

Green Infrastructure:

The backbone of the Sustainable Community

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Basic Principles

- Integrated is better than an isolated approach
- Think resource vs. nuisance
- Reduction before production
- Low tech before high tech
- Seek highest quality output from a resource

Major Categories

- Energy systems
- Water systems
- Waste systems
- Transport systems

Key Metrics

- kWh/ BTU per capita
- kWh / sf
- % renewable
- Gallons per capita
- % reclaimed water
- water balance
- runoff water quality
- Tons waste per capita
- % diversion
- Organics capture rate
- VMT
- % of units 'walkable' – walk score
- mode split
- alternative/ clean vehicle rates

Roll up Metrics

Carbon per capita

- energy level of use and carbon intensity of source
- water level of use and carbon (energy) intensity of pumping and treatment
- GHG potential of landfilled waste
- transportation related GHG – combination of total miles traveled, energy intensity of each mile and fuel source

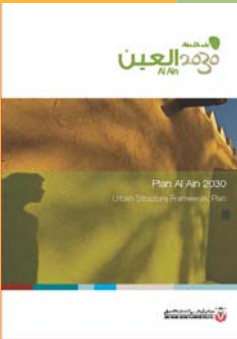
ESTIDAMA



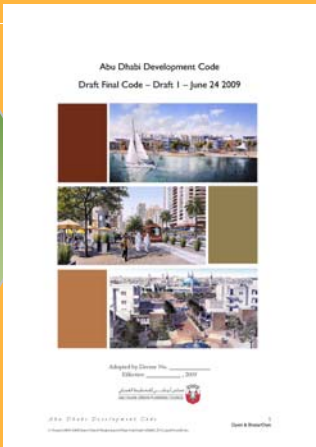
Envisions



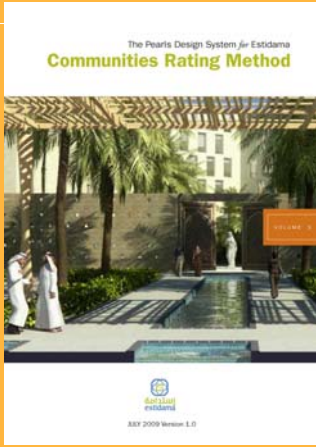
2030 Plans



Defines and Measures



Development Code



Pearls Design System

Informs



Conservation Development Guidelines



Urban Braille



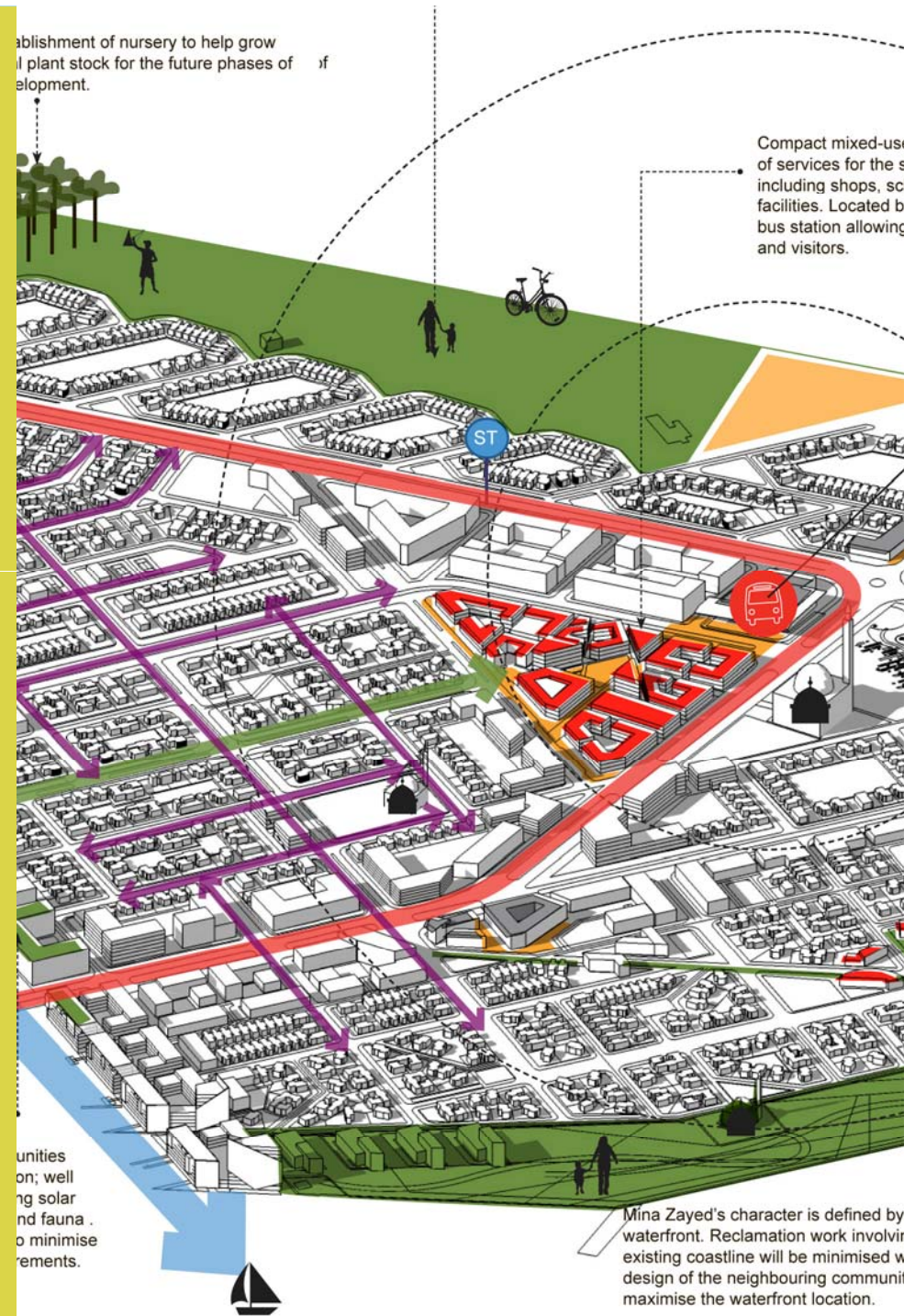
Roofscapes Guidelines



Streetscape Design Manual

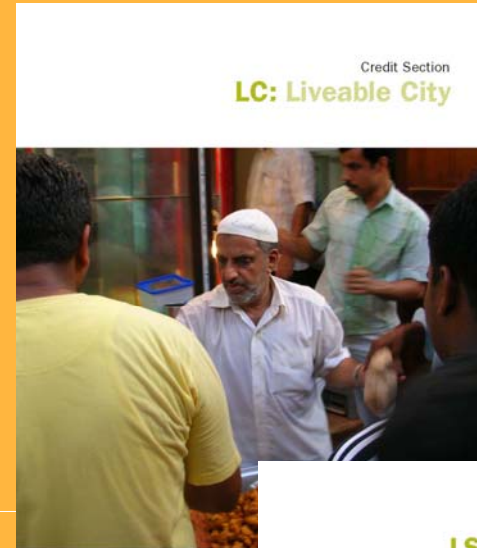
The Pearls Design System is a suite of documents with how-to information and a rating method to help move the built environment closer to achieving Estidama

Image Credit: Broadway Maylan



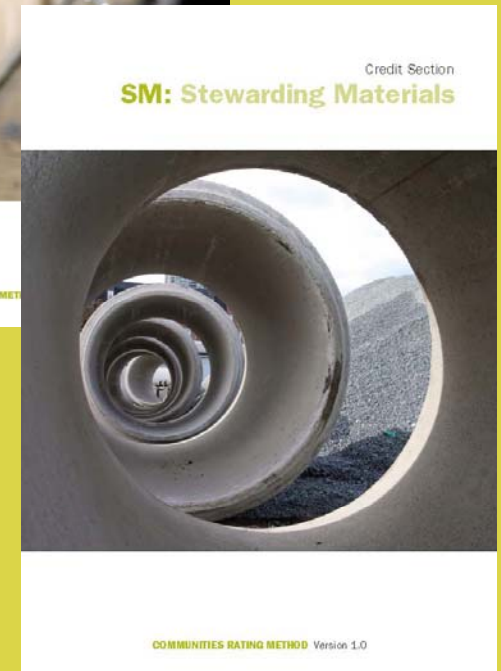
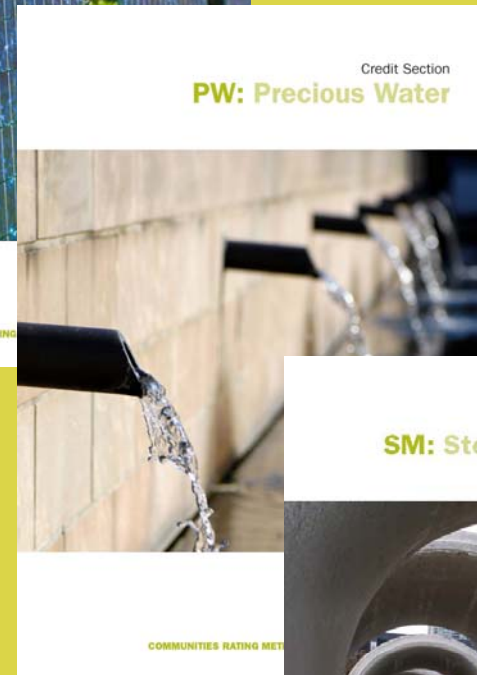
Two Meta Categories:

