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重叠城市：
再定义后化石时代的能源景观

The Overlapped City:
Redefining Energy Landscapes in the Post-fossil Era

陈忱
临界工作室创始合伙人
Chen CHEN
Founding Partner at reMIXstudio

校对 Proofread by / 李霞 Xia LI

摘要 ……
纵观人类文明的发展历史，能源系统的改变向来伴随着人类聚居景观的根本性变革。在新能源时代，能源的生产与分配将会深刻地影响城市空间布局及其扩张蔓延的模式。可再生能源的低能量密度和灵活产能规模的特征，使如今几乎是纯粹能源消费者的城市面临着在其范围内同时整合能源生产的挑战与机遇。能源不仅应被理解为一个空间问题，同时也是一个生态问题。我们将面临一场重新定义人类聚居与所处自然环境互动关系的革命。新的空间范式应该超越对技术进步的一味依赖而延展到政治、社会和文化等更为广泛的层面。名为“重叠城市”的课题研究在三个尺度上展开，旨在探索后化石时代城市的形态及空间整合策略：重新定义城市边界与城市组群（宏观）、能源基础设施的规划框架（中观）和一套新的城市空间规划导则（微观 ）（图1）。

关键词 ……
可再生能源；本地能源生产；空间整合；以设计为指向的信息视觉化

Abstract ...
Throughout the history of human civilization, changes in energy systems have always led to fundamental transformations in the landscapes of human occupation. In the new era, the logic of energy production and distribution will start having a significant impact on the spatial organization of the urban growth. Given the low power-density and flexible scales of renewables, cities that so far have been solely energy consumers face both the challenge and the opportunity of accommodating energy production within their boundaries. Energy is not only a spatial project but would increasingly become an ecological project, revolutionizing deeply how we should redefine the interaction between inhabitation and environment in the future. New models should go beyond purely technical advances to embrace broader political, social and cultural dimensions. “The Overlapped City” explores the morphology and synergetic spatial strategies of resilient post-fossil cities across three scales: redefining urban boundaries and urban clusters, energy infrastructure framework and a new set of urban codes (Fig. 1).

Key words ...
Renewable Energy; Local Energy Production; Spatial Synergy; Projective Representation

项目起源：未来的能源场景与人类聚居景观的转变

我们正在经历化石时代的终结，可再生能源正在逐渐替代我们对化石能源的依赖。纵观人类文明发展的历史，能源系统的改变向来伴随人类聚居景观的根本性变革（图 2）。回顾化石能源是如何将20世纪人类聚居的组织结构与逻辑彻底颠覆——深刻改变其密度、模式和尺度规模——我们不难预见新的能源场景将会如何重演这场颠覆，从而重新定义未来空间结构的形成与发展。能源生产、分配与消费的逻辑将会在各个尺度范围内对我们如何理解和定义城市的边界、基础设施及环境景观产生深刻的影响。可再生能源所具有的低能量密度和灵活产能规模的特征，使如今几乎是纯粹能源消费者的城市面临在其范围内同时整合能源生产的挑战与机遇（图3）。基于这些可能发生的深远变化，城市化的议题亟需被重新讨论与定义。

如今，设计师对能源问题的关注与实践大多停留在这一问题两个极其片面的方面，即节能设计与将能源采集设备（太阳能板、风车等）整合到已有的空间结构和原型中去。这些讨论将与能源相关的设计实践局限为对绿色能源技术的简单依赖，并常常停留在设计问题的肤浅层面和极为有限的尺度（建筑尺度的设计干预）。设计师对空间与形式的真正创新失去兴趣，而成为业余的技术使用者。能源与城市问题的根本层面鲜有人涉及。

