An Energy Abundant Eco City

“Optimizing the eco-city model after the energy revolution”
"Sustainability in Architecture. Only blabla?"

People
- health
- safety
- participation
- lifecycle resistance
- comfort
- social coherence
...

Planet
- energy
- water
- material
- mobility
- waste
- nature and landscape
...

Prosperity
- wealth
- affordability
- transparency
- employment
- accessibility
- management
...

Project
- reliability
- relation with surroundings
- image
- visual quality
- flexibility
- spatial structure
...

Things that directly influence planet destruction
- energy use
- water use
- material
- cropland usage
- grazingland usage
- waste
- CO2 emission
- forestry
- fishing

Things that don’t
Urgency

Problem Statement

Conclusion

Extremes

Model #1

Model #2

Model #3

Energy Revolution
Planet Earth

☐ water

■ land

70.8%

29.2%

www.footprintnetwork.org
Planet Earth

- **water**: 70.8%
- **land**: 29.2%
Earth's available resources

- 29,272,400 km² (fishing grounds)
- 1,515,343 km² (built up land)
- 48,583,358 km² (agricultural land)
- 36,777,123 km² (forests)
We're using more resources than the earth can provide!
Humanity's ecological footprint and biocapacity
(in billion global hectares)

We are in an environmental crisis!

www.footprintnetwork.org
Causes

World population growth throughout history

Causes

1. Industrialization

http://www.vaughn-1-pagers.com/history/world-population-growth.htm
US Department of Commerce
Causes

2

Development

Global Footprint/capita (gha)

Human Development Index (HDI)

earth’s biocapacity

high human development threshold

United Arab Emirates
Qatar
United States
United Kingdom
Netherlands
Norway
United Kingdom
Columbia

Global Footprint Network, 2009 report.
UN Human Development Index, 2009 data.
Conclusion

We’re putting more pressure on the earth’s resources

“The world is being required to accommodate not just more people, but effectively ‘larger’ people “
- Catton (1986)
Urbanisation = Concentration

of:
people, energy consumption, material consumption, knowledge, waste
50% of the world population lives in urban area’s

The prognosed world population growth will happen in cities

A sustainable solution should be found in cities

UN: World Urbanization Prospects: The 2005 Revision
Model #1:

“The generic self providing city”
"Self-reliant generic city"
research project with Ricardo Schoonewolff
Remote Cities

Remote City: more than 50% of the population lives more than 45 minutes travel by road to a city at least 50,000 inhabitants.

Remote cities as reference
Remote Cities

Average living area / capita
European standard average: 31.0 m² / capita

Eurostat living standards statistics
<table>
<thead>
<tr>
<th>generic city</th>
<th>eco-city</th>
<th>energy abundant</th>
<th>eco-city</th>
</tr>
</thead>
<tbody>
<tr>
<td>pop.: 1,000,000 inhabitants</td>
<td></td>
<td></td>
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</tbody>
</table>
_CITY MODEL

generic city  eco-city  energy abundant  eco-city

pop.: 1 000 000 inhabitants

Dwellings: 31.000.000 m²

28%
 generic city  eco-city  energy abundant eco-city

pop.: 1,000,000 inhabitants

Offices: 23,300,000 m²

21%
generic city | eco-city | energy abundant | eco-city

pop.: 1,000,000 inhabitants

Commerce: 13,300,000 m²

12%
Public buildings: 16,700,000 m²

15%
industry: 12.000.000 m²
generic city  eco-city  energy abundant eco-city
pop.: 1 000 000 inhabitants
industry: 12.000.000 m²  11%
Dwellings: 31.000.000 m2
Offices: 23.300.000 m2
Commerce: 13.300.000 m2
Public buildings: 16.700.000 m2
Parks and squares: 14.300.000 m2
Industry: 12.000.000 m2

Total: 110.600.000 m2
Agriculture: 16.700.000 m²
Dwellings: 31.000.000 m²
Offices: 23.300.000 m²
Commerce: 13.300.000 m²
Public buildings: 16.700.000 m²
Parks and squares: 14.300.000 m²
Industry: 12.000.000 m²

Total: 127.300.000 m²
SPECIFIC PROGRAMME:
624 hotels (54,200 bed places)
40 hospitals (11,100 beds)
27 theaters (21,200 seats)
66 libraries (2,000,000 volumes)
225 primary schools for 90,000 students
119 secondary 1 schools for 89,000 students
26 secondary 2 schools for 90,000 students
47 museums
20 fire stations

Dwellings: 31.000.000 m2
Offices: 23.300.000 m2
Commerce: 13.300.000 m2
Public buildings: 16.700.000 m2
Parks and squares: 14.300.000 m2
Industry: 12.000.000 m2
Agriculture: 16.700.000 m2