- Living Systems
- Liveable City (Buildings)



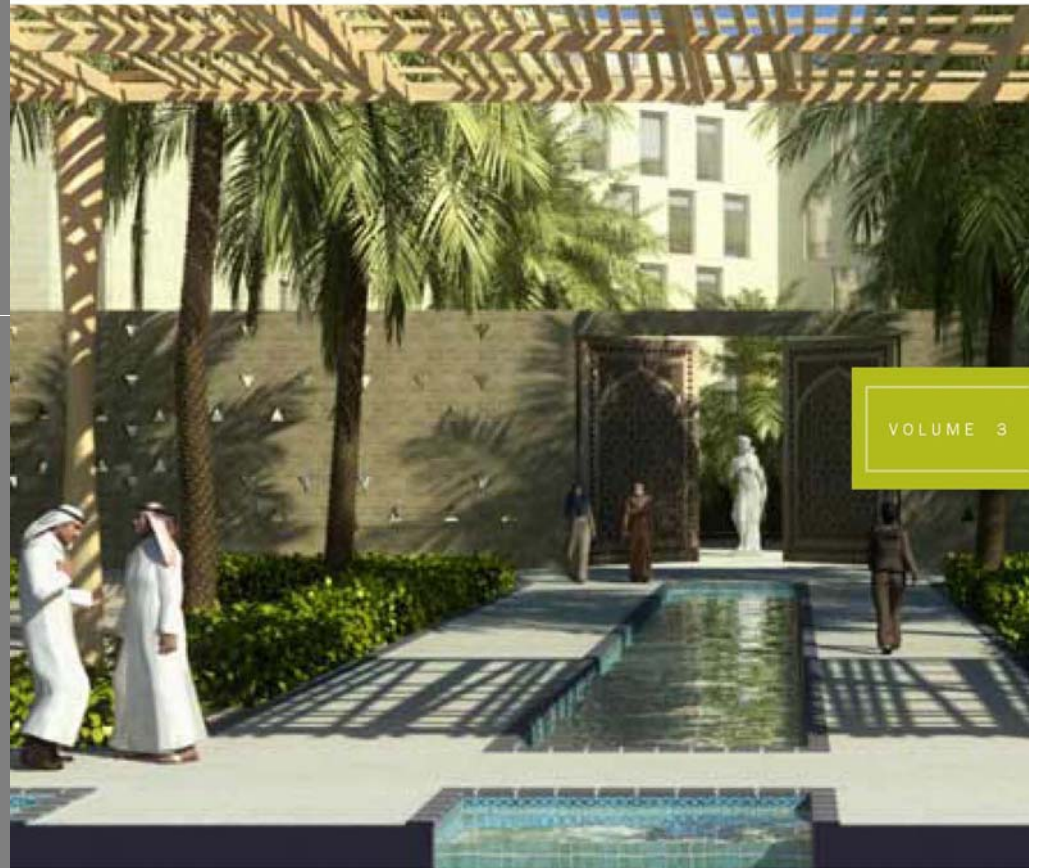
Three Resource Categories:

- Precious Water
- Resourceful Energy
- Stewarding Materials



The Pearls Design System *for* Estidama
New Communities Design Guide

Integrating Process	Required
Living Systems	9
Liveable Cities	22
Precious Water	8
Resourceful Energy	8
Stewarding Materials	7
Innovating Practice	1
Total Credits	55



JULY 2009 Pilot Version

Infrastructure Related Credits

LIVEABLE COMMUNITIES

- VKT Calculation and Required Reduction
- Additional VKT Emission Reduction
- Transit Supportive Practices
- Neighbourhood Connectivity
- Transportation Demand Management
- Light Pollution Reduction

PRECIOUS WATER

- Water Calculation and Minimum Reduction
- Potable Water Conservation Improvement
- Community Water Balance
- Stormwater
- Infrastructure Design for Water Reuse
- Infrastructure Design for Water Conservation

