

# Eco-Cities – Tools and Lessons

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# Overview

- **Introductory remarks**
- **Context**
- **An introduction to Ecological Footprinting**
- **An introduction to Integrated Resource Management (IRM) modelling**
- **Examples of projects**
- **Concluding remarks**

# Introductory remarks

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## - What makes an Eco-City?

- **Policy and strategy**

- Objectives
- Key performance indicators
- Targets
- Sustainability Management (tools; sustainable alternatives)

- **Practical implementation – design and (new) build**

- Land use (residential / commercial / industrial / retail)
- Infrastructure (road / rail, etc)
- Utilities (energy / water / waste)
- Planning
- Transportation
- Supply chain management
- Building design

# Context

# Example of a Sustainability Appraisal Framework



## Using the framework

This framework has been developed by Arup to set out a vision for Dongtan and a set of objectives to guide decision making. The framework should be used to:

1. Undertake sustainability appraisals of designs, projects, plans and strategies
2. Monitor progress towards a more sustainable city
3. Provide the context for policy development and decision making



## Environment

1. Physically and legally protect the internationally significant Dongtan wetlands from any man-made intervention such as physical encroachment, poaching of wildlife and pollution to land, water and air. Impose the strongest possible penalties on organisations and individuals in breach of these measures.
2. Protect and enhance the biodiversity and quality of the wider Dongtan and its urban areas, including the ecological communities and habitat, canals and waterways.
3. Avoid any physical degradation of the island through Dongtan's activities and monitor the impact of others on the rate of deposition and erosion of the eastern wetlands.
4. Enable sustainable lifestyles that minimise negative environmental impacts on resource use, waste and pollution through the provision of well connected, public transport links, cycling and walking routes and the availability of healthy food produced in a sustainable manner by local farmers and fishermen.
5. Create cleaner, safer, and greener neighbourhoods with ecologically sound, open spaces and landscape that encourage social interaction and healthy lifestyles. Build with people as the priority, not cars and encourage sustainable alternatives for the transport of freight, goods and food. Design for the likely effects of climate change for now and for the future, incorporating sustainable drainage and flood management techniques.

## Natural Resources

1. Design for energy efficiency and the use of renewable energy at macro and micro scale and in all lifestyle energy uses to minimise Dongtan's contribution to climate change. Produce local biomass for energy production. Maintain flexibility for future changes in energy supply and consumption. Ensure security of energy supply at a cost that is affordable whilst encouraging efficiency of use.
2. Design for the reduction, re-use and recycling of natural and man-made materials and develop policies that encourage resource management, sustainable production and consumption and the extraction of maximum benefit from residual wastes at Dongtan, through energy production and use in agriculture.
3. Design for water efficiency in all domestic, commercial, industrial, leisure and agricultural applications and develop infrastructure and policies that allow for the application of potable water to only those applications that require it. Identify and protect reliable sources of fresh water for now and for the future and ensure security of water supply at a cost that is affordable whilst encouraging efficiency of use.



## Societal

1. Create inclusive, cohesive and tolerant communities that recognise traditional and modern Chinese and other cultural values.
2. Ensure all citizens can engage with and are represented by governance systems that are accountable and that work towards the continued realisation of the fullest concepts of Dongtan as an eco-city.
3. Develop a city that enables healthy and safe lifestyles through the provision of key services and facilities accessible to all and which promote health, provide suitable healthcare when required, avoid car dependence and reduce opportunities for crime.
4. Provide jobs and cultural, leisure, community, sporting and educational facilities for all, regardless of age or ethnicity, and make everyone aware of these opportunities through world class information and communication technology.
5. Create an internationally, regionally and locally accessible city with user friendly facilities and a sustainable mix of development and housing opportunities blended with green spaces to create vibrant communities and a real sense of place.

## Economic

1. Aim for consistent economic progress, which recognises China's old and new economies and allows for the sustainability objectives of Dongtan to be met.
2. Develop an equitable balance and mix of uses to support sustainable investment and prosperity.
3. Provide incentives for businesses that meet the sustainability objectives of Dongtan and, conversely, ensure that environmental and social costs are met by organisations that are responsible for them.
4. Provide jobs diverse enough for all and maintain a culture of innovation and business creation, together with relevant life-long training and educational opportunities. Ensure economic benefits are realised within the local community.
5. Design and maintain suitable and flexible infrastructure, homes, buildings, transport links and information and communications technology to sustain the economic objectives of Dongtan. Ensure the city is suitably protected from flooding and extreme events.

## Overall objective

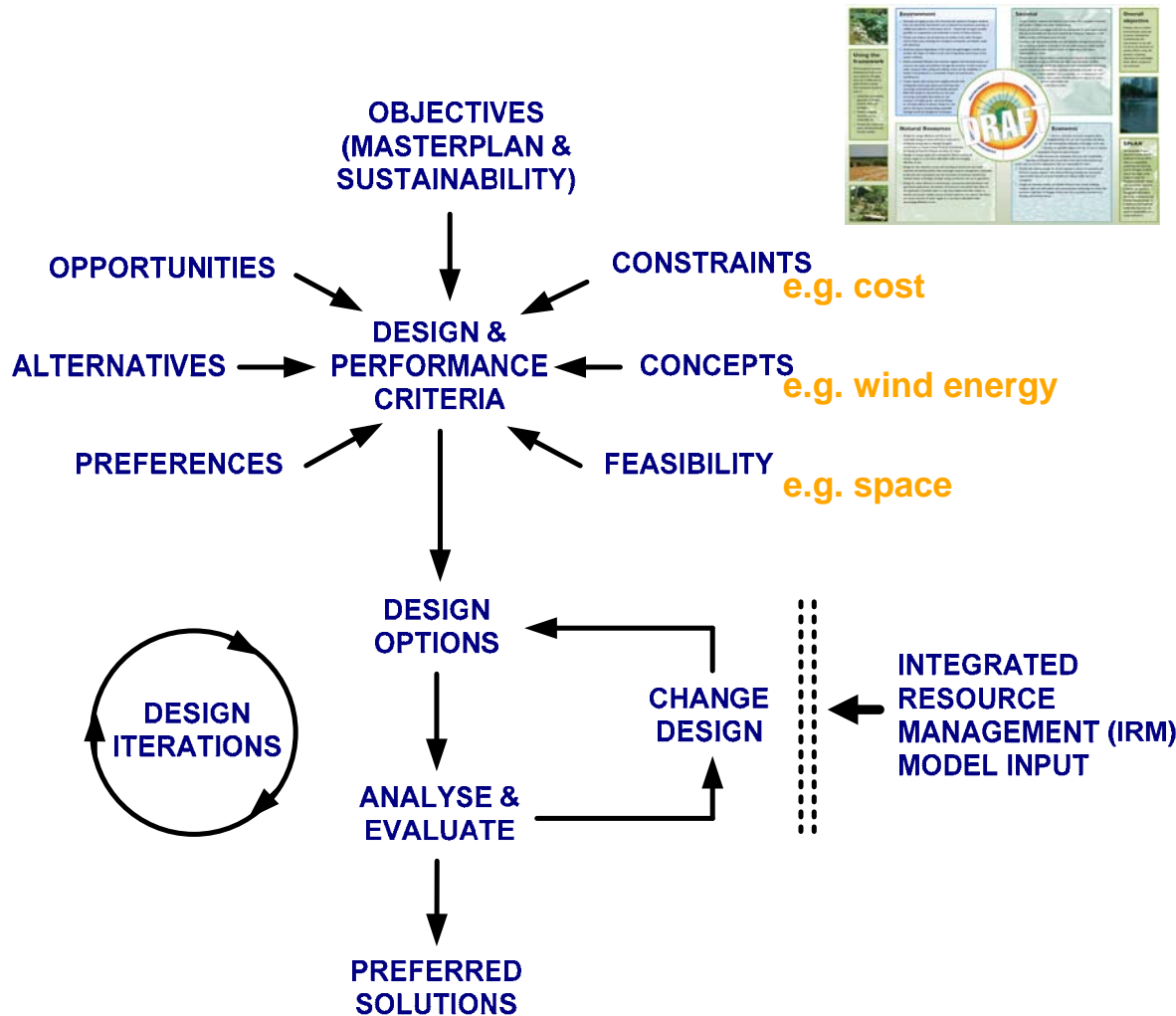
Dongtan aims to achieve environmental, social and economic development simultaneously; the improvement of one will not be to the detriment of another. Where trade offs between competing objectives are unavoidable, these will be transparent and minimised.



