Clean Energy Development Patterns

Making the ‘Clean Energy City’ in China
Preliminary work on Task 3.1: Low Energy Development Patterns
May 27, 2010

Massachusetts Institute of Technology
Tsinghua University
Supported by a grant from the Energy Foundation, China
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Massachusetts Institute of Technology
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Supported by a grant from the Energy Foundation China

**Credits**

Making the ‘Clean Energy City’ in China is funded by a grant from the Energy Foundation, China. Principal investigators: Dennis Frenchman and Christopher Zegras, MIT; Jie Zhang and Mao Qizhi, Tsinghua University.

The project is being undertaken in conjunction with the joint MIT-Tsinghua University Urban Design Studio, directed by Dennis Frenchman and Jan Wampler, MIT, and Jie Zhang, Tsinghua University.

**MIT**

Dennis Frenchman
Leventhal Professor of Urban Design and Planning

Jan Wampler
Professor of Architecture

Christopher Zegras
Asst. Professor of Transportation Planning

**MIT Research Assistants**

Zeng Heshuang
Daniel Daou Ornelas
Nah-yoon Shin
Jue Wang
Ira Winder
Aspasia Xypolia
Yun Zhan
Jiyang Zhang
Clean Energy Development Patterns
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* Red text denotes prototypical neighborhoods in Jinan, China, studied as part of the research. These were not designed for clean energy, and are included for comparison purposes, only.
**Cluster Size**

Cluster Grid - as much as possible, clusters are reduced to units that fit into simple multiples of a 180mx180m grid.

---

**Use Types**

**KEY**
- green
- roads
- shared roads
- commercial
- pedestrian
- residential
- parking
- public transit
- water
- civic

**Heavy Black Box** - represents relative total land area of a given unit cluster. All of the boxes are the same size graphically, but keep in mind that each cluster’s absolute total land area may vary, and the box should only be used for relative comparison.

**Relative Abundance of Uses**

**Colored Bar** - represents total use area of a given use relative to a clusters total land area. Note how multiple floors result in total use areas that exceed land area.

- Built Area - represents the total built area of a given use relative to the total land area of a cluster. In this case, residential built area is 129.25% of the total land area available. (Note that only built areas have the percentage shown, as these are the only numbers factored into FAR) See pages 38 and 39 to view other uses as percentage of land area.
Small Perimeter Block, Simple

Based on: Bo01 in Malmö, Sweden

1A

Booklet Walk-through

Please refer to the example information on this spread to interpret the data represented by various graphics.

**Use Diagram** - areas of which were utilized to calculate relative abundance of uses

**Aerial Photo**

**Spatial Use Diagram** - showing overall cluster organization, including building height information

**Southern Exposure** - percent of vertical facade oriented toward various intensities of ‘south’ (see page 41 for more information)

<table>
<thead>
<tr>
<th>Southern Sun Exposure</th>
<th>0°-13°</th>
<th>13°-90°</th>
<th>0°-90°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>21%</td>
<td>19%</td>
<td>40%</td>
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</tbody>
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**Key**

- Green
- Roads
- Shared Roads
- Commercial
- Pedestrian
- Residential
- Parking
- Public Transit
- Water
- Civic

**FAR** 1.32
**Land Coverage** 33.0%
**Units/Hectare** 172
Small Perimeter Block, Simple

1A Based on: Bo01 in Malmö, Sweden

CLUSTER AREA
32400 sq. m

KEY
- green
- roads
- shared roads
- commercial
- pedestrian
- residential
- parking
- public transit
- water
- civic

129.25%

FAR 1.32
LAND COVERAGE 33.0%
UNITS/HECTARE 172

Southern Sun Exposure
0°-13° 21%
13°-90° 19%
0°-90° 40%

45 90 180 m
Small Perimeter Block, Complex

1B

Based on: Ecolonia in Alphen, Netherlands

CLUSTER AREA
32400 sq. m

KEY

green
roads
shared roads
commercial
pedestrian
residential
parking
public transit
water
civic

FAR 0.63
LAND COVERAGE 21.2%
UNITS/HECTARE 39

Southern Sun Exposure
0°-13° 21%
13°-90° 24%
0°-90° 45%

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High Density Perimeter Block, Simple