Infrastructure Related Credits

RESOURCEFUL ENERGY

- Energy Conservation Improvement
- Onsite Renewable Energy
- Offsite Renewable Energy
- District Cooling Application
- Smart Grid Technology Application

STEWARDING MATERIALS

- Waste Strategy and Minimum Diversion
- Asphalt and Road Materials
- Material Reduction

LIVING SYSTEMS

- Cumulative Carbon Reduction

Integrated is better than an isolated approach

Credit Section IDP: Integrating Process



Image Credit: Abu Dhabi Urban Planning Council/Gillespies UK

PW-2: Community Water Balance

Intent

To balance reclaimed water generation with non-potable water demand within individual developments.



Background

See PW-1.

Strategies and Design Considerations

The water calculations leading to the Community Water Balance are meant shift thinking about the conventional development process. By requiring proposed developments to meet a 30% minimum reduction in their water consumption, Estidama is requiring design and development teams to engage with the challenges of Abu Dhabi's limited water supply and current inefficient use.

While PW-1 considers the use and potential of non-potable sources of water for sites. For this Fifth Pearl Credit, PW-2, design and development teams are required to explore alternative water supplies – through *municipal recycling or onsite treatment* – in pursuit of a balance.

A community water balance, as defined by Estidama, is one in which the total non-potable water demand for the entire development is equivalent to, or less than 90% of the wastewater generated by the development. In other words, the development's non-potable water demand must be sufficiently reduced so that it is equal to, or less than, water recaptured (or sent to municipal wastewater treatment facilities) from the annual operations of the development itself.

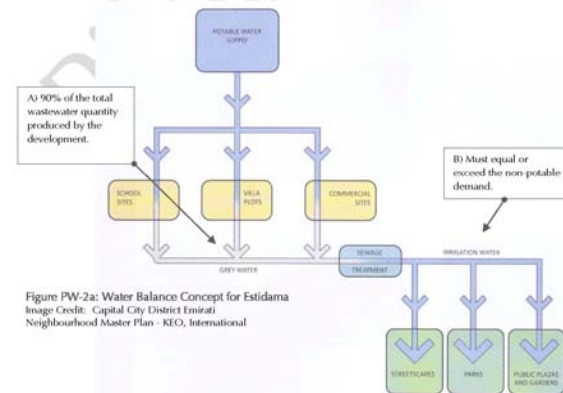
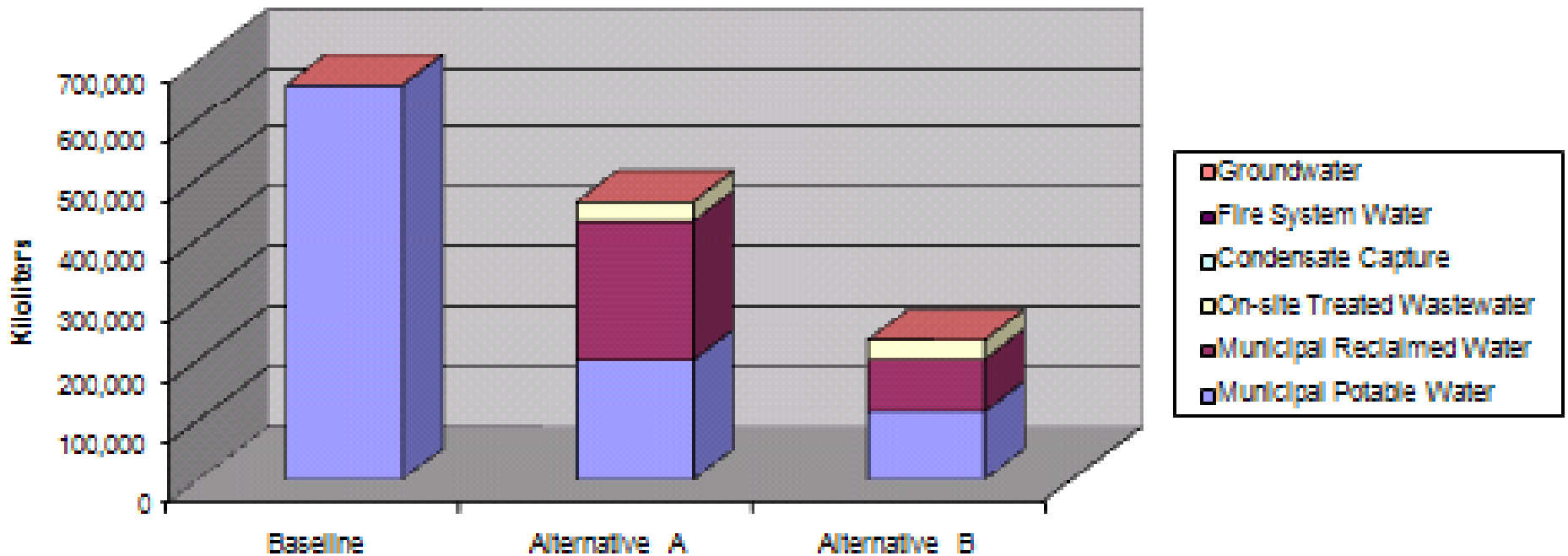