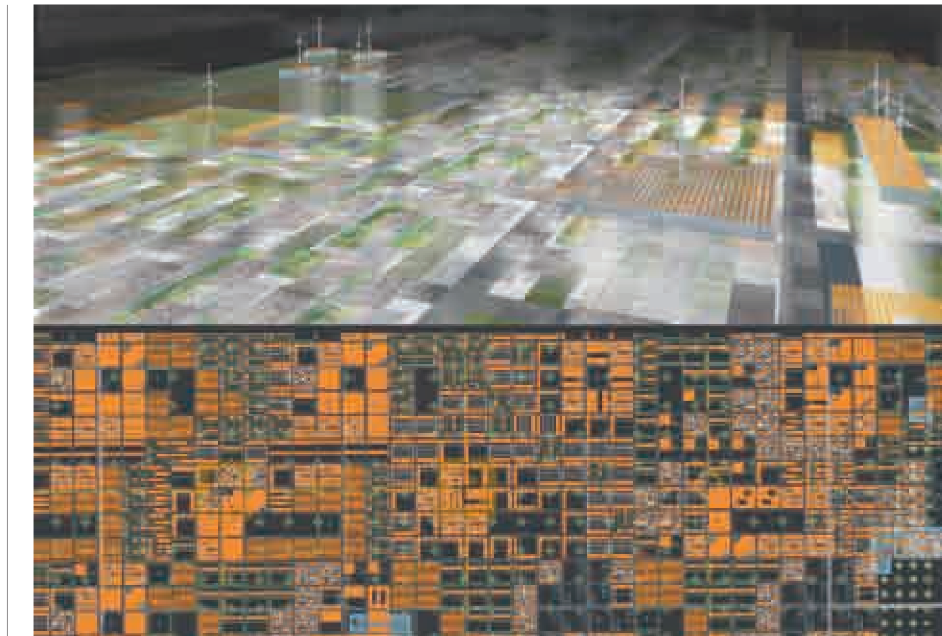
议题：超越技术层面的能源空间规划

我们需要探索一个涵盖多尺度和多学科的崭新空间范式以指导未来城市空间的发展。在亚洲城市化的文脉中尤为如此，我们对能源与城市的讨论应该更多地关注探索组织未来城市扩张的整合性策略，避免将自己束缚在对能源元素如何与已有城市结构结合的问题中。新的范式应该超越对技术进步的一味依赖而延展到政治、社会和文化等更为广泛的层面。这要求我们更全面而深刻地理解和干预城市及其所在更大范围的能源与生态系统。

我的研究始于对高度浓缩和高度移动性的化石能源在过去的两个世纪中如何影响现代城市的形成所进行的考察和分析，进而探索和讨论分散的空间布局以及会随之变动的后化石能源的运营尺度将如何催生新的空间条件及潜在的创新机会（图 4）。例如，与煤炭相比，森林也是能源燃料，但同时兼具空间性、植物性、休闲性、文化性和社会性等诸多衍生特征和价值（图5）。能源不仅应被理解为一个空间问题，同时也是一个生态问题。我们将面临一场重新定义人类聚居与所处的自然环境互动关系的革命。设计师将会涉及全新的设计参数、组织性逻辑，并面临全新的挑战。在空间问题的各个尺度（从建筑尺度到区域尺度），新的空间整合策略将在能源与生态基础设施的交叉区域产生。景观和公共开放空间将有机会成为经济收益的创造者。它们多用途的功能特征将会催生新的立体空间布置方式，强调纵向多层叠加，为景观设计开拓新的尺度。

研究方法：作为精确设计工具的信息视觉化

鉴于能源特有的动态性及非物质性，研究与工作方法需要多场景思考的思维方式，并能够将物质与非物质的影响因素纳入考虑。利用参数化的模型，我们可以将这些复杂、多元、多层次的信息整合起来形成一个综合性的系统。这样的模型允许我们包容多角度、多方面的设计原则及考虑，克服传统工程化思维方式对单一系统效率最大化的追逐，从而探索可以平衡多层次多因素的权宜之计。