Total: 127.300.000 m2
The generic city is unsustainable!
Urgency

Problem Statement

Energy Revolution

Model #1

Model #2

Model #3

Conclusion

Extremes
Problem Statement:
Can we create cities without negative impact on the environment?
Model #2:

“eco-city”
### City Model

<table>
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<th>generic city</th>
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</table>

### CASE STUDIES:

- MASDAR CITY
- DONGTAN CITY
- CAOFEIDEN
- SAN FRANCISCO

"Traditional eco-city model" analysis of current eco-cities

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http://www.sustainable-city.org/Plan/Food/Intro.htm

Ecopolis, Architecture and Cities for a Changing Climate, Paul F Downton

http://www.culturechange.org/cms/index.php?option=com_content&task=view&id=172&Itemid=1
CITY MODEL

generic city | eco-city | energy abundant eco-city

pop.: 1,000,000 inhabitants
generic city | eco-city | energy abundant eco-city

pop.: 1 000 000 inhabitants
CITY MODEL

The energy abundant eco city by Purcy Marte 2010 10 08

Generic city | Eco-city | Energy abundant eco-city

Pop.: 500,000 inhabitants

Limited city size
- Sensible public transport
- Energy reduction

Ecopolis: Architecture and Cities for a Changing Climate, Paul F Downton
green energy production

biomass power plant

wind turbines

solar power plant

pop.: 500 000 inhabitants
_CITY MODEL_

generic city | eco-city | energy abundant eco-city

pop.: 500,000 inhabitants

treatment plant

desalination plant

water systems
generic city | eco-city | energy abundant eco-city
pop.: 1,000,000 inhabitants
<table>
<thead>
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</table>
CITY MODEL

The energy abundant eco city by Purdy Marte 10 08

Generic city | Eco-city | Energy abundant eco-city

Pop.: 500,000 inhabitants
CITY MODEL

generic city  eco-city  energy abundant eco-city

pop.: 500 000 inhabitants

sun orientation
the energy abundant eco city by purcy marte 2010 10 08

CITY MODEL

generic city  eco-city  energy abundant eco-city

pop.: 500 000 inhabitants
narrow streets, high density
- sensible public transport
- walking distances
- climate control

generic city | eco-city | energy abundant eco-city

pop.: 500,000 inhabitants
CITY MODEL

generic city   eco-city   energy abundant eco-city

pop.: 500 000 inhabitants
limited building height
-reduction of building energy

generic city  eco-city  energy abundant eco-city
pop.: 500 000 inhabitants
generic city  eco-city  energy abundant eco-city

pop.: 1,000,000 inhabitants
_CITY MODEL

generic city | eco-city | energy abundant eco-city

pop.: 500,000 inhabitants
thick structure

-reduction of heating energy
| City Model                | Energy Abundant Eco City                        
<table>
<thead>
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<th></th>
<th></th>
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<tbody>
<tr>
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<td>Eco-City</td>
</tr>
<tr>
<td>Pop.: 500,000 inhabitants</td>
<td><img src="image" alt="Diagram of an energy abundant eco-city model" /></td>
</tr>
</tbody>
</table>
ECO CITY MODEL

DOMAIN

Energy

Materials

Food

Water

Air

Waste

Land Use

generic city | eco-city | energy abundant eco-city

pop.: 500,000 inhabitants

the energy abundant eco city by purcy marte 2010 10 08
200MW green energy produced by pv cells, windfarm, other small sources, insulation, public transit.

Accepting 30 degrees indoor climate instead of 20 degrees.

Interview, Peter Mensinga
200MW green energy produced

pv cells, windfarm, other small sources, insulation, public transit

ECO CITY MODEL

Energy

Materials

Food

Water

Air

Waste

Land Use

30 kWh = The energy to light thirty 100W lightbulbs for 10 hours

sources
World Resource Institute
http://earthtrends.wri.org/searchable_db/index.php?step=countries&ccID%5B%5D=0&allcountries=checkbox&theme=6&variable_ID=351&action=select_years
200MW green energy produced
pv cells, windfarm, other small sources, insulation, public transit

ECO CITY MODEL

Energy
- 200MW green energy produced
- pv cells, windfarm, other small sources, insulation, public transit

Materials
- concrete, stone, insulation
- exhaustion

Food

Water

Air

Waste

Land Use

Well insulating, but deplatable
- closed facades, concrete, stone
- well insulated

Duivesteijn, K, DCBA-kwartet Duurzaam Bouwen, 2001
ECO CITY MODEL

Energy
- 200MW green energy produced
- pv cells, windfarm, other small sources, insulation, public transit