Figure PW-2a: Water Balance Concept for Estidama
Image Credit: Capital City District Emirat
Neighbourhood Master Plan - KEO, International

PW-r1 WATER CALCULATION METHODOLOGY

C	D	E	F	G	H	K	L	M	N	O	P	Q	R
ESTIDAMA WATER CALCULATOR						ESTIDAMA WATER CALCULATOR MODIFIED REFERENCES						DESCRIPTION and EXPLANATION JUSTIFYING REDUCTIONS	
Annual Water Demand by Source						Annual Water Demand by Use							

Annual Water Demand by Source



Reduction before production

RE-r1: Energy Calculation and Minimum Reduction

Requirement

Intent

To focus the design and development team on energy conservation, while making informed decisions about the master plan implications of renewable energy strategies.

Background

The energy calculation is required because it forms the foundation for the entire energy strategy, and is a powerful tool to shape thinking and decision making regarding energy use and provision. The premise for moving towards more sustainable community development requires significant reductions in collective energy use, from all aspects of the community.

Essentially, the energy calculation should guide the design and development team through the following steps:

- To use passive cooling strategies such as master plan block orientation and building massing to reduce cooling load required by buildings;
- To further reduce energy demand through commitments to higher performing buildings
- To explore energy reductions that can be achieved through infrastructure design changes
- To balance remaining energy needs with renewable, low carbon footprint sources;
- Strive for an energy net positive community by not demanding energy from the grid and providing energy onsite.

Strategies and Design Considerations

In order to achieve reduced energy use, consider the following strategies and concepts during the programming and design phase of the project:

Passive Cooling – Well conceived planning and design solutions in this region should make the most of the cooling properties of shade, vegetation and natural breezes to greatly reduce solar gain on buildings and public spaces. These strategies are addressed in LC-14 and LC-15, but play an important part in reducing the development's annual energy demand.

Density – Higher-density urban areas are more energy efficient than low-density, single family homes, even those striving to save energy. This is due to inherent efficiencies in infrastructure and lower cooling requirements through reduced solar exposure on wall surfaces.

Infrastructure – infrastructure typically represent <10% of the community's total energy demand. Savings can be realised through infrastructure designed to reduce electricity line loss, centrally located district cooling operations, low-impact or energy efficient wastewater treatment, and high-efficiency street lighting and traffic signals.

RE-2: Onsite Renewable Energy

Credit Points Available: 3 – 8

Intent

To reduce transmission losses, curb peak power demand, and reduce reliance on a single source of power.

Background

Renewable energy refers to energy derived from replenishable resources such as the sun, winds, tides, geothermal activity and even the processing of bio-matter. Although it is a misnomer to think of renewables as having no environmental impacts (e.g. wind farms can cause noise pollution and affect ecosystems) they usually provide preferable options to energy from fossil fuels since they contribute no net CO₂ to the atmosphere and hence do not contribute to global warming.

The other advantage of renewable energy generation (and other solar technologies such as solar hot water) is that they serve to reduce the load on energy infrastructure at peak times. For Abu Dhabi, these peak loads usually occur in summer, when air conditioning, fridges and other appliances are in full demand. By encouraging communities to reduce their demand during these periods of extreme peak loads, the supply authorities can save the considerable cost of backup generation infrastructure (which may only be needed for a few dozen hours a year, to cope with the peak demand).

Abu Dhabi is particularly well situated to take advantage of solar energy technologies which can provide: electrical generation by heat engine or photovoltaic means; solar space cooling by solar thermal powered absorption chillers; potable water via distillation and disinfection; hot water and thermal energy for cooking, laundry, bathroom; and high temperature process heat for industrial purposes (such as solar thermal power plants).