## SPeAR<sup>®</sup>

The Sustainable Project Appraisal Routine (SPeAR<sup>®</sup>) developed by Arup, will be used as a sustainability monitoring and reporting tool for Dongtan. It will be used at key stages of the design to assess the Dongtan masterplan against the sustainability objectives. It will also be used as a management information tool in the development and decision making process. It is based on a four-quadrant model, that structures the issues of sustainability into a robust framework.

# Sustainable Appraisal / Management Process



**Task 1:** Sustainability Appraisal Framework [Objectives]

**Task 2:** Sustainability assessment criteria [KPIs; Targets]

**Task 3:** Development of design options

**Task 4:** Populate IRM model and assess design options (+ use of SPeAR...)

**Task 5:** Reporting on outputs of IRM model

Tools to inform decision  
making

*Ecological Footprinting*

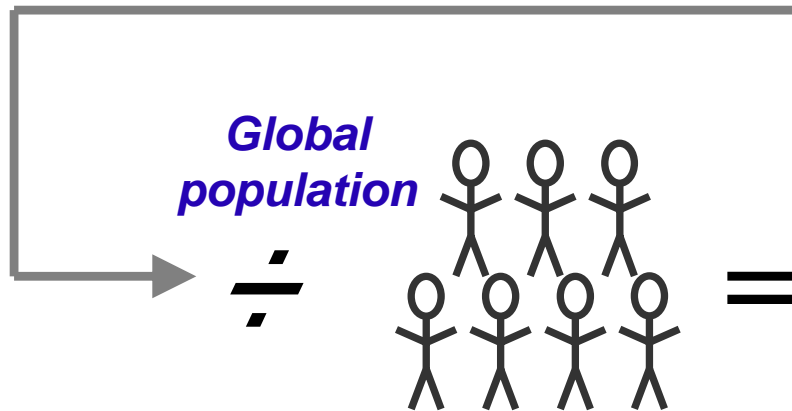
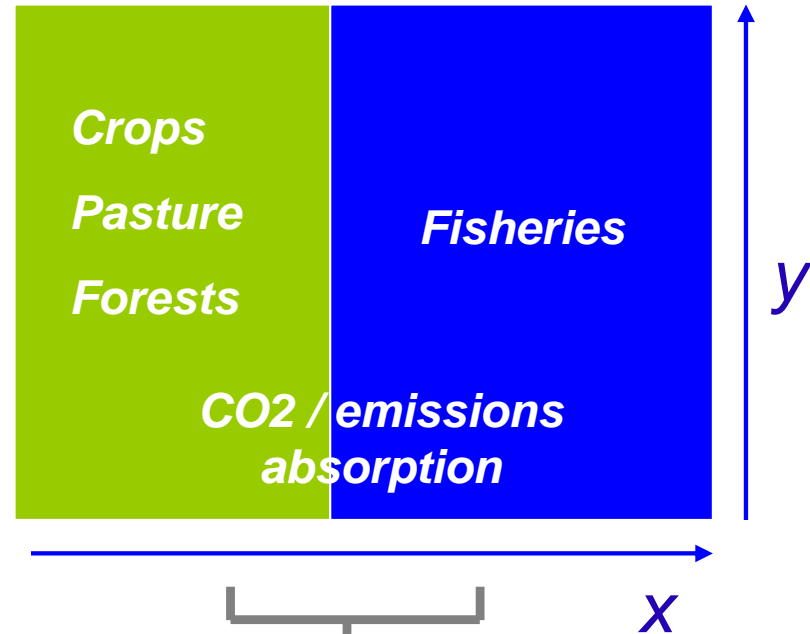
*Integrated Resource  
Management modelling*