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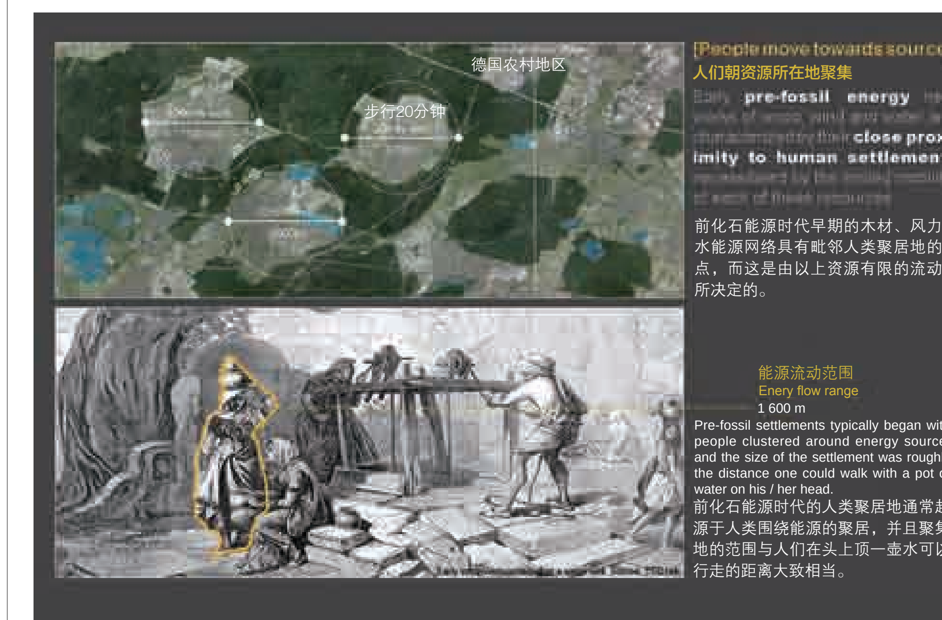

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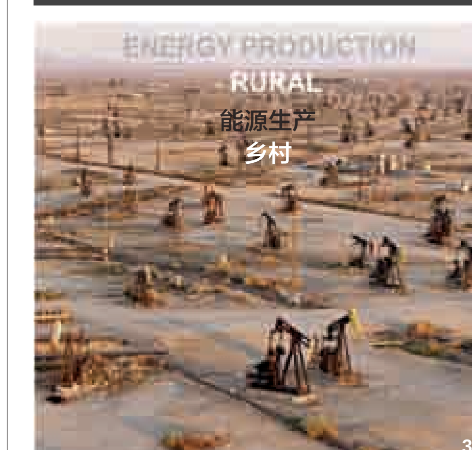