Sunlight can be converted into electricity using solar PV (photovoltaics), solar thermal energy technologies and various other experimental technologies. Solar thermal collectors are capable of reducing peak energy demands and generating hot water with efficiency much higher than the efficiency of photovoltaic cells.

Peak Load Reduction

One great advantage of renewable energy (especially solar energy, not to mention other solar technologies, such as solar hot water) is that they can serve to significantly reduce the loads on energy infrastructure at times of peak demand.

For Abu Dhabi, these peak loads usually occur in summer, when air conditioning, fridges and other appliances are in full demand. By encouraging buildings to reduce their demand during these periods of extreme peak loads, the supply authorities can save the considerable cost of backup generation infrastructure (which may only be needed for a few dozen hours a year, to cope with the peak demand).

Low tech before high tech

PW-4: Infrastructure Design for Water Reuse

Credit Points Available: 1 – 2

Intent

To ensure the community can efficiently use reclaimed water for non-potable uses, upon delivery by PFRD or onsite facilities.

Background

The hot, arid climate, rapid urban and rural development, spread of agricultural land and high water consumption rates have resulted in the scarcity of water in Abu Dhabi. Desalinated water has been a resource for potable water, but this process is detrimental to both the environment and the economy. With future policy plans to reduce usage of desalination, the water demand must be supplemented from other resources. Reclaimed water, an overlooked water resource, can be reused for non-potable purposes with proper treatment. Additional infrastructure will be required to collect and distribute reclaimed water throughout the community for irrigation and other non-potable purposes. This credit ensures that the reclaimed water distribution system extends to the majority of the site to maximise reclaimed water use.



For reclaimed water sources and descriptions, see PW-r1.

Figure PW-4a: Recycled water distribution line from Clovis, CA. Image Credit: Sherwood Design Engineers

Strategies and Design Considerations

An early step in designing a community that meets the criteria for Credit PW-4 is developing a distribution system for non-potable water. In the **Utility Schematic** to be submitted with credit application, the layout of the community's piping network(s) must be shown. The non-potable and potable water transmission and distribution pipeline(s) must be separated and clearly marked. Piping and fixtures must be easily distinguishable, either through varying colours or markings. Pipe identification is important to prevent cross contamination between different water supplies.

The schematic drawings must clearly show the reclaimed water transmission loop(s), the irrigated area that will be served by this loop, and how the reclaimed water will be distributed to this area. A narrative that describes the total area to be irrigated by reclaimed water and the calculations that prove that this area is 80% of the development's total irrigated public realm, must be submitted with these schematic drawings. The narrative should also identify type and location of treatment strategies for the applicable reclaimed water strategies that meet RSB requirements.

RE-6: Smart Grid Technology Application

Credit Points Available: 2

Intent

To reduce peak load demand and increase efficiency of electric energy delivery through intelligent design of the community's electric supply and demand systems.

Background

Defining a "Smart Grid"

Traditional electricity infrastructure is based on decades old technology and increasingly is being found to have a number of limitations. A "Smart Grid" is simply the application of the latest technology (computerised controls, microprocessor-driven hardware, software, advanced technology, web-based communication systems, etc.) to a community's electrical supply system in a systematic and integrated manner. When included into the design of the electricity delivery and reporting infrastructure, it will be smarter and more efficient operation of the system.

Smart grid technology brings increased communication capabilities to the electricity supply system, which enables improved control at the power generation, transmission, and end-use stages. This results in greater overall energy efficiency, reduced peak demand, lower operating costs, and greater reliability.



Figure RE-6a: Smart grid as enabling engine. Image Credit: *The Smart Grid: An Introduction* (US Dept of Energy).

Think resource vs. nuisance

SM-2: Asphalt and Road Materials

Credit Points
Available: 1 – 2

Intent

To increase the use of recycled materials in roads and asphalt paths.

Background

Asphalt concrete is the basic material in the construction of transportation networks in the developed world, paving everything from highways to rural laneways. Asphalt concrete is created by combining asphalt (also known as bitumen) with mineral aggregate, which is then put over at least one layer of road sub base made of aggregate.

There is a huge opportunity to reduce the amount of waste associated with old automobile tyres and to reduce the impacts of aggregate used for roads through the design and construction of roads and paths. By recycling old car tyres into asphalt, a rubberised asphalt can be made that is safer, quieter and minimises the urban heat impacts from roads all while reducing resource consumption and mitigating a serious waste issue. Similarly, aggregate made from recycled materials can be used for road sub base, thereby reducing the impacts of aggregate mining and reducing resource consumption.