Materials
- concrete, stone, insulation
- exhaustion

Food

Water

Air

Waste

Land Use

pop.: 500,000 inhabitants

ECO CITY MODEL

city model
energy abundant eco-city
the energy abundant eco city by purcy marte 2010 10 08
200MW green energy produced insufficient, rest imported

pv cells, windfarm, other small sources, insulation, public transit

concrete, stone, insulation

exhaustion

insufficient, rest imported

hydroponic farm

Insufficient

Rest must be imported

lager farms consume too much energy

http://www.sustainable-city.org/Plan/Food/intro.htm

Pop-Up Cities: China Builds a Bright Green Metropolis, Interview with Alejandro Gutierrez
200MW green energy produced insufficient, rest imported
100% primary consumption insufficient for virtual use
desalination, grey and black water recycling
hydroponic farm
 pv cells, windfarm, other small sources, insulation, public transit
concrete, stone, insulation
insufficient, rest imported
100% primary consumption insufficient for virtual use

**Insufficient**

<80 L per capita per day
Desalination
Water recycling

80L = 1/60 th of western consumption
200MW green energy produced, insufficient, rest imported

100% primary consumption insufficient for virtual use

desalination, grey and black water recycling

hydroponic farm

electric transportation

air control regulations

exhaustion

Materials

Energy

O.K.

CO2 Capture

Electric transportation

Air quality regulations

Dan Weisser, Masdar City Project Development Overview
ECO CITY MODEL

DOMIAN

Energy
Materials
Food
Water
Air
Waste
Land Use

generic city eco-city energy abundant eco-city

pop.: 500 000 inhabitants

ECO CITY MODEL

<2% to landfill

Waste to energy

Organic waste recycling

Returnable packaging

Metal, glass, plastic recycling

max 2 percent to landfill

recycling system, PRT waste collection, waste to energy

Dan Weisser, Masdar City Project Development Overview
200MW green energy produced insufficient, rest imported
100% primary consumption insufficient for virtual use
desalination, grey and black water recycling
hydroponic farm
electric transportation
pv cells, windfarm, other small sources, insulation, public transit
air control regulations

ECO CITY MODEL
sufficient
max 2 percent to landfill recycling system,
PRT waste collection,
waste to energy

Average density

FSI 1,5
dens. copenhagen
pop. 150,000

Energy
Materials
Food
Water
Air
Waste
Land Use

CITY MODEL
generic city eco-city energy abundant eco-city
pop.: 500,000 inhabitants

CITY MODEL
the energy abundant eco city by purcy marte 2010 10 08
200MW green energy produced insuffi cient, rest imported
100% primary consumption insufficient for virtual use
desalination, grey and black water recycling
hydroponic farm
air control regulations electric transportation
recycling system, PRT waste collection, waste to energy
max 2 percent to landfill average

Energy
Materials
Food
Water
Air
Waste
Land Use

ECO CITY MODEL

pop.: 500,000 inhabitants

Energy
200MW green energy produced
pv cells, windfarm, other small sources, insulation, public transit

Materials
concrete, stone, insulation
exhaustion

Food
insufficient, rest imported
hydroponic farm

Water
100% primary consumption insufficient for virtual use
desalination, grey and black water recycling

Air
sufficient
air control regulations electric transportation

Waste
max 2 percent to landfill recycling system, PRT waste collection, waste to energy

Land Use
average medium density

CITY MODEL

generic city eco-city energy abundant eco-city

the energy abundant eco city by pucy marte 2010 10 08
Ecocity analysis conclusion:

Not holistic, due to green energy shortage

Eco-city aim to minimize energy consumption to make every Joule count!
Problem Statement:
Can we create cities without negative impact on the environment?

model #2 = “No”
Energy Revolution
The sun will solve the energy problem
-Peter Mensinga, ARUP
Energy from the Sun

How the sun produces energy

Fusion reaction:

\[ ^2\text{H} + ^3\text{H} \rightarrow ^4\text{He} + 3.5 \text{ MeV} \]

\[ \text{n} + 14.1 \text{ MeV} \]

energy

E=mc^2
Solar thermal power

Capture it

3% of the Sahara covered to meet to the world’s energy demand

Solar Millennium. The parabolic trough power plants Andasol 1 to 3
Core fusion reactor

The amount of energy released is about four million times as high as i.e. burning of coal.

