Principles and Criteria for Assessing Urban Energy Resilience

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Background and Aims

- Frequency and enormity of damages caused by climate-related disasters
- A large volume of research on urban resilience
- Existing research on urban resilience is mainly discipline based
- Adaptation aspects have not received enough attention
- No appropriate metrics and indices for assessing the resilience of cities
- Such indices can play the role of decision support system and facilitate a more informed decision making process
- Here the focus in on both adaptation and mitigation issues
Merits

- Capture the complexity and effectively simplify the route to resiliency
- Measure resilience and track achievement of goals
- Provide guidelines for future developments that can be communicated to planners and policy makers
Literature Review

Year of Publication

- Year Range: 1996 to 2016
- Publication Count: 300
Geographical Distribution of the Authors
Geographical Focus
Risk Index
Vulnerability

Vulnerability
Vulnerability of society as the sum of susceptibility, lack of coping capacities and lack of adaptive capacities

Data: UNU-EHS, based on the PREVIEW Global Risk Data Platform, CRISIS, CIESIN and global databases; detailed information at www.WorldRiskReport.org
Major Approaches

- Engineering Resilience
  - Resistance to change and return to the equilibrium after receiving a shock

- Ecological Resilience
  - Persistence of a system and its ability to absorb the disturbance and sustain its structure or function.
    The system may return to the old or a new equilibrium(s)

- Adaptive (socio-ecological) Resilience
  - The latest approach toward resilience which suggests that complex, dynamic, and adaptive systems (e.g. cities) would not necessarily return to an equilibrium state. This approach advocates the concept of living with risk
Dominant approach

- Engineering resilience
- Ecological resilience
- Adaptive resilience
Characteristics of a resilient system
Some characteristics

Resilience
- Robustness,
- stability,
- flexibility,
- resourcefulness,
- coordination capacity,
- redundancy,
- diversity,
- foresight capacity,
- independence,
- interdependence,
- collaboration,
- agility,
- adaptability,
- self-organization,
- creativity,
- efficiency,
- equity
Conceptual framework

Sustainability of the Energy System

Availability  Accessibility  Affordability  Acceptability

Plan/prepare  Absorb  Recover  Adapt

Resourcefulness  Robustness  Flexibility  Adaptability
Coordination  Stability  Resourcefulness  Foresight Capacity
Redundancy  Flexibility  Coordination  Self-organization
Foresight  Redundancy  Agility  Creativity
Collaboration  Diversity  Independence  Collaboration
Creativity  Efficiency  Interdependence  Diversity
...  ...  ...  ...
Tasks

- Planning and design criteria that can be used for assessing urban energy resilience;
- The association between the components of the energy resilience framework;
- Criteria’s relevance to mitigation and adaptation to climate change.
Criteria

- 196 planning and design criteria identified
  - Infrastructure
    - Supply, transmission, distribution; Back-up and storage; Green and Blue Infrastructure; buildings and neighborhoods; transportation
  - Resources
    - Energy, water-energy nexus; food-water-energy nexus
Criteria

- Land use and urban form
  - Land use; urban morphology; urban geometry; passive design
- Governance
  - Monitoring and assessment; planning and management; regulatory basis and law enforcement; pricing; supports and incentives
- Socio-demographic aspects and behavior
  - demographics, health, and equity; behavioral aspects
## Relevance to the components

<table>
<thead>
<tr>
<th>Urban infrastructure</th>
<th>Ability</th>
<th>Sustainability</th>
<th>Characteristic</th>
<th>Ref</th>
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<td></td>
<td></td>
</tr>
<tr>
<td>I1</td>
<td>Fortification and robustness (physical security)</td>
<td>P, Ab</td>
<td>A1</td>
<td>R</td>
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<tr>
<td>I2</td>
<td>Diversification of energy supply (fuel mix, multisourcing)</td>
<td>P, Ab</td>
<td>A1,2</td>
<td>D</td>
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# Overall relevance