# *Ecological Footprinting*

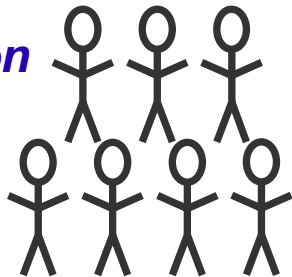
# Global Productive Capacity



*Global biologically productive land / sea area*



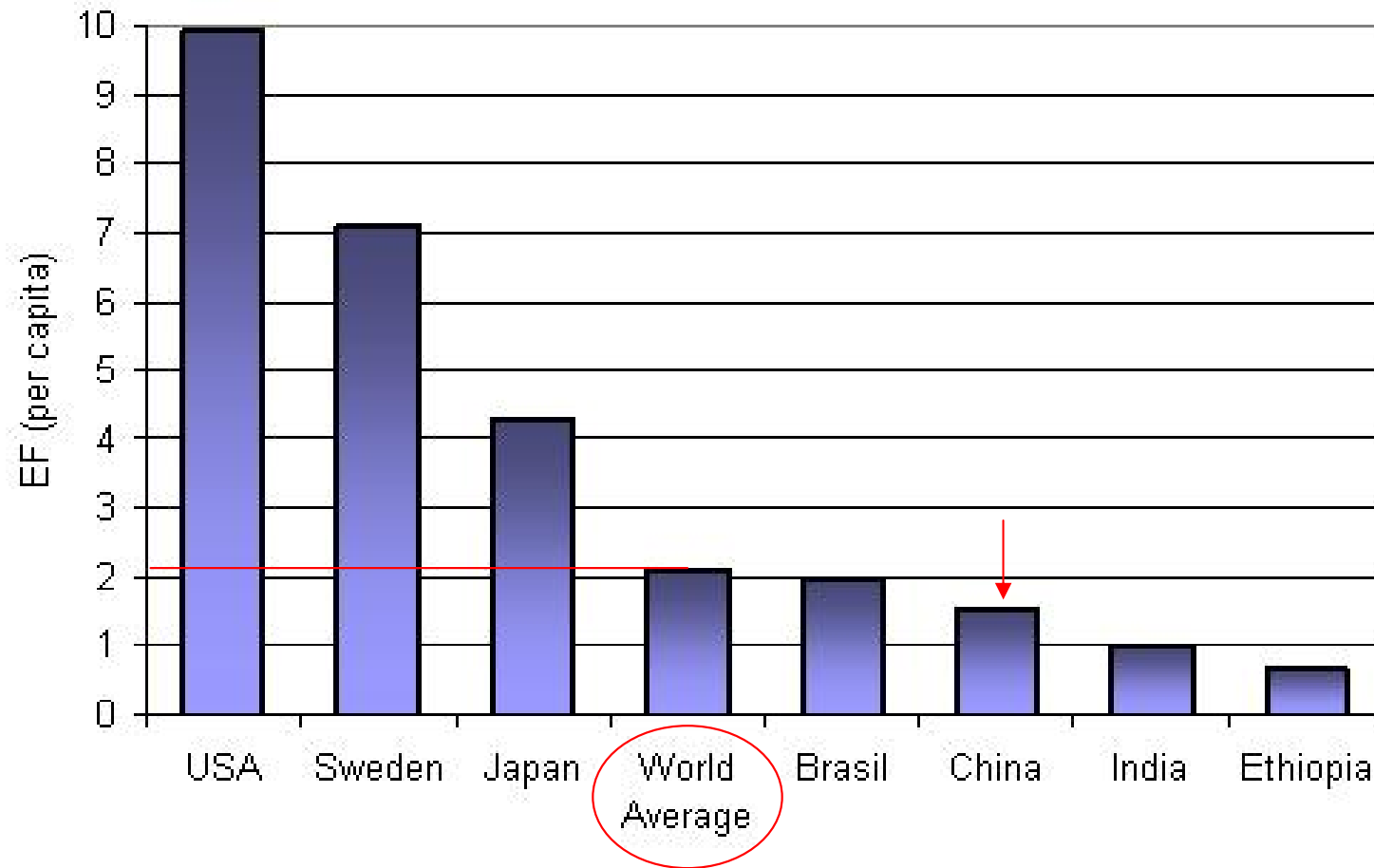
*Global population*



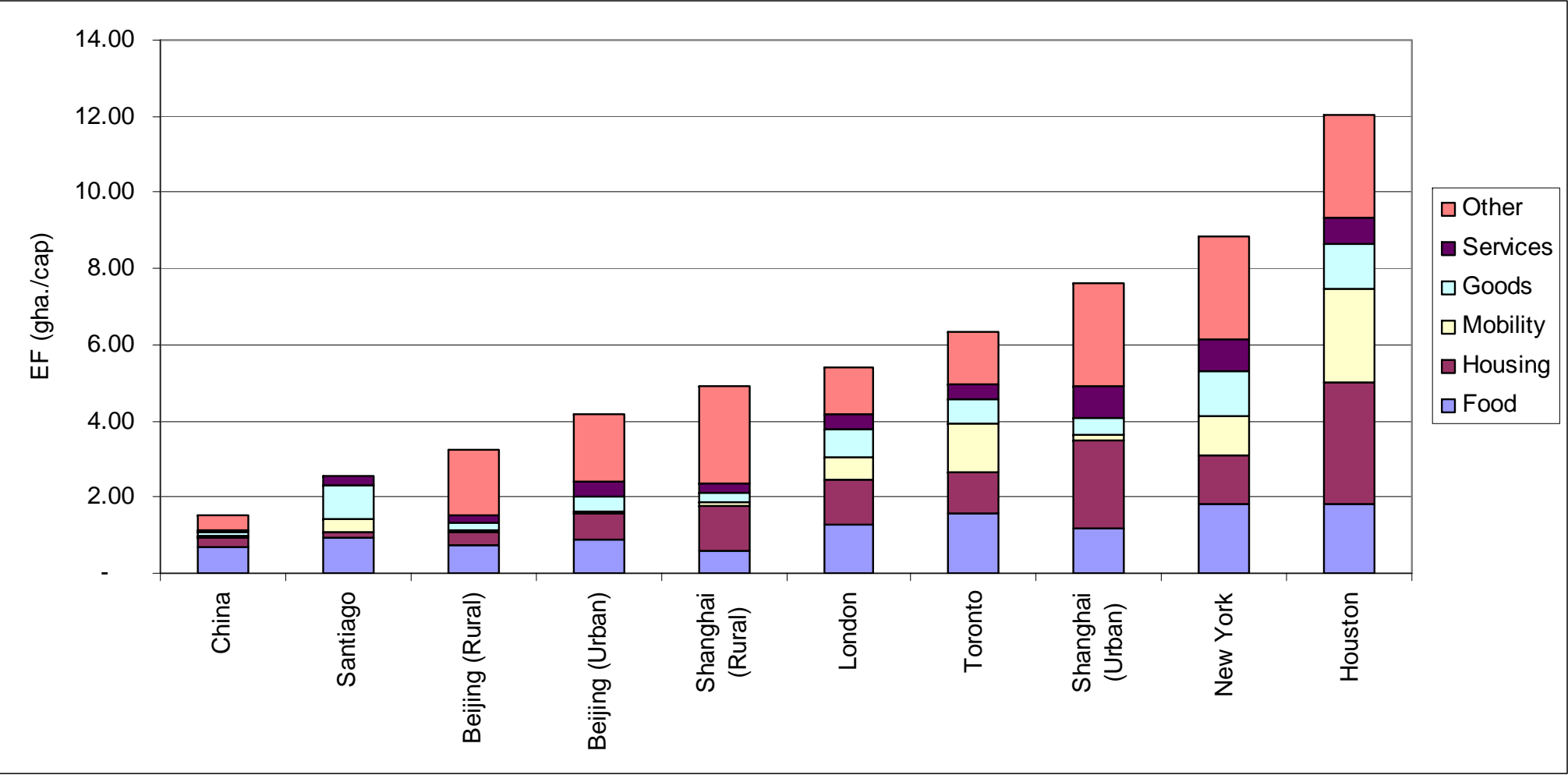
*1.8 global hectares per capita (available)*



# Ecological Footprints - Countries

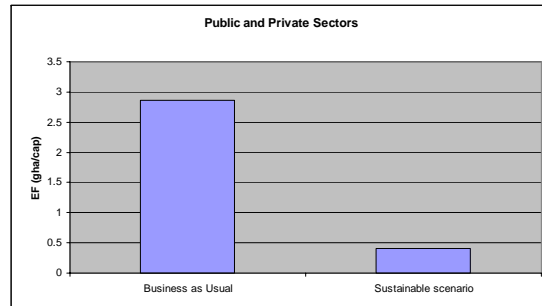


# Ecological Footprint - Cities



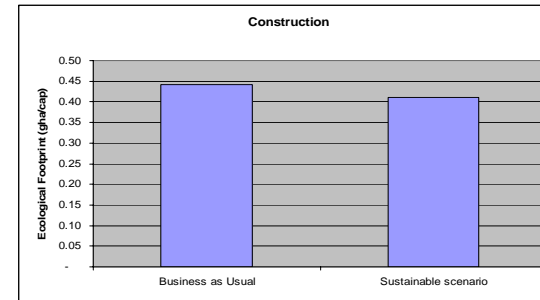
# Results – Dongtan (new build)

## Services and Government



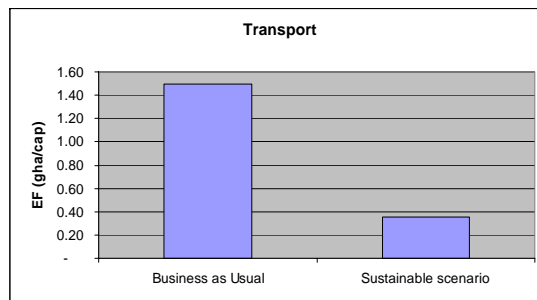
- **85% decrease through energy reduction and supply**

## Construction



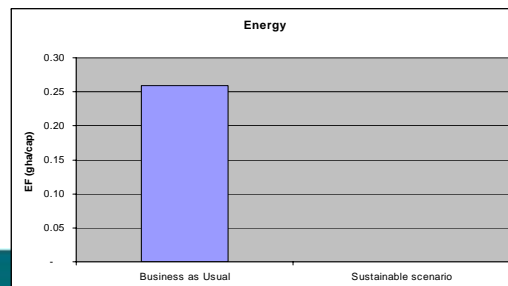
- **13% Increase in the quantity of materials used albeit 7% reduction in the EF**

## Transport



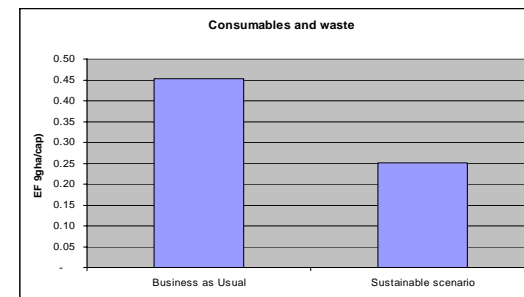
- **76% Reduction in the Ecological Footprint**