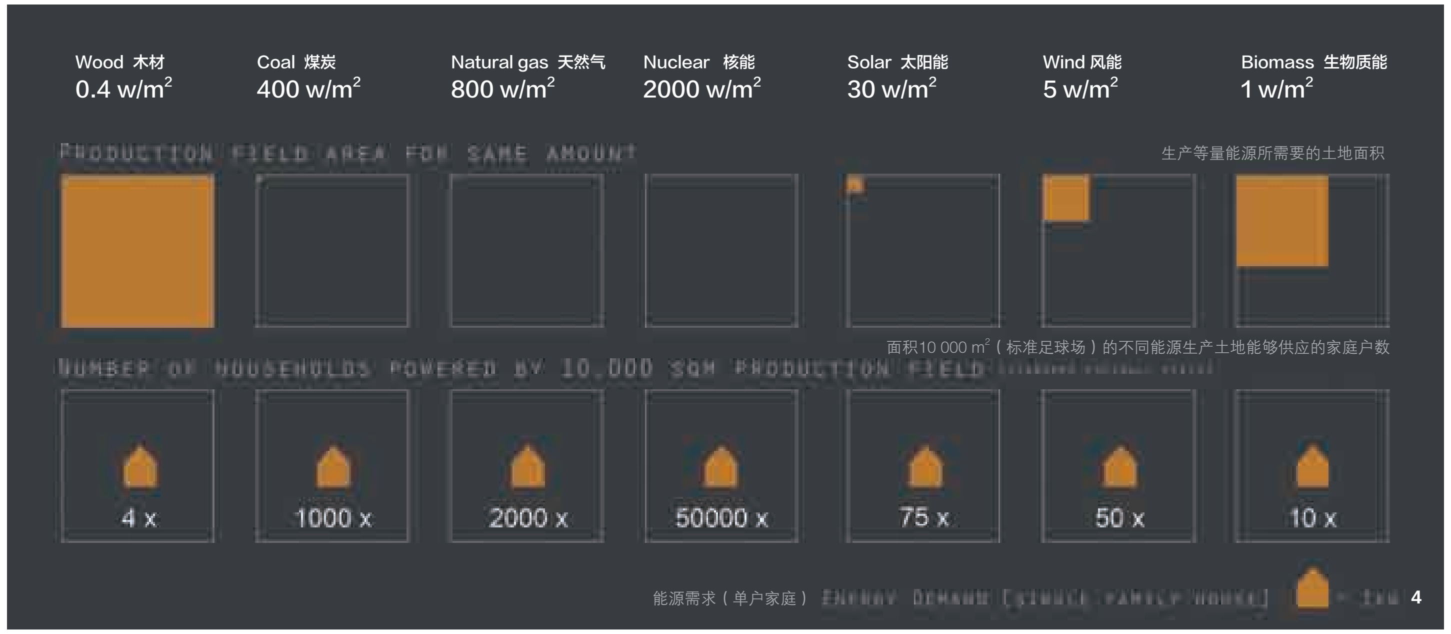
3-1

Oil extraction field
Huge, noisy, waste-generating
Remain invisible: far from consumers
石油开采这一规模庞大、伴有噪音和废物产生的能源生产活动处在偏远地区和能源消费者的视野之外

3-2

Manhattan
Connected / intense activities / quite devices
Extending the time of world through night lights
曼哈顿城中各个区域相互连接，活动密集，耗能设施遍布，通过夜间照明延长工作时间

1. 重叠城市 © Chen Chen
2. 前化石时代的居住模式。图片由陈忱编辑，图片来源: http://www.ted.com/talks/kent_larson_brilliant_designs_to_fit_more_people_in_every_city. com/talks/kent_larson_brilliant_designs_to_fit_more_people_in_every_city。
3-1. 郊区和城市：能源生产和消耗的典型空间特征——加利福尼亚油井。图片来源: www.ibabuzz.com。
3-2. 郊区和城市：能源生产和消耗的典型空间特征——曼哈顿夜景。图片来源: www.picstopin.com。
1. The Overlapped City © Chen Chen
2. Settlements pattern of pre-fossil era. Image edited by Chen Chen, Source: http://www.ted.com/talks/kent_larson_brilliant_designs_to_fit_more_people_in_every_city. com/talks/kent_larson_brilliant_designs_to_fit_more_people_in_every_city.
3-1. Rural and urban: distinguished spatial characteristics of energy production and consumption — California oil wells. Source: www.ibabuzz.com.
3-2. Rural and urban: distinguished spatial characteristics of energy production and consumption — Manhattan night view. Source: www.picstopin.com.



4

通过参数化设计工具而得到加强的最终的精度和缜密的量化表达，可以揭示最为微妙的设计条件差异和临界阈值。它因此将视觉表现从分析工具拓展成设计工具，以帮助挖掘隐藏的设计机会。一旦各设计参数被选定，其间的关系将被解读和转化为量化的算式，对设计原型的定义便允许设计师在空间与数据间“游走”。扁平的、无形的数据可以被物质化与空间化以反映其所各自对应的特殊空间特征；不同的发展目标被视觉化从而方便评估更好的辅助设计决策过程，形式与空间这些设计专业的核心问题从而重新成为人们关注的焦点（图6）。基于过程的设计方法将设计师从已有的传统的设计概念中解放出来，而获得探索全新的空间模型和组织模型的机会。与传统城市规划设计追求固定的蓝图不同，本研究的设计目标是通过对基于关系的系统框架的定义及对设计过程的精确控制而实现的。设计的结果因此具有潜在的动态性和对未来变化的可适应性。在不同的建设阶段、不同的预景和不同的尺度中，设计都可以得到预览、评估和优化——这是一个不断循环的过程，这种机制尤其适用于长期的发展规划——它是可变的，同时也是精确而具体的（图7）。