Figure SM-2a: Rubber tyre waste in the desert.
Image Credit: EAD Waste Management Strategy 2008

Rubberised Asphalt

Rubberised asphalt is widely used in the United States, particularly in California and Arizona (which can experience high temperatures similar to the UAE). In California alone, over 44 million reusable and waste tyres are generated annually,²³ making their reuse and recycling an important issue. Integrating old tyres into asphalt uses approximately 2,400 tyres per kilometre lane (at a 2.5 cm surface depth),²⁴ reducing the amount of non-rubberised asphalt needed and diverting a large amount of waste from landfill.

Rubberised asphalt is created from old tyres by separating the components and removing the steel and fabric (the steel is removed with magnets). The remaining rubber is ground to a coarse material with the consistency of coffee²⁵ - this is known as crumb rubber and becomes a component of the asphalt.

²³ California Integrated Waste Management Board, retrieved 12 June 2009.

²⁴ Arizona Dept of Transportation, retrieved 12 June 2009.

²⁵ Arizona Dept of Transportation, retrieved 12 June 2009.

SM-5: Green Waste Management

Credits Points
Available: 2

Intent

To create an amendment for increasing soil health, while reducing organic landfill waste.

Background

Municipal solid wastes often contain up to 70% by weight of organic material.²⁶ Green waste is relatively clean and biodegradable. Sending green waste to landfills is a waste of space, and as it decomposes in a landfill it generates methane gas, which is a powerful contributor to the greenhouse gas emissions. Green waste also contributes to acidity in landfills, making other waste more toxic.²⁹ Estidama seeks to divert this resource from landfills and have it converted to a valuable soil amendment to enrich the region's poor organic soil makeup, through composting. Composting has many environmental benefits aside from eliminating waste sent to landfills (thus extending the life of municipal landfills) and the resulting methane gas.

Soil Enrichment

The composting process encourages the production of bacteria, fungi, and other micro-organisms, which in turn break down organic matter to create humus. Humus is the dark organic material in soils rich in nutrients, which helps create more fecund soil and retain moisture, increasing soil productivity. Compost can also suppress plant diseases and pests and reduce or eliminate the need for chemical fertilisers. Because of this, it can be a low cost alternative to soil amendments.



Figure SM-5a: Soil enriched by product of green waste composting.

Soil Remediation and Pollution Prevention

Composting can cost-effectively remediate contaminated soils, clean stormwater runoff, and prevent erosion and sedimentation. The composting process can capture and destroy 99.6% of volatile organic compounds (VOCs), including fuels, polyaromatic hydrocarbons (PAHs), and explosives. It can also bind heavy metals, preventing them from migrating to water resources or being absorbed by plants. The process also degrades or even eliminates wood preservatives, pesticides, and chlorinated and nonchlorinated hydrocarbons in contaminated soils. Where composting is a feasible remediation technique, it can provide cost savings of at least 50% over conventional soil, water and air pollution remediation technologies.

²⁶ www.epa.gov/epawaste/conservation/composting/pubs/chapter7.pdf.

²⁹ EPA Composting Facts.

Seek highest quality output from a resource

RE-2: Onsite Renewable Energy

Intent

To reduce transmission losses, curb peak power demand, and power.

Background

Renewable energy refers to energy derived from replenishable geothermal activity and even the processing of bio-matter renewables as having no environmental impacts (e.g. wind ecosystems) they usually provide preferable options to energy net CO₂ to the atmosphere and hence do not contribute to global warming.

The other advantage of renewable energy generation (and of hot water) is that they serve to reduce the load on energy infrastructure during peak loads usually occur in summer, when air conditioning demand. By encouraging communities to reduce their energy loads, the supply authorities can save the considerable cost that may only be needed for a few dozen hours a year, to cope with peak demand.

Abu Dhabi is particularly well situated to take advantage of renewable energy: electrical generation by heat engine or photovoltaic thermal powered absorption chillers; potable water via solar thermal energy for cooking, laundry, bathroom; and high temperatures (such as solar thermal power plants).

Sunlight can be converted into electricity using solar technologies and various other experimental technologies: reducing peak energy demands and generating hot water with photovoltaic cells.

Peak Load Reduction

One great advantage of renewable energy (especially solar technologies, such as solar hot water) is that they can serve infrastructure at times of peak demand.