## Energy



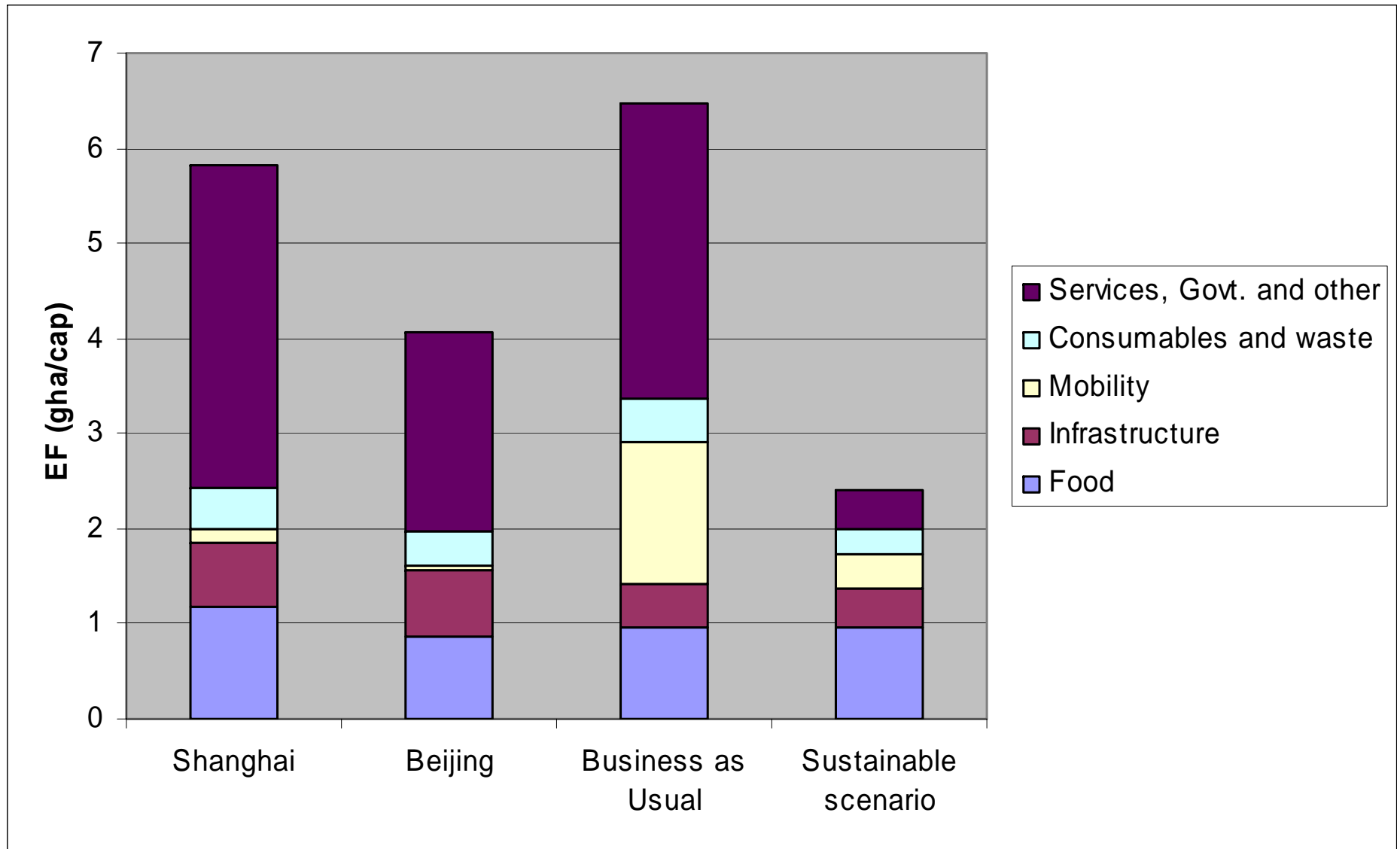
- **Substantial (> 95%) reduction due to use of renewable technologies**

## Consumables and Waste



- **44% Reduction due to 65% recycling rate**

# Overall Results of Analysis



# Conclusions

- Dongtan will not be a “One Planet City”
- But will be one of the most sustainable cities in the world
- 63% Reduction in Ecological Footprint due to design

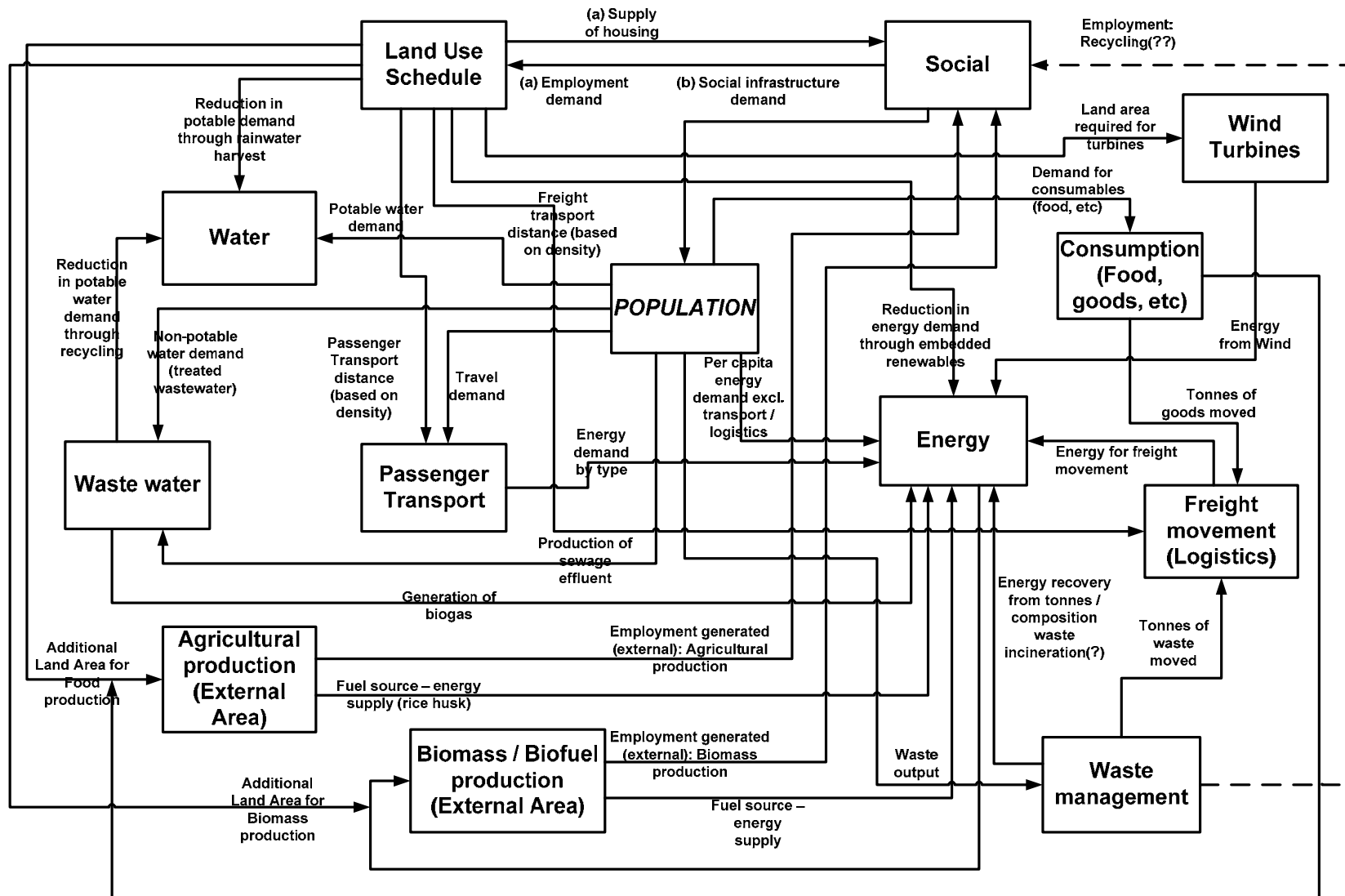
*Integrated Resource Management  
(IRM) modelling*