Virtually limitless fuel supply

Inherently safe

International research programme

http://www.efda.org/fusion_energy/fusion_research_today.htm
A few decades from now, Energy abundance might become reality

Consequences?
The Venus Project?

post scarcity society

-Scarcity is the root of all evil

-The monetary system creates scarcity

-Abundant resources: no reason to sell or buy anything

-End of the capitalistic system

-Free of labor, crime, greed, hate and fear
Zeitgeist, Addendum

Scarcity is the root of all evil

The monetary system creates scarcity

Abundant resources: no reason to sell or buy anything

End of the capitalistic system

Free of labor, crime, greed, hate and fear

The Venus Project?
## Economy

“The allocation of scarce resources by human beings in the most efficient way”

<table>
<thead>
<tr>
<th>CURRENT ECONOMY:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW VALUE</td>
<td>air</td>
</tr>
<tr>
<td>VALUE</td>
<td>food, water, goods, services, real estate, raw materials</td>
</tr>
<tr>
<td>HIGH VALUE</td>
<td>knowledge, energy</td>
</tr>
</tbody>
</table>

[http://www.kurzweilai.net/articles/art0671.html?printable=1](http://www.kurzweilai.net/articles/art0671.html?printable=1)
## Economy

<table>
<thead>
<tr>
<th>CURRENT ECONOMY:</th>
<th>WIDESPREAD ABUNDANCE</th>
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<tbody>
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<td><strong>LOW VALUE</strong></td>
<td>air</td>
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<tr>
<td></td>
<td>energy</td>
</tr>
<tr>
<td></td>
<td>knowledge</td>
</tr>
<tr>
<td></td>
<td>raw materials</td>
</tr>
<tr>
<td></td>
<td>food, water, goods</td>
</tr>
<tr>
<td></td>
<td>services</td>
</tr>
<tr>
<td></td>
<td>real estate</td>
</tr>
<tr>
<td><strong>VALUE</strong></td>
<td>food, water, goods</td>
</tr>
<tr>
<td></td>
<td>services</td>
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<td></td>
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<td>raw materials</td>
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<td><strong>HIGH VALUE</strong></td>
<td>knowledge</td>
</tr>
<tr>
<td></td>
<td>energy</td>
</tr>
<tr>
<td></td>
<td>reputation</td>
</tr>
</tbody>
</table>

http://www.kurzweilai.net/articles/art0671.html?printable=1
http://en.wikipedia.org/wiki/Post_scarcity
### Economy

<table>
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<tr>
<th>LOW VALUE</th>
<th>ENERGY ABUNDANCE</th>
<th>WIDESPREAD ABUNDANCE</th>
</tr>
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<tbody>
<tr>
<td>air</td>
<td>air energy</td>
<td>air energy knowledge</td>
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<td>food, water, goods</td>
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</tr>
<tr>
<td>energy</td>
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<td></td>
</tr>
</tbody>
</table>

Central in new economy: materials and knowledge

http://www.kurzweilai.net/articles/art0671.html?printable=1
http://en.wikipedia.org/wiki/Post_scarcity
Conclusion:

Energy abundance no reason for new socialism

Capitalistic economy survives

but changes radically..
“The end of oil”

..now that two of the biggest producers are out of business. The competition from the green energy camp is simply too mighty...
The end of oil now that two of the biggest producers are out of business. The competition from the green energy camp is simply too mighty...

“Huge market for electric technology”
“Recycling business booming”
..with this crazy electricity rate, it’s simply cheaper to re-use materials rather than to quarry for new.
“Household electricity consumption doubles”

..energy is spilled like water since the negative consequences for the environment and wallet dissappeared ...

“Recycling business booming”

“Huge market for electric technology”

“The end of oil”..now that two of the biggest producers are out of business. The competition from the green energy camp is simply too mighty...


electric transport sector
The end of oil

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"Free electricity spots in Vondelpark"

..the city counsel agreed that energy should be given a more public character..

"electric transport sector"
“The end of oil”

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“Electric transport sector”

“Huge market for electric technology”

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“Free electricity spots in Vondelpark”

..the city council agreed that energy should be given a more public character..

“365 days of summer”

..the subsurface heatpumps generate a pleasant 30 degrees climate..
The end of oil
now that two of the biggest producers are out of business. The competition from the green energy camp is simply too mighty...

electric transport sector

“Huge market for electric technology”

“Household electricity consumption doubles”
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“Free electricity spots in Vondelpark”
..the city council agreed that energy should be given a more public character..

“Zeppelins use powerplant’s waste product”
..helium powered airships offer cheap intercity transit..

“365 days of summer”
..the subsurface heat pumps generate a pleasant 30 degrees climate..

Jean Marie Massaud

Headlines
The end of oil
now that two of the biggest producers are out of business. The competition from the green energy camp is simply too mighty...

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Jean Marie Massaud
“Zeppelins use powerplant’s wasteproduct”
..helium powered airships offer cheap intercity transit..