For Abu Dhabi, these peak loads usually occur in summer months when appliances are in full demand. By encouraging buildings to reduce extreme peak loads, the supply authorities can save the considerable cost of infrastructure (which may only be needed for a few dozen hours a year).



SM-5: Green Waste Management

Intent

To create an amendment for increasing soil health, while reducing organic landfill waste.

Background

Municipal solid wastes often contain up to 70% by weight of organic material, which is relatively clean and biodegradable. Sending green waste to landfills is a waste of space. As it decomposes in a landfill it generates methane gas, which is a powerful contributor to the greenhouse effect. Green waste also contributes to acidity in landfills, making other waste management options more difficult. Estidama seeks to divert this resource from landfills and have it converted to a valuable amendment to enrich the region's poor organic soil makeup, through composting. Composting provides environmental benefits aside from eliminating waste sent to landfills (thus extending the life of landfills) and the resulting methane gas.

Soil Enrichment

The composting process encourages the production of bacteria, fungi, and other micro-organisms, which in turn break down organic matter to create humus. Humus is the dark organic matter in soils rich in nutrients, which helps create more fecund soil and retain moisture, increasing soil productivity. Compost can also suppress plant diseases and pests and reduce or eliminate the need for chemical fertilisers. Because of this, it can be a low cost alternative to soil amendments.



Figure SM-5a: Soil enriched by produced from composting.

Soil Remediation and Pollution Prevention

Composting can cost-effectively remediate contaminated soils, clean stormwater runoff, and prevent erosion and sedimentation. The composting process can capture and destroy 99.6% of volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and explosives. It can also bind heavy metals, preventing them from migrating to water resources or being absorbed by plants. The process also degrades or breaks down wood preservatives, pesticides, and chlorinated and nonchlorinated hydrocarbons in soil. Where composting is a feasible remediation technique, it can provide cost savings of up to 50% over conventional soil, water and air pollution remediation technologies.

³⁸ www.epa.gov/epawaste/conservation/composting/pubs/chapter7.pdf.

³⁹ EPA Composting Facts.



LS-7: Soil Health

Credit Points Available: 1 – 4

Intent

To develop strategies and regimens that will increase the capacity of the soil to support more vital plant life, hold moisture and increase carbon sequestration while not increasing toxicity levels in soil.

Background

Without healthy soil, the majority of the land-based plant and animal life we value and depend on for our quality of life could not exist. Indeed, healthy soils, as well as clean water, are critical components for life on this planet. Soils not only provide a matrix for plant growth, but also process waste and pollution, clean and store water, and sequester carbon. Where irrigated landscapes are required or desired, soil structure and health are keys to reducing both maintenance cost and time required for watering and fertilising. Soils, then, are more than just dirt—they are a resource to be protected.

Failure to recognise the importance of soil health can lead to problems that affect all living systems. Over-irrigated and fertilised soils can increase in salinity and alkalinity, thus reducing the ability of the soil to support life. Further, poorly managed and unhealthy soils become easily airborne, creating serious public health issues due to particulate pollution and visibility hazards. In general, building projects give us the opportunity to protect and even improve this valuable resource.

In Abu Dhabi, the low annual rainfall and typically sparse vegetation has created soils with low levels of organic matter. Because the sparse vegetation equates to sparse plant root and carbon web matrices, the soils are easily moved by wind or water. Plant decomposition is slow, and water retention and nitrogen cleansing abilities are low in the predominantly sandy soils. Nevertheless, soil quality can be increased simply by recognising opportunities to protect what exists by adding biomass through landscape mulching and composting.

Soils and plant communities native to Abu Dhabi have evolved unique ways of functioning that are often unfamiliar to those familiar with more temperate landscapes. Plants ranging from algae to dew-watered forests help to stabilise soils, treat and store water, and sequester carbon in ways specific to this ecosystem. As a result, the soils themselves have unique dynamics. For example, the stones covering *gibber deserts* (small stone areas left behind after loose material has been blown away) stabilise the lighter underlying soils. Sandy areas, under the influence of wind, form large, slowly moving *barcan* dunes, each containing a lens of freshwater at its base. Disturbance of these structures can not only disrupt a fragile ecosystem, but also cause difficulties and expense both during and after development.

To protect soil health it is important to not only protect soil structures, but also the chemistry and composition of the soil. Salinity and alkalinity of soils (as well as water) can greatly limit plant communities as well as the ability to cycle nutrients. Many common land-use practices jeopardise soil health by raising the soil's salt concentrations and pH. In order to protect soil health, it is important to identify and avoid these practices.

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