重叠城市：再定义后化石时代的能源景观

如图4所示，后化石能源时代的能源生产将会以可再生资源为主导。与化石能源相比，可再生能源的生产需要占据更大的面积才能产生等量的能量。但同时太阳能板、风车等更适合在城市环境中安装，对于不同的场地也具有更灵活的适应性。另外，可再生资源的生产可以利用不同规模的场地，而且其分散式的传输模式能够利用更高效、更灵活的微电网而有效节能。传统城市几乎都是能源的消费者。新能源时代，在城市内部解决部分供能问题成为可能，这既是挑战，也是机遇。在紧凑且高密度的开发模式下所进行的城市扩张，将会令这种挑战更加艰巨。

历史上，传统城市多由政治、宗教和地理因素所定义。在新能源时代，能源的生产与配置将会深刻地影响城市空间布局及其扩张蔓延模式。该课题研究从三个尺度上展开，旨在探索后化石时代的城市形态：重新定义城市边界与城市组群（宏观）、能源基础设施的规划框架（中观）和一套新的城市空间规划导则（微观）。我试图从设计前期就将能源规划的逻辑融入到传统城市规划的考虑中来。“重叠城市”的概念试图在上述的各个尺度中探寻

Wood 木材 0.4 w/m²

5-1

瑞士的森林和溪流 Working forest and stream, Switzerland

Coal 煤炭 400 w/m²

5-2

美国西弗吉尼亚州的煤矿 Coal mine, West Virginia

新的空间整合策略，以协调能源生产和其他城市空间元素（图8）。

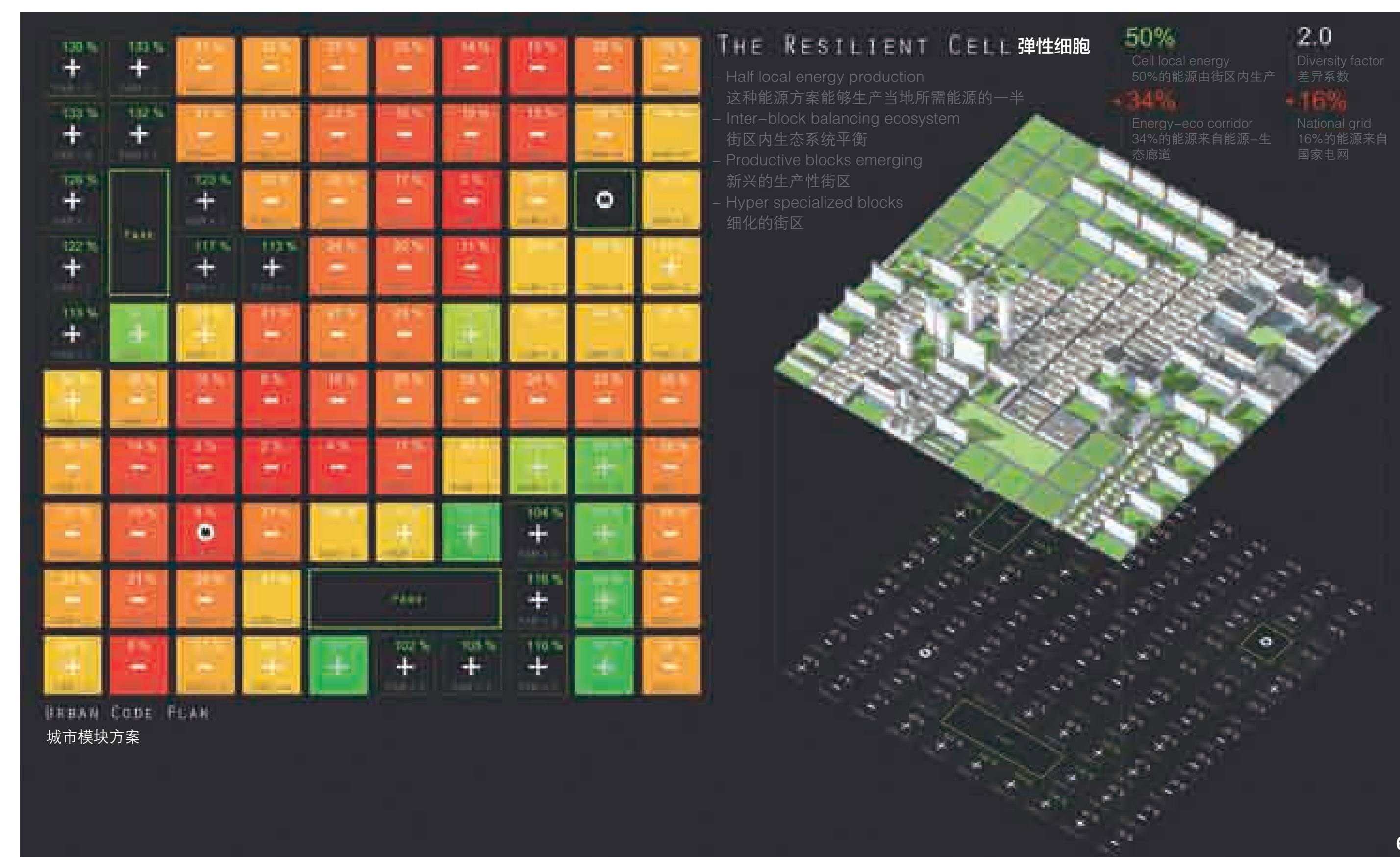