“First bike on fusion power!”
..the city council agreed that energy should be given a more public character..

weburbanist.com
Model #3:

“The energy abundant eco city”
New Evaluation system for the City Model:
1: test resource acquisition (quantification)
2: test sustainability (environmental effects)

Resource

amount: \( x \) unit / capita

1

source: source

2

‘How much resource is supplied to the city? What are the consequences of acquiring those resources?’
simplified parameterset:

- World population
- City population
- EnergyConsumption (num)
- EnergySource (name)
- EnergySustainability (int)
- FoodAmount (num)
- FoodSource (name)
- FoodSustainability (int)
- WaterAmount (num)
- WaterSource (name)
- WaterSustainability (int)
- SpaceAmount (num)
- Density (num)
- SpaceSustainability (int)
- Materialtype (name)
- MaterialAmount (num)
- MaterialSource (name)
- MaterialSustainability (int)
The energy abundant eco-city by Purcy Marte 2010 10 08

**CITY MODEL**

**generic city**  **eco-city**  **energy abundant eco-city**

*pop.: 1 000 000 inhabitants*

<table>
<thead>
<tr>
<th><strong>Population:</strong></th>
<th>1.000.000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy Production:</strong></td>
<td>140 kW/h capital day = 56.333 MW/city</td>
</tr>
<tr>
<td><strong>Food production:</strong></td>
<td>3000000 kcal/city</td>
</tr>
<tr>
<td><strong>Water production:</strong></td>
<td>8000 L/capita day = 8000000 m³/city</td>
</tr>
<tr>
<td><strong>Floor space production:</strong></td>
<td>95.3 m² capita = 95.300000 m²/city</td>
</tr>
<tr>
<td><strong>Material production:</strong></td>
<td>19.885 kg/capita/year = 19.885 000 tonnes/city</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>source</strong></th>
<th><strong>no. floors</strong></th>
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<tbody>
<tr>
<td>core fusion</td>
<td>1</td>
</tr>
<tr>
<td>vertical farm</td>
<td>1</td>
</tr>
<tr>
<td>desalinization plant</td>
<td>1</td>
</tr>
<tr>
<td>steel</td>
<td>recycling</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>land use</strong></th>
<th><strong>energy use</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>76.923 077 m²</td>
<td>26.319 MW</td>
</tr>
<tr>
<td>26.319 MW</td>
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</tr>
<tr>
<td>320.000 m²</td>
<td>63.333 333 m²</td>
</tr>
<tr>
<td>26.319 MW</td>
<td>21 320 MW</td>
</tr>
</tbody>
</table>
generic city  eco-city  energy abundant  eco-city

pop.: 1,000,000 inhabitants

city size unlimited
Energy Consumption = 7330 MW

MASDAR use:
30 kWh/day/capita

High income use:
176 kWh/day/capita
Energy amount: 174 kWh / capita / day
source: core fusion

city model

energy abundant eco-city

pop.: 1,000,000 inhabitants

core fusion
17,500,000 m² / MW
**Energy amount:** kWh / capita / day

**Food amount:** kCal / capita / day

3503

**core fusion**

【图】

### Food Consumption per capita per day
(west european countries)

3503 kCal/capita avg.

<table>
<thead>
<tr>
<th>Country</th>
<th>Energy Consumption (kCal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>3503</td>
</tr>
<tr>
<td>Denmark</td>
<td>3503</td>
</tr>
<tr>
<td>France</td>
<td>3503</td>
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<tr>
<td>Germany</td>
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<td>3503</td>
</tr>
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<td>United Kingdom</td>
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FAO Stat 2005
Energy amount: 174 kWh / capita / day
source: core fusion

Food amount: 3503 kCal / capita / day
source: core fusion
Energy amount: 174 kWh / capita / day

Food amount: 3503 kCal / capita / day

CITY MODEL

generic city  eco-city  energy abundant eco-city

pop.: 1,000,000 inhabitants

Energy
amount: 174 kWh / capita / day
source: core fusion

Food
amount: 3503 kCal / capita / day
source: vertical farm

hydroponic farms
19,230,769 m²
Energy abundant eco-city

Population: 1,000,000 inhabitants

Energy:
- Amount: 174 kWh/capita/day
- Source: core fusion

Food:
- Amount: 3,503 kCal/capita/day
- Source: vertical farm

Space:
- Amount: 96.3 m²/capita
- Density: low

Map of newly available land for the eco-city model.
Water Consumption = 4,739,000 m³ / day

Water use per capita per day (West European countries)

avg. 4739 L/capita

Energy
- Amount: 174 kWh / capita / day
- Source: Core fusion

Food
- Amount: 3503 kcal / capita / day
- Source: Vertical farm

Water
- Amount: 4739 L / capita / day
- Source: 