2A  Based on: Greenwich Millennium Village, London

CLUSTER AREA
32400 sq. m

KEY
- green
- roads
- shared roads
- commercial
- pedestrian
- residential
- parking
- public transit
- water
- civic

127.80%
1.21%

FAR  1.25
LAND COVERAGE  32.1%
UNITS/HECTARE  105

Southern Sun Exposure
0°-13°  0%
13°-90°  50%
0°-90°  50%
High Density Perimeter Block, Towers

2B Based on: Symphony Park in Las Vegas, NV US

Cluster Area
48,600 sq. m

Key
- Green
- Roads
- Shared Roads
- Commercial
- Pedestrian
- Residential
- Parking
- Public Transit
- Water
- Civic

129.47%
146.53%

FAR 2.40
Land Coverage 35.7%
Units/Hectare 72

Southern Sun Exposure
- 0°-13° 0%
- 13°-90° 53%
- 0°-90° 53%
Low-Rise Slabs, Aligned

3A
Based on: Bedzed in Hackbridge, UK

CLUSTER AREA
8100 sq. m

KEY

- green
- roads
- shared roads
- commercial
- pedestrian
- residential
- parking
- public transit
- water
- civic

FAR
1

LAND COVERAGE
44.0%

UNITs/HECTARE
75

Southern Sun Exposure

- 0°-13°: 0%
- 13°-90°: 49%
- 0°-90°: 49%
Low-Rise Slabs, Staggered

3B Based on: Geos in Denver, CO USA

CLUSTER AREA
32400 sq. m

KEY

green
roads
shared roads
commercial
pedestrian
residential
parking
public transit
water
civic

FAR
0.81
LAND COVERAGE
29.4%
UNITS/HECTARE
46

Southern Sun Exposure

0°-13° 21%
13°-90° 21%
0°-90° 42%
Low-Rise Slabs, Enclave

3C Based on: DongCang in Jinan, China

*Prototypical neighborhood in Jinan, China, studied as part of the research. This was not designed for clean energy, and is included for comparison purposes, only.

FAR 1.82
LAND COVERAGE 33.5%
UNITS/HECTARE 253

Southern Sun Exposure
- 0°-13°: 38%
- 13°-90°: 0%
- 0°-90°: 38%

CLUSTER AREA 32400 sq. m
The Grid, Regular

4A

Based on: Old Comm. Ctr. in Jinan, China

*Prototypical neighborhood in Jinan, China, studied as part of the research. This was not designed for clean energy, and is included for comparison purposes, only.

**KEY**
- green
- roads
- shared roads
- commercial
- pedestrian
- residential
- parking
- public transit
- water
- civic

**FAR**: 2.72
**LAND COVERAGE**: 46.1%
**UNITS/HECTARE**: 374

**Southern Sun Exposure**
- 0°-13°: 0%
- 13°-90°: 49%
- 0°-90°: 49%

**CLUSTER AREA**: 36100 sq. m

**CLUSTER AREA**: 36100 sq. m
The Grid, Regular

4A Based on: Kronsberg in Hannover, GR

<table>
<thead>
<tr>
<th>KEY</th>
<th>Percentage Net Area</th>
<th>FAR</th>
<th>LAND COVERAGE</th>
<th>UNITS/HECTARE</th>
</tr>
</thead>
<tbody>
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<td>green roads</td>
<td>4.69%</td>
<td>0.73</td>
<td>18.2%</td>
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<tr>
<td>roads</td>
<td>74.37%</td>
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<tr>
<td>shared roads</td>
<td>0.47%</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>commercial</td>
<td>0%</td>
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<td></td>
</tr>
<tr>
<td>pedestrian</td>
<td>32.34%</td>
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</tr>
<tr>
<td>residential</td>
<td>6.51%</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>parking</td>
<td>0%</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>public transit</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>water</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>civic</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Southern Sun Exposure

- 0°-13°: 0%
- 13°-90°: 50%
- 0°-90°: 50%

CLUSTER AREA 97200 sq. m

155 270 340 m
The Grid, New Urbanist

4B
Based on: Civano in Arizona, USA

CLUSTER AREA
32400 sq. m

KEY
- green
- roads
- shared roads
- commercial
- pedestrian
- residential
- parking
- public transit
- water
- civic