本项目以美国休斯敦西部的新区为实验基地——这是美国人口增长最快的地区，且当地的太阳能和风能资源丰沛。场地中的景观元素如小溪、水塘和森林等都被仔细地定位和保留下来。通过将一定距离内的生态元素相连，可以建立起一个线性的景观走廊网络。这个景观系统也将作为限制未来城市组团过度扩张的缓冲带。场地现有的景观元素为未来城市的绿化景观和开放空间提供了选址线索。城市中各地块的建筑密度由其距离公交枢纽和公共空间的距离而决定，距离越近则密度越高。

参数化的设计分析方法使得我能将城市建筑形态与不同能源的生产潜能联系起来（4种典型的建筑体量类型因其特殊的几何比例特征而在新能源采集中蕴含各自不同的内在特点）（图9）。我建立了这样一种激励机制：每块用地的开发者需要在本地进行清洁能源生产为自身提供一定比例的供能，由此在传统城市设计中诸如限高、容积率等参数与新能源的生产率之间建立一种复杂而动态的联系（图10）。建筑形态的设计体现了“重叠城市”的概念，即将功能性表面最大化，使同一紧凑地段兼顾城市活动和能源生产的多重功能。

为实现提供一定清洁能源比例的目标，开发商可以选择最大化能源生产，或减低街区能耗。同时为避免僵化的能源目标规划，以形成灵活互动的能源市场经济，系统允许街区间存在互补的差异化：城市中将产生不同属性的区块——一些相对耗能，一些相对产能（图11）。区块之间可进行能源交易，形成一个动态平衡状态的能源“生态系统”，共同实现城市总体能源目标。此外，城市还可结合绿化空间创造一些以产能为主的区块以弥补总体产能的不足（图12）。