Space
- Amount: 96.3 m² / capita
- Density: Low
Energy amount: 174 kWh / capita / day
source: core fusion

Food amount: 3503 kCal / capita / day
source: vertical farm

Water amount: 4739 L / capita / day
source: desalination

Space amount: 95.3 m² / capita
density: low

desalination plant
189 560 m²
_CITY MODEL_

generic city  eco-city  energy abundant eco-city

pop.: 1 000 000 inhabitants

purification plant
544 985 m²
Last Challenge: Materials

Material consumption; the less the better (new restriction)

MaterialAmount = ‘minimize’
Material consumption; the less the better (new restriction)
.MaterialAmount= ‘minimize’
CITY MODEL

generic city  eco-city  energy abundant eco-city

pop.: 1 000 000 inhabitants

Energy
- Amount: 174 kWh / capita / day
- Source: core fusion

Food
- Amount: 3503 kCal / capita / day
- Source: vertical farm

Water
- Amount: 4739 L / capita / day
- Source: desalination

Space
- Amount: 96.3 m² / capita
- Density: low

Materials
- Type: 
- Amount: kg / capita / year
- Source: 

Relative building weight shows hyperbolic increase with building height

O., Gunes, O. High-Rise Buildings: Evolution and Innovations, 2004
Rovers, Ronald. How Tall is a sustainable building?, 2008
http://www.magnaclad.com/pages/Construction/
Energy amount: 174 kWh / capita / day
source: core fusion

Food amount: 3503 kCal / capita / day
source: vertical farm

Water amount: 4739 L / capita / day
source: desalination

Space amount: 95.3 m² / capita
density: low

Materials type:
amount: kg / capita / year
source:
Energy amount: 174 kWh / capita / day
source: core fusion

Food amount: 3503 kCal / capita / day
source: vertical farm

Water amount: 4739 L / capita / day
source: desalination

Space amount: 96.3 m² / capita
density: low

Materials type: M
amount: kg / capita / year
source:
**CITY MODEL**

**generic city**  **eco-city**  **energy abundant eco-city**

pop.: 1 000 000 inhabitants

---

**Energy**
- amount: 174 kWh/capita/day
- source: core fusion

**Food**
- amount: 3503 kcal/capita/day
- source: vertical farm

**Water**
- amount: 4739 L/capita/day
- source: desalination

**Space**
- amount: 96.3 m²/capita
- density: low

**Materials**
- type: M
- amount: kg/capita/year
- source: terrestrial

---

Rovers, Ronald. How Tall is a sustainable building?, 2008
http://www.magnaclad.com/pages/Construction/
Energy amount: 174 kWh / capita / day
source: core fusion

Food amount: 3503 kCal / capita / day
source: vertical farm

Water amount: 4739 L / capita / day
source: desalination

Space amount: 96.3 m² / capita
density: low

Materials type: kg / capita / year
source: 

CITY MODEL

generic city eco-city energy abundant eco-city
pop.: 1 000 000 inhabitants
generic city  eco-city  energy abundant eco-city

pop.: 1 000 000 inhabitants

Energy amount: 182 kWh / capita / day
source: core fusion

Food amount: 3503 kCal / capita / day
source: vertical farm

Water amount: 4739 L / capita / day
source: desalination

Space amount: 96.3 m² / capita
density: low

Materials type: non
amount: kg / capita / year
source: non
Energy amount: 186 kWh / capita / day
source: core fusion

Food amount: 3503 kcal / capita / day
source: vertical farm

Water amount: 4739 L / capita / day
source: desalination

Space amount: 96.3 m² / capita
density: low

Materials type: kg / capita / year
source:
Energy is not a factor anymore

D. J. Harris. *A quantitative approach to the assessment of the environmental impact*
### Material Type: Steel, Glass

### Material Source: Recycling

#### Energy Abundant Material Assessment Method:

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Recycling Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral wool</td>
<td></td>
</tr>
<tr>
<td>Timber (local oak)</td>
<td></td>
</tr>
<tr>
<td>Brick (Flattens)</td>
<td></td>
</tr>
<tr>
<td>Crushed granite aggregate</td>
<td></td>
</tr>
<tr>
<td>Clay tiles</td>
<td></td>
</tr>
<tr>
<td>Concrete</td>
<td></td>
</tr>
<tr>
<td>Lightweight blocks</td>
<td></td>
</tr>
<tr>
<td>Timber (Imported softwood)</td>
<td></td>
</tr>
<tr>
<td>Cement</td>
<td></td>
</tr>
<tr>
<td>Plastics</td>
<td></td>
</tr>
<tr>
<td>Glass</td>
<td></td>
</tr>
<tr>
<td>Steel</td>
<td></td>
</tr>
<tr>
<td>Synthetic finishes</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td></td>
</tr>
<tr>
<td>Aluminium</td>
<td></td>
</tr>
</tbody>
</table>