FAR
0.60

LAND COVERAGE
29.7%

UNITS/HECTARE
40

Southern Sun Exposure
- 0°-13°: 19%
- 13°-90°: 10.0%
- 0°-90°: 30%

Dongcang
Jinan, China

360X360 - 4 TIMES
Low-Rise Superblock, Pedestrian Cluster

5A

Based on: Vauban in Freiburg, GR

CLUSTER AREA
32400 sq. m

KEY

- green
- roads
- shared roads
- commercial
- pedestrian
- residential
- parking
- public transit
- water
- civic

171.23%

FAR 1.97
LAND COVERAGE 49.1%
UNITS/HECTARE 257

Southern Sun Exposure
0°-13° 0%
13°-90° 51%
0°-90° 51%
Low-Rise Superblock, Pedestrian Matrix

5B

Based on: Masdar in Abu Dhabi, UAE

CLUSTER AREA
64800 sq. m

KEY

green
roads
shared roads
commercial
pedestrian
residential
parking
public transit
water
civic

27.39%
49.43%
32.75%

FAR
1.1

LAND COVERAGE
27.4%

UNITS/HECTARE
47

Southern Sun Exposure

0°-13° 4%
13°-90° 41%
0°-90° 45%
Low-Rise Superblock, Traditional Form

5C  Based on: Zhang-Jia Village in Jinan, China

*Prototypical neighborhood in Jinan, China, studied as part of the research. This was not designed for clean energy, and is included for comparison purposes, only.
Prototypical neighborhood in Jinan, China, studied as part of the research. This was not designed for clean energy, and is included for comparison purposes, only.

High-Rise Superblock, Towers in Park

6A

Based on: Sunrise 100 in Jinan, China

CLUSTER AREA
64800 sq. m

KEY
- green
- roads
- shared roads
- commercial
- pedestrian
- residential
- parking
- public transit
- water
- civic

1.44%
254.04%

FAR 2.37
LAND COVERAGE 15.4%
UNITS/HECTARE 222

Southern Sun Exposure
0°-13° 15%
13°-90° 29%
0°-90° 45%

*P*rototypical neighborhood in Jinan, China, studied as part of the research. This was not designed for clean energy, and is included for comparison purposes, only.
High-Rise Superblock, Linked Towers

Based on: Linked Hybrid in Beijing, China

CLUSTER AREA
48600 sq. m

FAR    3.00
LAND COVERAGE 39.4%
UNITS/HECTARE 222

Southern Sun Exposure
0°-13°  22%
13°-90°  9%
0°-90°  31%

6B

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### Cluster Data

For each unit-cluster, data for areas of various use types were tabulated as a percentage of total land area. Note how multiple floor buildings may have resulted in FARs greater than 1, and some clusters’ number of floors may vary from building to building.

Using average areas for each cluster’s residential unit, and the total residential area of each cluster (taking into account circulation) average units per cluster were calculated.

Unless otherwise noted, units are in metric meters, square meters, etc.

<table>
<thead>
<tr>
<th>use</th>
<th>net area</th>
<th>percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>green</td>
<td>16373</td>
<td>47.57</td>
</tr>
<tr>
<td>roads</td>
<td>2067</td>
<td>6.00</td>
</tr>
<tr>
<td>shared roads</td>
<td>4632</td>
<td>13.46</td>
</tr>
<tr>
<td>commercial</td>
<td>1209</td>
<td>3.51</td>
</tr>
<tr>
<td>pedestrian</td>
<td>503</td>
<td>1.46</td>
</tr>
<tr>
<td>residential</td>
<td>9632</td>
<td>27.99</td>
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<tr>
<td>parking</td>
<td>0</td>
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<tr>
<td>public transport</td>
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<td>water</td>
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<tr>
<td>civic</td>
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<td>0.00</td>
</tr>
<tr>
<td>TOTAL</td>
<td>34416</td>
<td>100.00</td>
</tr>
</tbody>
</table>

| residential floors | 6 |
| commercial floors  | 1 |
| footprint           | 10841 |
| built residential  | 57794 |
| built commercial   | 1209  |
| built civic        | 0     |
| total built        | 59003 |
| cluster dimensions | 180*180 |
| cluster area       | 32400 |
| multiplier         | 1.00  |
| FAR                 | 1.82  |
| coverage            | 33.46 |
| average unit size  | 60   |
| units per cluster  | 819  |
| clusters per hectare | 0.31 |