这个系统将以分期及多中心的形式发展，回应诸如更多居民的迁入和技术的逐步完善等不断变化的设计条件，以逐渐对自身进行调整和优化。从较为保守的本地清洁能源覆盖率目标出发，这个城市将不断提高其在能源自给自足方面的独立性和弹性，逐渐减少对传统化石能源的依赖（图13）。这套基于能源逻辑的城市导则将可能催生出新的空间关系与体验，展开一种不同以往的城市化模式。系统假设了未来城市发展的不同场景，并对其相应的城市形态进行预览、分析和评估。LAF

4. 化石燃料和可再生能源的功率密度比较 © Chen Chen
5-1. 木材和煤炭：瑞士的森林与溪流。图片来源：http://livingingeneva.wordpress.com/2012/08/14/hiking-in-genevas-countryside/。
5-2. 木材和煤炭：美国西弗吉尼亚州的煤矿。图片来源：http://earthobservatory.nasa.gov/IOTD/view.php?id=8693。
6. 各种能源方案的空间影响分析 © Chen Chen
4. Power density comparison between fossil fuels and renewables © Chen Chen
5-1. Wood and Coal: working forest and stream, Switzerland. Source: http://livingingeneva.wordpress.com/2012/08/14/hiking-in-genevas-countryside/.
5-2. Wood and Coal: coal mine in West Virginia. Source: http://earthobservatory.nasa.gov/IOTD/view.php?id=8693.
6. Spatial implications of various energy scenarios © Chen Chen



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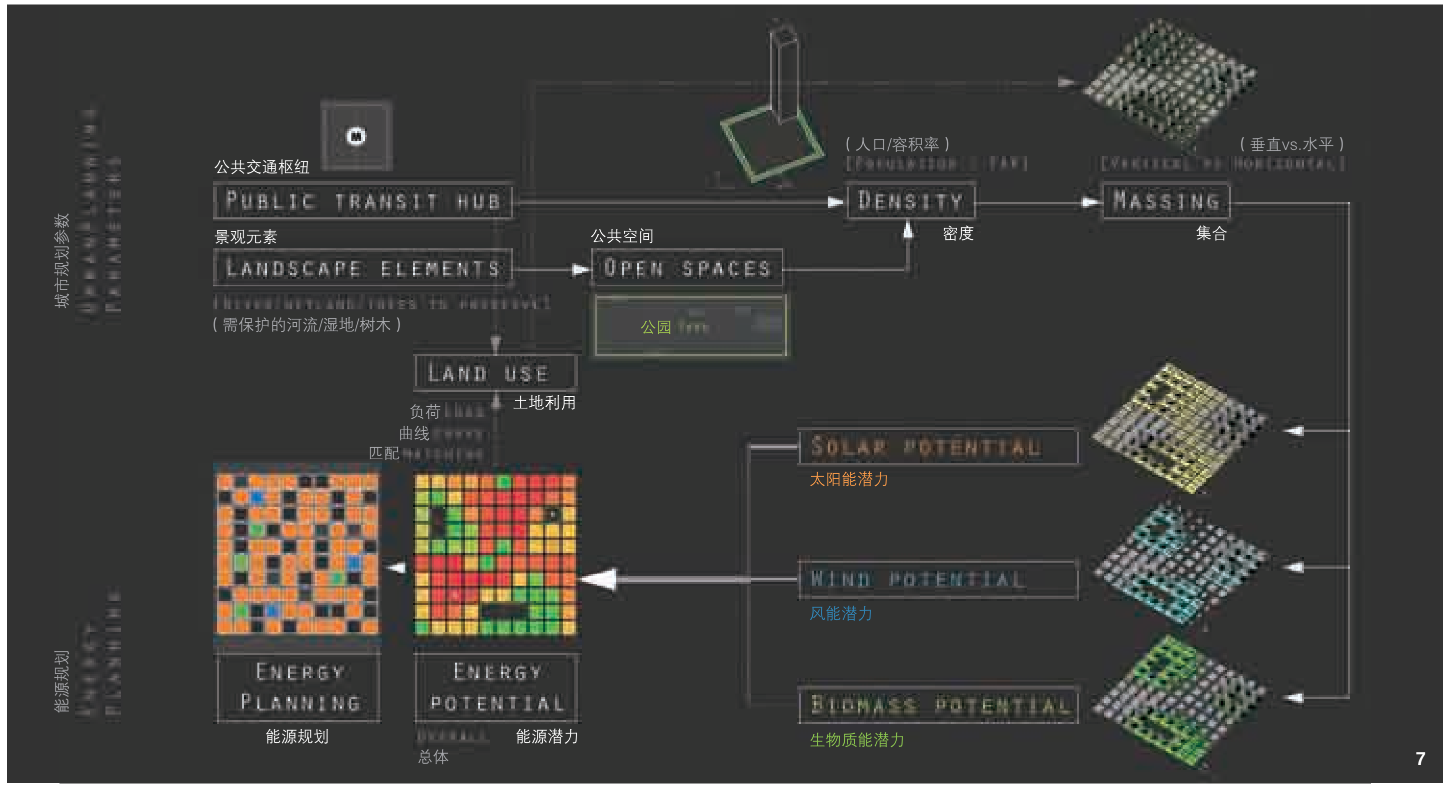


