heat and power, based on household waste. There has been an increased focus on sorting the waste and recycling resources instead of just waste incineration. The heat is distributed as district heating in urban and suburban networks. Waste water is biologically treated in centralized plants before it is emitted to the sea. Waste from the wastewater treatment plant is converted to biogas and distributed as heat and power in the utility company's own facilities.

CURRENT ACTIVITIES RELATED TO DOMAIN (PER CONSTITUENT):

1. **Sonderborg's ProjectZero:**

   All household and company waste is being sorted, and a high percentage is being recycled into new materials and products. The combined heat and power plant is operating at a very high level of efficiency regarding energy and emissions.

CURRENT CHALLENGES RELATED TO DOMAIN (PER CONSTITUENT):

1. **Sonderborg's ProjectZero:**

   Challenges include the need for better utilization of energy in wet biowaste from households, farmers, and industry. Improving the recycling of resources is another challenge, as the world must preserve its dwindling resources, and incineration is not very resource-friendly. New, stronger regulations and policies from central government are to be implemented in 4–6 years.

SUCCESSES RELATED TO DOMAIN (PER CONSTITUENT):

1. **Sonderborg's ProjectZero:**

   Children and adults have very positive attitudes regarding the sorting of waste. There is very high acceptance of new household garbage cans. There is also very high efficiency and very low emissions from the combined heat and power plant.

AREAS OF GREATEST INTEREST RELATED TO DOMAIN (PER CONSTITUENT)

1. **Sonderborg's ProjectZero:**

   There is a need for best practices in resource management and for more efficient utilization of waste–to-energy.

Participant Snapshot	
Crosscutting and Integrative Technology Domain	**Cities – Demand-Side Management (e.g., smart grid, buildings – thermal management, green lighting, cool roofs, district heating and cooling infrastructure)**
Country Participant	**Denmark**
Network Constituents	**Sonderborg's ProjectZero**

PROFILE OF NETWORK CONSTITUENTS

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HISTORICAL CONTEXT AND EXPERIENCE RELATED TO DOMAIN (PER CONSTITUENT):

1. **Sonderborg's ProjectZero:**

In Denmark, the power and utility companies have been obliged to supply power to cover any need at any time in the market. This obligation has been fulfilled very successfully, and the power grid has been very stable—with very few power cuts in recent years. The government (Energinet.dk as regulatory body) plays a vital role in securing stand-by capacity to cover any potential shortage, and the associated cost is part of the users' energy bills. In recent years, more wind power has been added to the grid (current level is 30%), thereby adding fluctuations to the grid. More power from wind will be added in years to come (50% of electricity from wind by 2020), and the power companies have begun closing down traditional coal-fired power stations. As heat for district heating in many cities is a by-product of heat produced by coal-fired power-stations, the change is also adding volatility to the district-heating systems all over Denmark. This is partly compensated by adding solar power, geothermal, and woodchip-burners to the power generation system.

CURRENT ACTIVITIES RELATED TO DOMAIN (PER CONSTITUENT):

1. **Sonderborg's ProjectZero:**

   The Danish government has completed a study of more than 30 smart grid initiatives, and further discussions will take place over the next 18 months, concluding with a joint, national action plan. Electric cars and heat pumps play a vital role in securing a stronger demand-side management. In Sonderborg, comprehensive trials including both technologies are being carried out.

CURRENT CHALLENGES RELATED TO DOMAIN (PER CONSTITUENT):

1. **Sonderborg's ProjectZero:**

   Technologies such as heat pumps and electric cars are still too expensive compared to conventional fossil-fueled solutions. The education of craftsmen must be improved.

SUCCESSES RELATED TO DOMAIN (PER CONSTITUENT):

1. **Sonderborg's ProjectZero:**

   Strong consumer interest has been demonstrated in local trials for electrical cars and heat pumps. The world's first intelligent heat pump was implemented in Sonderborg in 2010. Sonderborg is improving craftsmen competencies in an EU social-fund project.

AREAS OF GREATEST INTEREST RELATED TO DOMAIN (PER CONSTITUENT)

1. **Sonderborg's ProjectZero:**

   There is a need to create a roadmap for smart grid implementation. Smart grid solutions for district heating networks are a huge green field.