D. J. Harris. *A quantitative approach to the assessment of the environmental impact.*

---

**Energy Amount:** 186 kWh / capita / day

**Food Amount:** 3503 kcal / capita / day

**Water Amount:** 4739 L / capita / day

**Space Density:** Low

**Materials Amount:** kg / capita / year

---

**City Model:**
- Energy abundant eco-city by Purdy Marte 2010 10 08
- Generic city
- Eco-city
- Pop: 1,000,000 inhabitants
Energy amount:
source:
kWh / capita / day

Water amount:
source:
L / capita / day

Food amount:
source:
kCal / capita / day

Space amount:
source:
m² / capita

Materials amount:
source:
kg / capita / year

Recycling Potential Scarcity of Raw Materials

Mierrerlowo

Timber (local oak)

Brickb (Flettob)

Crushed graniteaggregate

Clay tiles

Concrete

Lightweight blocks

Timber (imported softwood)

Cement

Plastics

Glass

Steel

Synthetic finishes

Copper

Aluminium

D. J. Harris. A quantitative approach to the assessment of the environmental impact.

http://www.magnuslarsson.com/architecture/dune.asp

http://www.neatorama.com/tag/bacillus-pasteurii/

Bacillus Pasteurii bacteria turn sandgrains into solid rock. It won’t decay, and there’s no waste.

- Bob Ursem
**CITY MODEL**

**generic city**  **eco-city**  **energy abundant eco-city**

pop.: 1,000,000 inhabitants

---

**Energy**
- **amount:** 201 kWh / capita / day
- **source:** core fusion

**Water**
- **amount:** 4739 L / capita / day
- **source:** desalination

**Food**
- **amount:** 3503 kCal / capita / day
- **source:** vertical farm

**Space**
- **amount:** 96.3 m² / capita
- **density:** low

**Materials**
- **type:** steel
- **amount:** 19,885 kg / capita / year
- **source:** recycling

---

**CITY MODEL**

the energy abundant eco city by purcy marte 2010 10 08
The energy abundant eco-city by Purcy Marte 2010 10 08

**CITY MODEL**

generic city  eco-city  energy abundant eco-city

pop.: 1 000 000 inhabitants
Material Consumption = ‘minimize’

minimal structure:

Forces should be transferred to the foundation as direct as possible.

Moments of force require more material than normal forces.

Effective beams are thick on the outside and thin around the neutral area.

light steel frame
MaterialConsumption = ‘minimize’

minimal surface:

surface/volume ratio (m2/m3):

\[
\frac{1}{R} = \frac{1}{r_2} - \frac{1}{r_1}
\]

The ratio between outer surface and volume should be as low as possible. The sphere and cylinder have the lowest ratio.

Two merged soap bubbles provide the optimum way of enclosing two given volumes of air of different size with the least surface area.
CITY MODEL

generic city  eco-city  energy abundant eco-city

pop.: 1 000 000 inhabitants

Energy
amount: 201 kWh / capita / day
source: core fusion
desalination

Food
amount: 3503 kCal / capita / day
source: vertical farm

Water
amount: 4739 L / capita / day
source: desalination

Space
amount: 96.3 m² / capita
density: low

Materials
type: steel
amount: 12 254 kg / capita / year
source: recycling

vonoroi shape
Energy amount: 201 kWh/capita/day
source: core fusion

Food amount: 3503 kCal/capita/day
source: vertical farm

Water amount: 4739 L/capita/day
source: desalination

Space amount: 95.3 m²/capita
density: low

Materials type: steel
amount: 12 254 kg/capita/year
source: recycling

The energy abundant eco-city by Purcy Marte 2010 10 08

Generic city  Eco-city  Energy abundant eco-city

Pop.: 1 000 000 inhabitants
### Core fusion material requirements (tonne)