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## Overall relevance

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<th>CC</th>
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<td>6</td>
<td>22</td>
<td>9</td>
<td>4</td>
<td>76</td>
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Mitigation and adaptation

- Mainly related to adaptation (literature)
- (74.49%) are related to both mitigation and adaptation
- 24.49% to adaptation only
- 1.02 to mitigation only
- Adaptation and mitigation need to go hand in hand.
|   | A | R | Ad | A1 | A2 | A3 | A4 | R | S | F | Re | CC | Rd | D | FC | I | In | C | A | Ad | SO | Cr | E | Eq |
|---|---|---|----|----|----|----|----|---|---|---|----|----|----|---|----|---|---|---|----|----|----|---|----|
| P | 79 | 30 | 87 | 92 | 32 | 46 | 80 | 2 | 12 | 7 | 16 | 12 | 5 | 22 | 15 | 17 | 6 | 4 | 5 | 18 | 9 | 4 | 71 | 14 |
| A | 26 | 56 | 85 | 29 | 46 | 74 | 2 | 9 | 7 | 12 | 10 | 4 | 22 | 11 | 16 | 5 | 5 | 6 | 22 | 8 | 4 | 68 | 12 |
| R | 17 | 31 | 23 | 14 | 20 | 0 | 5 | 5 | 10 | 8 | 3 | 6 | 4 | 5 | 4 | 3 | 4 | 4 | 4 | 1 | 17 | 5 |
| Ad | 21 | 22 | 45 | 69 | 0 | 7 | 4 | 10 | 8 | 1 | 19 | 8 | 15 | 3 | 5 | 3 | 20 | 8 | 3 | 64 | 11 |
| A1 | 83 | 50 | 33 | 2 | 11 | 8 | 17 | 12 | 5 | 22 | 14 | 17 | 6 | 6 | 6 | 22 | 9 | 4 | 76 | 12 |
| A2 | 21 | 26 | 0 | 5 | 6 | 6 | 9 | 2 | 11 | 5 | 10 | 0 | 1 | 4 | 6 | 2 | 1 | 23 | 4 |
| A3 | 49 | 0 | 5 | 2 | 10 | 5 | 0 | 15 | 4 | 13 | 1 | 3 | 3 | 17 | 5 | 2 | 45 | 11 |
| A4 | 18 | 4 | 15 | 10 | 1 | 21 | 12 | 15 | 4 | 5 | 4 | 22 | 8 | 4 | 75 | 14 |
| R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| S | 1 | 2 | 1 | 0 | 2 | 1 | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 5 | 3 |
| F | 1 | 1 | 2 | 1 | 0 | 1 | 1 | 2 | 1 | 1 | 0 | 3 | 0 |
| Re | 7 | 1 | 1 | 2 | 1 | 0 | 2 | 1 | 3 | 1 | 1 | 12 | 4 |
| CC | 0 | 1 | 0 | 0 | 3 | 1 | 1 | 1 | 1 | 0 | 8 | 3 |
| Rd | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| D | 5 | 13 | 1 | 0 | 1 | 1 | 2 | 1 | 20 | 2 |
| FC | 1 | 0 | 0 | 3 | 1 | 1 | 0 | 10 | 2 |
| I | 2 | 0 | 0 | 1 | 3 | 1 | 30 | 0 |
| In | 0 | 1 | 0 | 1 | 1 | 3 | 1 |
| C | 0 | 2 | 3 | 0 | 5 | 1 |
| A | 1 | 0 | 0 | 3 | 1 |
| Ad | 2 | 1 | 21 | 3 |
| SO | 0 | 8 | 2 |
| Cr | 4 | 0 |
| E | 9 |

>10% Correlation is significant
Summary

- Decisions related to one component are likely to affect other components too.
- Complex, interconnected, and multi-faceted nature of energy resilience as a synergistic concept.
- Importance of adopting a systemic approach.
- Tailoring the tool.
- Data availability and accessibility.
- Cost of developing tools and conducting assessment.
Next steps

- Trade offs
- Co-benefits
- Indicators
- Composite index
Thanks for your attention