# Adding value through IRM

- **To support masterplanning and sustainability appraisal work**
- **To help inform decision making**
- **To help identify risks and opportunities**
- **To maximise opportunities to achieve resource efficiency**
- **To facilitate iterative process of testing and refinement of solutions**
- **To provide a commentary on robustness of conclusions/ recommendations**



# A systems approach to masterplanning



# Development of IRM model software for masterplanning

The screenshot shows the IRMA 1.0 software interface. The main window displays a map of a city area with various land use zones color-coded. A 'LandUse' dialog box is open, showing a tree view of the data structure. A 'Data Tree' dialog box is also open, displaying a table of data for different land use types.

| Area name:                      | Total block area (ha): | Average plot ratio:   |
|---------------------------------|------------------------|-----------------------|
| Non-urban area                  | 194.86                 | 1                     |
| Total gross external area (ha): | 194.86                 | Number of villages: 0 |

|          | A                          | B                        | C     | D               | E     | F                  |
|----------|----------------------------|--------------------------|-------|-----------------|-------|--------------------|
|          | Use                        | Gross external area (ha) | %     | Block area (ha) | %     | Average plot ratio |
| Defaults |                            |                          |       |                 |       |                    |
| 1        | Residential                | 0.00                     | -1.00 | 0.00            | -1.00 |                    |
| 2        | Commercial                 | 0.00                     | -1.00 | 0.00            | -1.00 |                    |
| 3        | Retail                     | 0.00                     | -1.00 | 0.00            | -1.00 |                    |
| 4        | Cultural                   | 0.00                     | -1.00 | 0.00            | -1.00 |                    |
| 5        | Industrial                 | 0.00                     | -1.00 | 0.00            | -1.00 |                    |
| 6        | Educational                | 0.00                     | -1.00 | 0.00            | -1.00 |                    |
| 7        | Hotel/Tourism/Service Apt. | 0.00                     | -1.00 | 0.00            | -1.00 |                    |
| 8        | Health/Hospital            | 0.00                     | -1.00 | 0.00            | -1.00 |                    |
| 9        | Distribution/Freight       | 0.00                     | -1.00 | 0.00            | -1.00 |                    |
| 10       | Equine facilities          | 0.00                     | -1.00 | 0.00            | -1.00 |                    |
| 11       | Tertiary roads             | 0.00                     | -1.00 |                 |       |                    |
| 12       | Access                     | 0.00                     | -1.00 |                 |       |                    |
| 13       | Wind Farm                  | 7.98                     | 1.00  |                 |       |                    |
| 14       | Parking                    | 12.01                    | 1.00  |                 |       |                    |



User interface – modeller ‘captures’ design characteristics in multi-sectoral resource model

# Example: Transport



# Example: Transport

.../3

## 'Business as Usual':

Population: 50,000

| Mode              | Pass. kms per day | Vehicle km's     | Fuel Technology      |
|-------------------|-------------------|------------------|----------------------|
| Car               | 2,100,107         | 1,400,071        | Petrol / Diesel      |
| Bus               | 1,819,254         | 60,642           | Diesel               |
| Light rail / tram | 1,345,629         | 6,728            | Electricity (fossil) |
| Cycling           | 89,567            | 89,567           | -                    |
| Walking           | 25,439            | 25,439           | -                    |
| <b>Total:</b>     | <b>5,379,996</b>  | <b>1,582,447</b> |                      |

## Sustainability:

Population: 80,000

| Mode              | Pass. kms per day | Vehicle km's   | Fuel Technology             |
|-------------------|-------------------|----------------|-----------------------------|
| Light rail / tram | 1,816,930         | 9,085          | Electricity (wind turbines) |
| Bus               | 1,522,894         | 50,763         | Biodiesel                   |
| Car               | 889,575           | 563,050        | Biodiesel, Petrol, Diesel   |
| Cycling           | 49,463            | 49,463         | -                           |
| Walking           | 17,045            | 17,045         | -                           |
| <b>Total:</b>     | <b>4,295,908</b>  | <b>719,406</b> |                             |

# Example: Transport

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higher density – sustainability scenario transport impacts reduced on per capita basis

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...decrease in overall trip distances

# Example: Transport

.../6

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Change in the dominant transport modes

# Example: Transport

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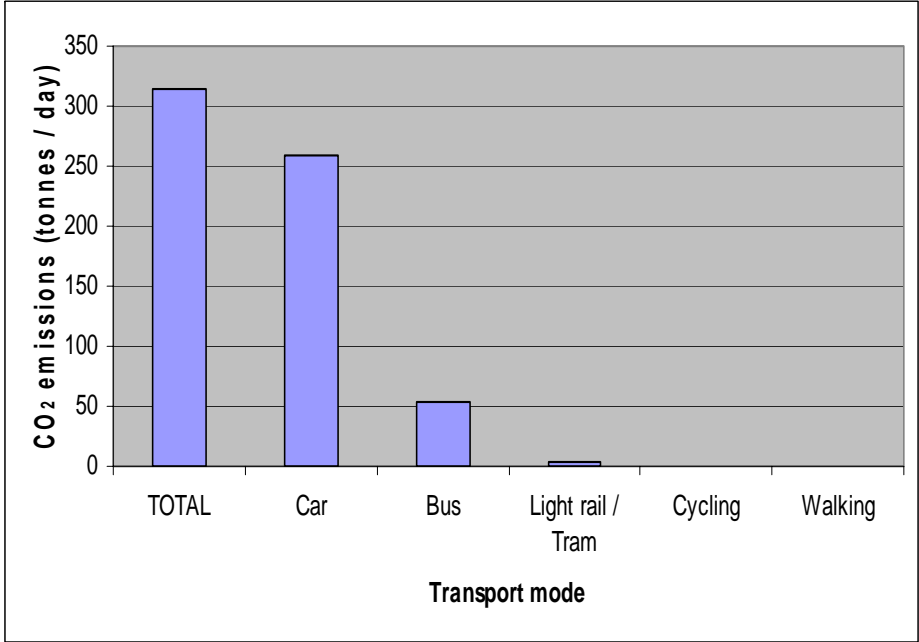
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Switch to alternative fuel technologies

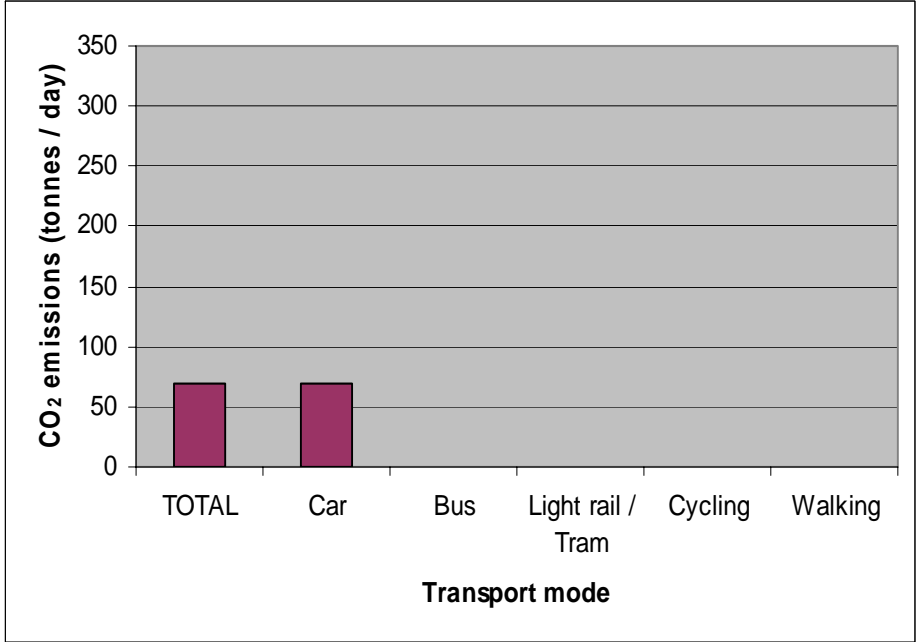
# Example: Transport

Example performance output – comparison of fossil carbon dioxide (CO<sub>2</sub>) emissions -BaU and sustainability scenarios:

### ‘Business as Usual’:



### Sustainability:

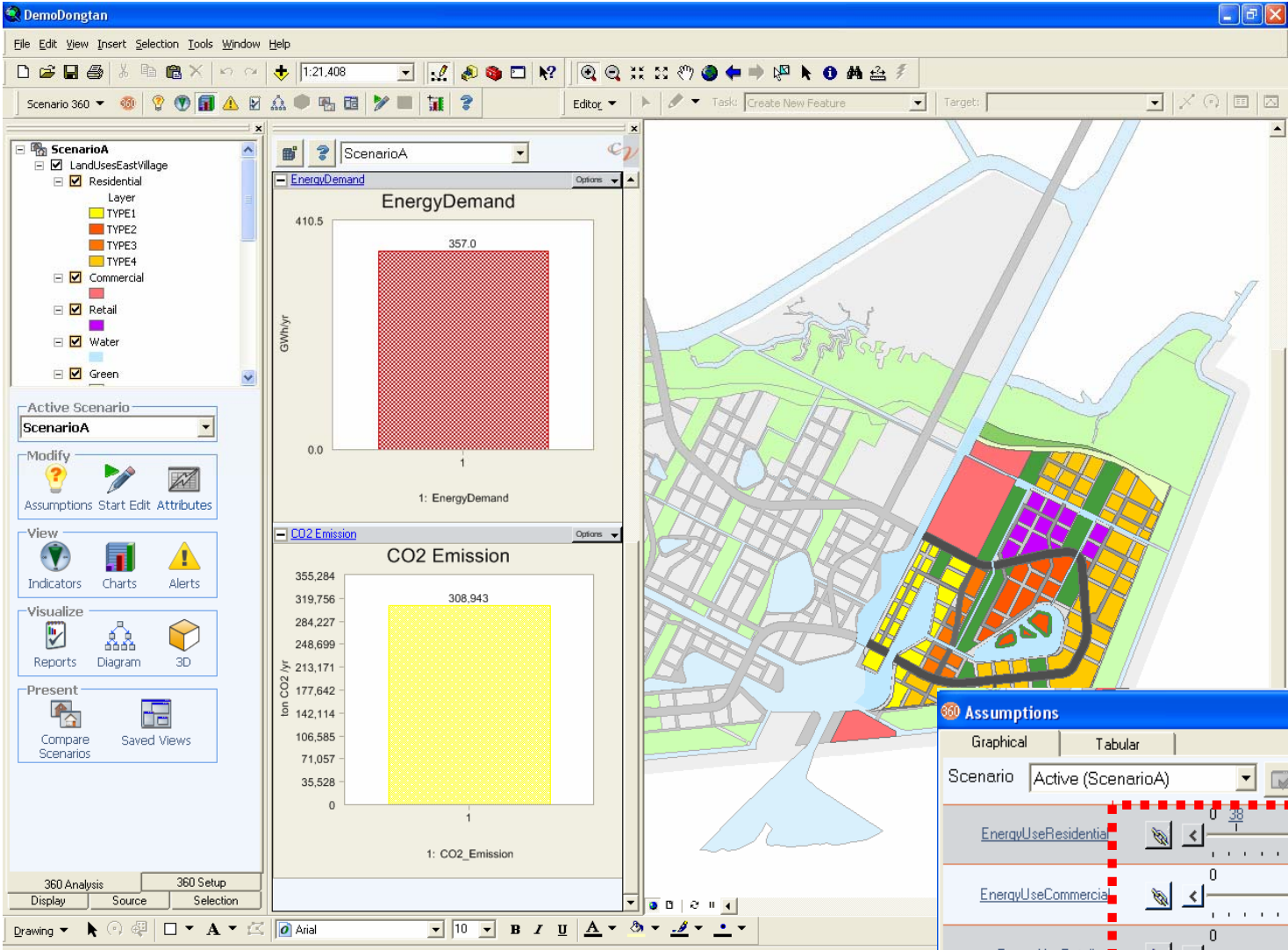


# Example: Energy use in buildings

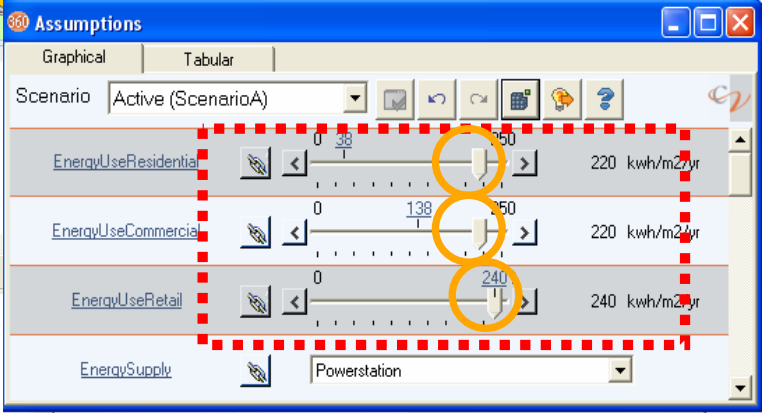


# Example: Energy use in buildings

.../1

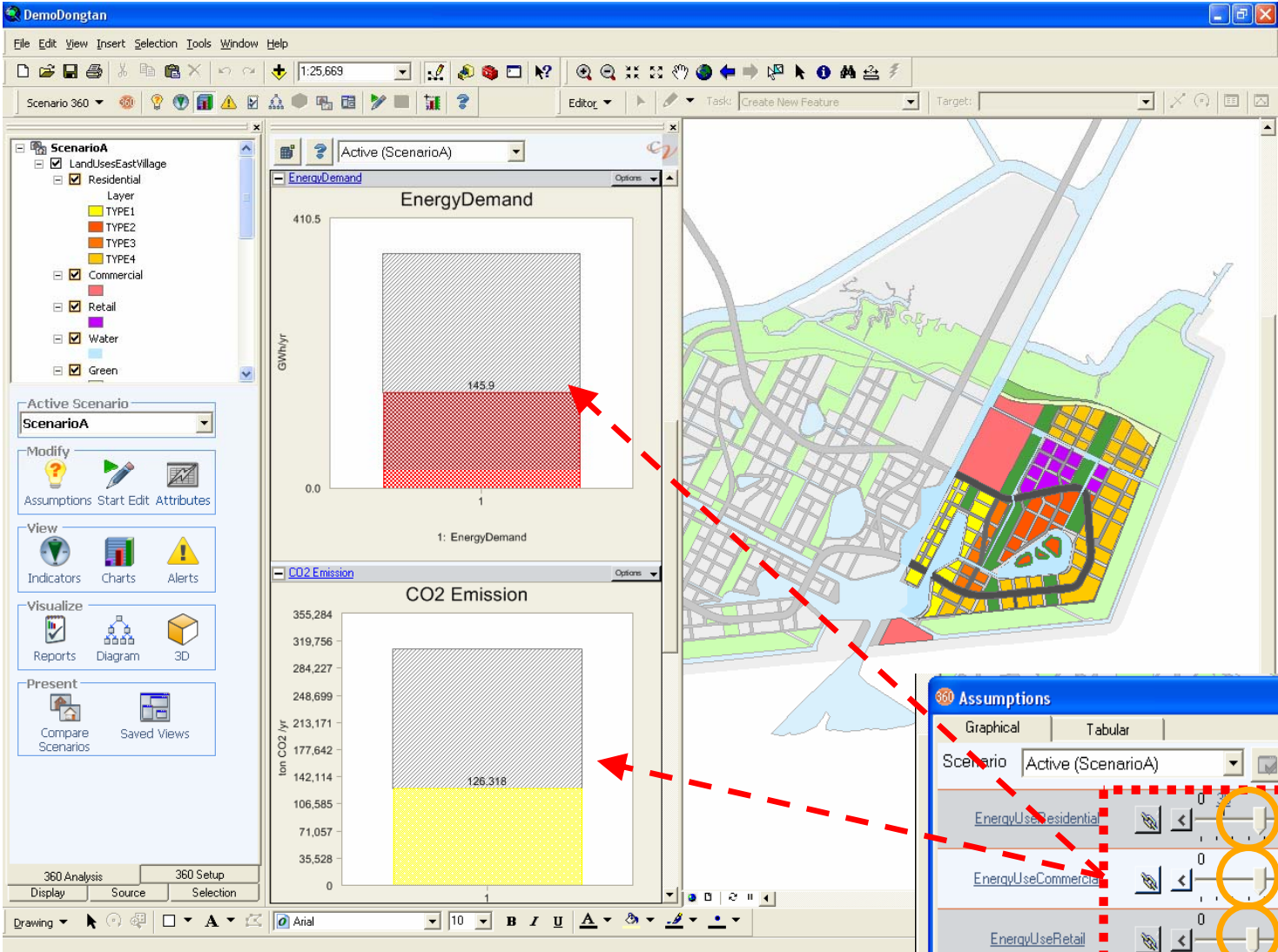


**BaU energy demand and supply**



# Example: Energy use in buildings

.../2



**Reduce demand (e.g. through energy efficient design)**

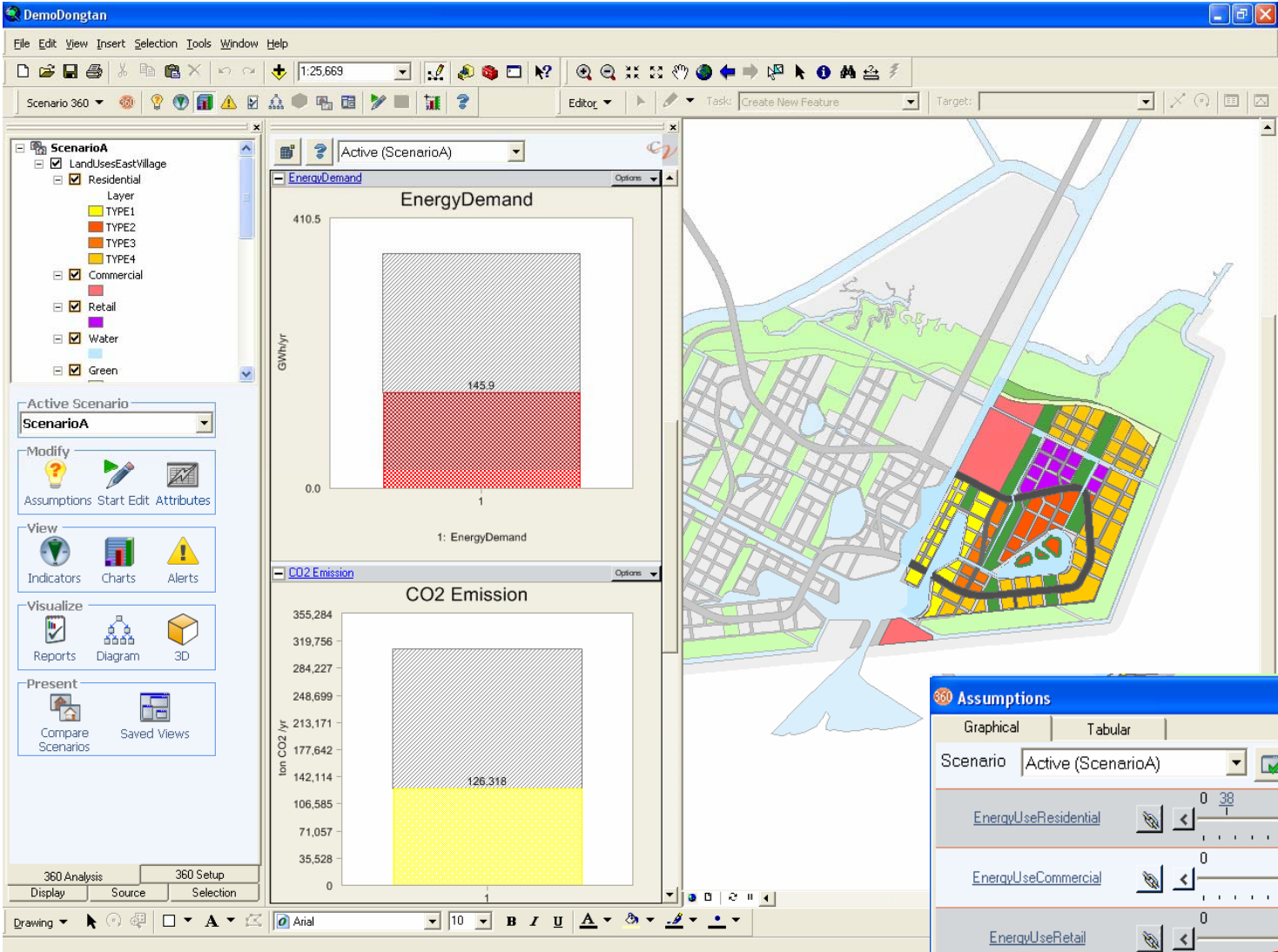
The Assumptions window shows the following settings:

| Assumption           | Value        | Unit      |