Red Shading denotes prototypical neighborhoods in Jinan, China, studied as part of the research. These were not designed for clean energy, and are included for comparison purposes, only.
<table>
<thead>
<tr>
<th>Net Area</th>
<th>Percentage</th>
<th>Use Net Area Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>bo01 malmo</td>
<td>129.25</td>
<td>33.0%</td>
</tr>
<tr>
<td>ecolonia alphen</td>
<td>68.33</td>
<td>21.2%</td>
</tr>
<tr>
<td>zhianjiacun jinan</td>
<td>19.40</td>
<td>76.1%</td>
</tr>
<tr>
<td>the grid jinan</td>
<td>56.72</td>
<td>121.0%</td>
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<tr>
<td>sunshine jinan</td>
<td>6.23</td>
<td>222.39</td>
</tr>
<tr>
<td>bedzed</td>
<td>254.04</td>
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<td>civano</td>
<td>18.33</td>
<td></td>
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<tr>
<td>linked hybrid</td>
<td>83.66</td>
<td></td>
</tr>
<tr>
<td>masdar</td>
<td>49.40</td>
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</table>

<table>
<thead>
<tr>
<th>FAR</th>
<th>LAND COVERAGE</th>
<th>UNITS/HECTARE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.82</td>
<td>33.5%</td>
<td>253/ha</td>
</tr>
<tr>
<td>0.81</td>
<td>29.4%</td>
<td>46/ha</td>
</tr>
<tr>
<td>2.40</td>
<td>35.7%</td>
<td>72/ha</td>
</tr>
<tr>
<td>1.25</td>
<td>32.1%</td>
<td>105/ha</td>
</tr>
<tr>
<td>0.73</td>
<td>18.2%</td>
<td>106/ha</td>
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<tr>
<td>1.32</td>
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<td>172/ha</td>
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<tr>
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<td>21.2%</td>
<td>39/ha</td>
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<td>0.76</td>
<td>76.1%</td>
<td>121/ha</td>
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<td>2.72</td>
<td>46.1%</td>
<td>374/ha</td>
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<td>1.12</td>
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<td>3.00</td>
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<td>222/ha</td>
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<td>1.10</td>
<td>27.4%</td>
<td>47/ha</td>
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</table>

<table>
<thead>
<tr>
<th>bo01 malmo</th>
<th>ecolonia alphen</th>
<th>zhianjiacun jinan</th>
<th>the grid jinan</th>
<th>sunshine jinan</th>
<th>bedzed</th>
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<th>Percentage</th>
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<table>
<thead>
<tr>
<th>Built Residential</th>
<th>Built Commercial</th>
<th>Built Civic</th>
<th>Total Built</th>
</tr>
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<td>57794</td>
<td>1209</td>
<td>351</td>
<td>66420</td>
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<table>
<thead>
<tr>
<th>Cluster Dimensions</th>
<th>Cluster Area</th>
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<td>180*180</td>
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<table>
<thead>
<tr>
<th>Multiplier</th>
<th>FAR</th>
<th>LAND COVERAGE</th>
<th>UNITS/HECTARE</th>
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Red Shading denotes prototypical neighborhoods in Jinan, China, studied as part of the research. These were not designed for clean energy, and are included for comparison purposes, only.

### Solar Exposure Data

Each unit-cluster’s surface areas were tabulated, and then categorized in terms of their relative orientation toward south. Facades within 13 degrees of south’s perpendicular were one category, facades between 13 and 90 degrees of south’s perpendicular were another, and all other (basically northern-facing facades) were placed into a third category. The breakdown of total southerly exposed facade (0 to 90 degrees), as a fraction of total facade may be viewed at the right.

### Unit Qualities for Given Clusters

<table>
<thead>
<tr>
<th>Floors per unit per unit</th>
<th>Bedrooms</th>
<th>Bathrooms</th>
<th>Balcony</th>
<th>Unit Area, Enclosed (sqm)</th>
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*MASDAR has 0 southern facade with sunshade