<table>
<thead>
<tr>
<th>Material</th>
<th>Tokamak building (t)</th>
<th>Tokamak service building (t)</th>
<th>Conventional buildings (t)</th>
<th>Fusion core (t)</th>
<th>Conventional parts (t)</th>
<th>Total (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>806.82</td>
<td>187.89</td>
<td>68.775</td>
<td>5.177</td>
<td>201</td>
<td>1,072.014</td>
</tr>
<tr>
<td>Rebar</td>
<td>109.431</td>
<td>12.203</td>
<td>18.582</td>
<td>5.177</td>
<td>201</td>
<td>140.216</td>
</tr>
<tr>
<td>Embedded steel</td>
<td>5.177</td>
<td>201</td>
<td></td>
<td></td>
<td></td>
<td>5.378</td>
</tr>
<tr>
<td>Structural steel</td>
<td>22.358</td>
<td>19.778</td>
<td></td>
<td></td>
<td></td>
<td>52.144</td>
</tr>
<tr>
<td>Lithium</td>
<td>232</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>232</td>
</tr>
<tr>
<td>Beryllium</td>
<td>232</td>
<td></td>
<td></td>
<td></td>
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<td>232</td>
</tr>
<tr>
<td>Boron</td>
<td>54</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>54</td>
</tr>
<tr>
<td>Carbon</td>
<td>224</td>
<td></td>
<td></td>
<td></td>
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<td>224</td>
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<tr>
<td>Nitrogen</td>
<td>68</td>
<td></td>
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<td></td>
<td></td>
<td>68</td>
</tr>
<tr>
<td>Silicon</td>
<td>281</td>
<td></td>
<td></td>
<td></td>
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<td>281</td>
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<tr>
<td>Vanadium</td>
<td>58</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>58</td>
</tr>
<tr>
<td>Chrome</td>
<td>7,882</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7,882</td>
</tr>
<tr>
<td>Manganese</td>
<td>2,604</td>
<td></td>
<td></td>
<td></td>
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<td>2,604</td>
</tr>
<tr>
<td>Iron</td>
<td>39,953</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>39,953</td>
</tr>
<tr>
<td>Nickel</td>
<td>2,766</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2,766</td>
</tr>
<tr>
<td>Copper</td>
<td>3,339</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3,339</td>
</tr>
<tr>
<td>Niobium</td>
<td>128</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>128</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>577</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Zirc</td>
<td>91</td>
<td></td>
<td></td>
<td></td>
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<td>91</td>
</tr>
<tr>
<td>Tantalum</td>
<td>111</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>111</td>
</tr>
<tr>
<td>Tungsten</td>
<td>465</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>465</td>
</tr>
<tr>
<td>Lead</td>
<td>34,423</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>34,423</td>
</tr>
<tr>
<td>Copper</td>
<td>210</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>210</td>
</tr>
<tr>
<td>Oil</td>
<td>359</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>359</td>
</tr>
<tr>
<td>Plastic</td>
<td>125</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>125</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>1,363.788 tonne</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Desalination plant:

- 300m²/ MW
- 2000 tonne/MW
- 0.25 L/MW

### Recycling plant:

- x MW/tonne
- x L/tonne

### Core fusion reactor:

- 300m²/ MW
- 2000 tonne/MW
- 0.25 L/MW

### Recycling plant:

- x MW/tonne
- x L/tonne

### Land use (biocapacity)

- CITY MODEL
- the energy abundant eco city by purcy marte 2010 10 08

### Popul: 1 000 000 Inhabitants

### Energy abundant eco-city

- POP: 1 000 000 inhabitants

- CITY MODEL: generic city energy abundant eco-city

---

**Notes:**

- The table lists the core fusion material requirements for various materials, including concrete, rebar, embedded steel, structural steel, lithium, beryllium, boron, carbon, nitrogen, silicon, vanadium, chrome, manganese, iron, nickel, copper, niobium, molybdenum, zirconium, tantalum, tungsten, vanadium, and lead.

- The total requirements are calculated and summed up to 1,363.788 tonne.

- Desalination plants are considered with area and tonne requirements.

- Recycling plants are also noted for area and tonne requirements.

- Land use (biocapacity) is mentioned as a relevant consideration for energy abundant eco-cities.
CITY

size: 1,000,000 in.

need: 140 kWh/day/capita

lighting
heating
cooling
devices
transport
construction

CITY MODEL

generic city eco-city energy abundant eco-city

pop.: 1,000,000 inhabitants

CITY

Desalination plant:

x MW/tonne
x L/tonne

58,333 MW

Core fusion reactor

300 m²/MW
2,000 tonne/MW
0,25 L/MW

Recycling plant

x MW/tonne
x L/tonne

land use (biocapacity)
Urgency

Problem Statement

Conclusion

Extremes

Model #1

Model #2

Model #3

Energy Revolution

Conclusion
Problem Statement:
Can we create cities without negative impact on the environment?

model #2 =
“Once green energy is abundant, Yes we can!”
Ultimate dematerialization is replacing matter by energy..

how far can we go?
### Energy
- **Amount:** 500 kWh / capita / day
- **Source:** core fusion

### Materials
- **Type:** steel
- **Amount:** 400 kg / capita / year
- **Source:** recycling
The end..