|----------------------|--------------|-----------|
| EnergyUseResidential | 93           | kwh/m2/yr |
| EnergyUseCommercial  | 93           | kwh/m2/yr |
| EnergyUseRetail      | 81           | kwh/m2/yr |
| EnergySupply         | Powerstation |           |

Yellow circles highlight the sliders for EnergyUseResidential, EnergyUseCommercial, and EnergyUseRetail, which are being adjusted to reduce demand.

# Example: Energy use in buildings

.../3



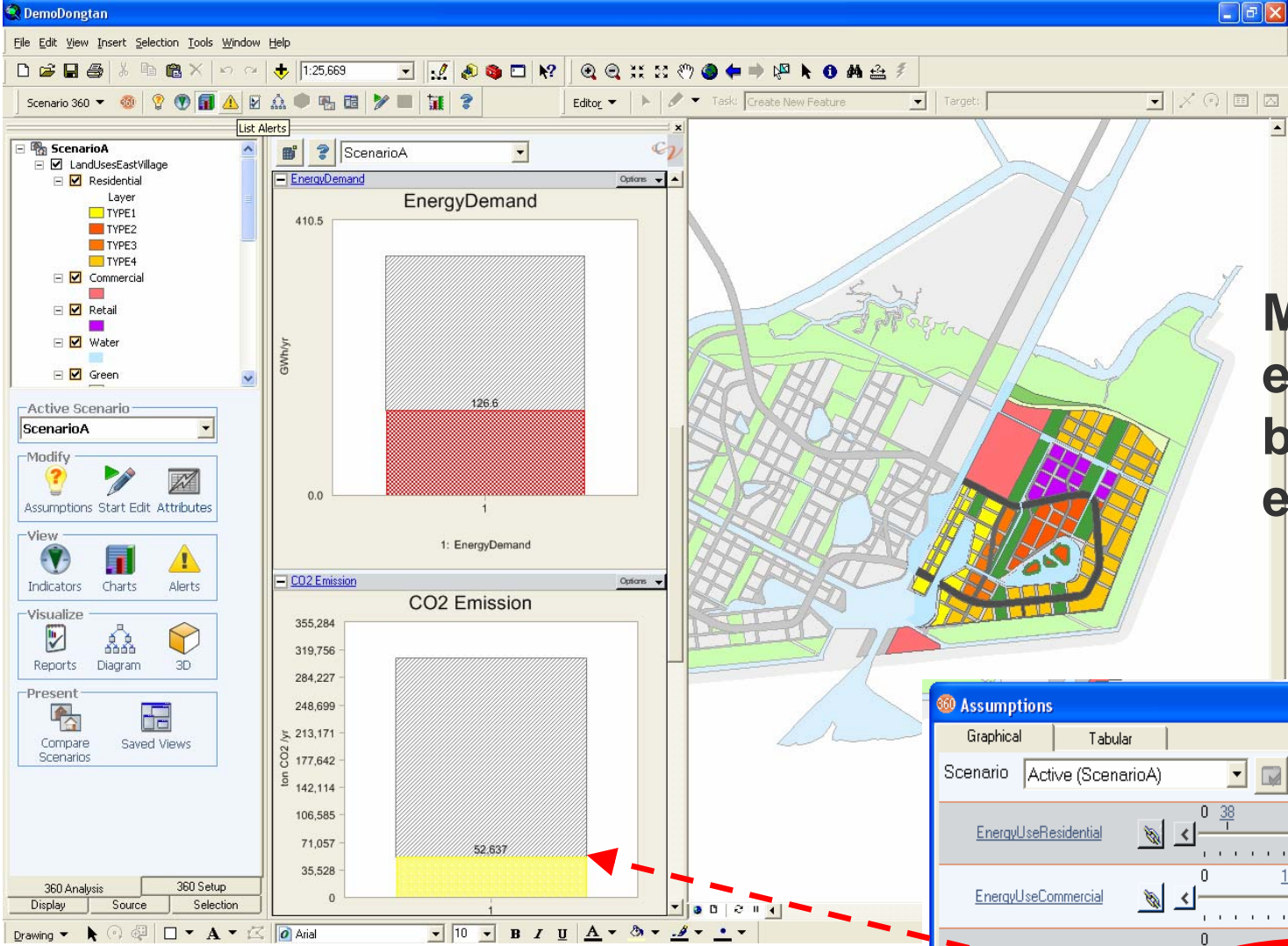
Change in energy supply from power station to CHP (gas)

The Assumptions dialog box is open, showing various energy use and supply parameters. The EnergySupply parameter is highlighted with a red circle, and its dropdown menu is open, showing the following options:

- Combined Heat and Power (Gas)
- Powerstation
- Combined Heat and Power (Gas)
- Combined Heat and Power (Biomass)

# Example: Energy use in buildings

.../4



Meet same energy demand but with reduced emissions (CO<sub>2</sub>)

The Assumptions dialog box shows the following settings:

| Parameter            | Value                         | Unit      |
|----------------------|-------------------------------|-----------|
| EnergyUseResidential | 220                           | kwh/m2/yr |
| EnergyUseCommercial  | 220                           | kwh/m2/yr |
| EnergyUseRetail      | 240                           | kwh/m2/yr |
| EnergySupply         | Combined Heat and Power (Gas) |           |

The EnergySupply dropdown menu is circled in red.

# Outputs and (KPIs)

**Scenarios**

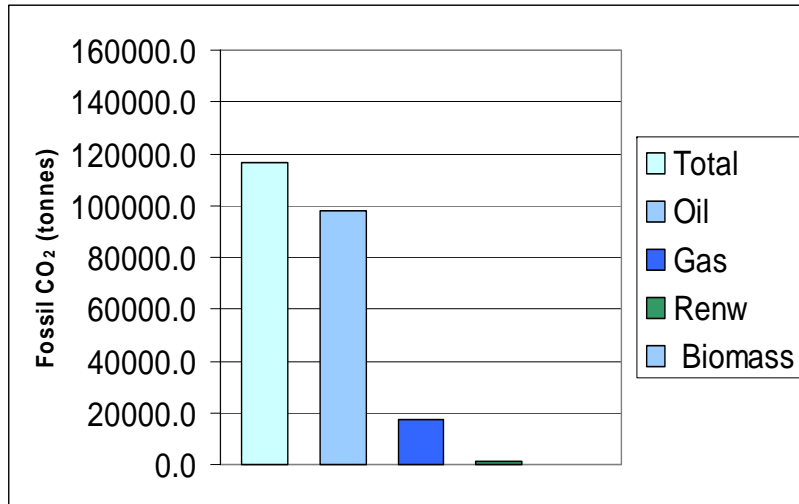
- BaU
- Sustainability

**Indicator**

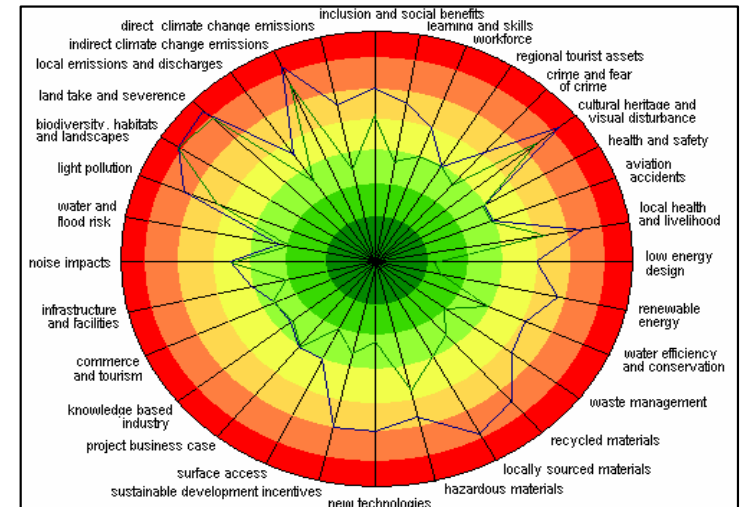
Units of measure



Performance Output



*Indicators represent a 'bridge' between the scenario definition and the performance output...*



# Example: Thames Gateway Feasibility Study



# Project aims

- **To quantify the levels of carbon emissions generated in the Thames Gateway**
- **To determine the levels of reduction possible through decreasing demand and use of alternative technologies / solutions to meet supply**
- **To determine the costs associated with achieving these levels of reduction**
- **To guide / inform policy to ensure Government targets are met**

# Summary of results

**EMBARGOED!!!!**

# Summary benefits of the IRM approach

- **Holistic approach to masterplan (integrating spatial and non-spatial components)**
- **Prompt appropriate questions: Identify opportunities and constraints at an early stage**
- **Supports decision-making: choice of options and scenarios (comparisons)**
- **Supports iterative process of design refinement and optimization**
- **Links design objectives to sustainability objectives through assessment of design performance**

# Recent and current projects

- **Dongtan – SIIC**
- **Northstowe - Gallagher's; English Partnerships**
- **Gallions Park (Mayor of London's Zero Carbon project) – LDA**
- **Thames Gateway Feasibility Study – DCLG**
- **Ropemaker Place - British Land**
- **Down Ampney (Co-operative Group)**
- **Opportunity Peterborough – Sustainable Masterplan**
- **GLA – Climate Change London Plan Review**
- **Land Securities**
- **Cape Town Railway Station**

# Challenges for existing cities / 1

- **Focus on *Regeneration* .. Not an entire new build!**
- **Need to establish a Vision + define Sustainability Objectives for the city**
- **What is most relevant to the city...**
  - Carbon neutrality?
  - Waste management?
  - Water management?
  - Social issues (employment, health, education...)?

## Challenges for existing cities / 2

- **Where to focus efforts to bring about improvements (quick wins, cost versus benefit)?**
- **Setting targets for a defined time period**
- **Monitoring, mitigation and reporting**

# Concluding remarks

# Concluding remarks

- **An Eco-City requires a Vision for the city and demands a structured approach to ensure delivery**
- **Sustainability Objectives / Targets specific for Plymouth should be set at an early stage**
- **Tools such as Ecological Footprinting and Integrated Resource Management modeling are essential to guide / inform decision making**
- **Monitoring and reporting are key considerations to ensure targets are met in the most cost effective manner possible (eg as part of a Sustainability Management system for Plymouth)**

For further information

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