Background: Future Energy Scenarios and the Transformation of Inhabitation Landscapes

Nowadays we are experiencing the end of the fossil era and regenerative resources are gradually reducing our reliance on fossil fuels. Throughout the history of human civilization, changes in energy systems have always led to fundamental transformations in the landscapes of human occupation. (Fig. 2) Looking back on how fossil-fuels completely altered the organizational logic of 20th century settlements, drastically affecting their density, patterns and scale, we start foreseeing that the new energy scenario will significantly transform the development and formation of tomorrow's spatial structures. The logic of energy generation, distribution and consumption will dramatically influence how we understand and define urban boundaries, infrastructure and landscape at multiple scales. Given the low power-density and flexible scales of renewables, cities that so far have been solely energy consumers face both the challenge and the opportunity of accommodating energy production within their boundaries (Fig. 3). In light of these changes, the whole question of urbanization must be readdressed.

So far designers' attention on energy has been concentrated only on two limited areas of the problem: energy conservation and the incorporation of energy harnessing devices (solar PVs, wind turbines, etc.) into existing spatial structures and typologies. Both focuses have reduced energy-related design practices to the mere application of green technologies, which usually work on a superficial level and at limited scales (building scale intervention). Designers are losing their interest for formal innovation, becoming amateur technological users. The big picture still remains untapped.

Thesis: Towards a Spatial Paradigm that Goes beyond Technical Advances

I believe that a new spatial paradigm with multi-scalar and cross-disciplinary wisdom should be explored to provide a normative model for future developments. In the context of Asian urbanization in particular, the debate should be less about how energetic components can fit into existing cities and more about exploring integrated solutions to structure future urban growth. New models should go beyond purely technical advances to embrace broader political, social and cultural dimensions, which require a better understanding and manipulation of the energetic and ecological components of the larger urban context.

My research started from the observation and analysis of how fossil fuels that are highly concentrated and mobile have shaped urban development over the past 200 years, and then moved on to address the issue of how the disperse spatial pattern and thus changing operational scale of post-fossil energies would trigger new spatial conditions and innovations (Fig. 4). For example, beyond just a material (like coal), wood is at the meantime spatial, biotic, recreational, cultural, social etc. (Fig. 5). Thus energy is not only a spatial project but would increasingly become an ecological project, revolutionizing deeply how we should redefine the interaction between inhabitation and environment in the future. Designers would therefore engage exploration of new sets of design parameters, organizational logics, and facing new challenges. At all scales (from architectural to regional), new spatial synergies could arise between the energetic and ecological infrastructure, allowing landscape and public open spaces to become generators of revenue. Their multi-functionality will also trigger new three-dimensional arrangements that can exploit more the vertical axis, introducing a new perspective into landscape design.

Methodology: Projective Representation as an Accurate Design Device

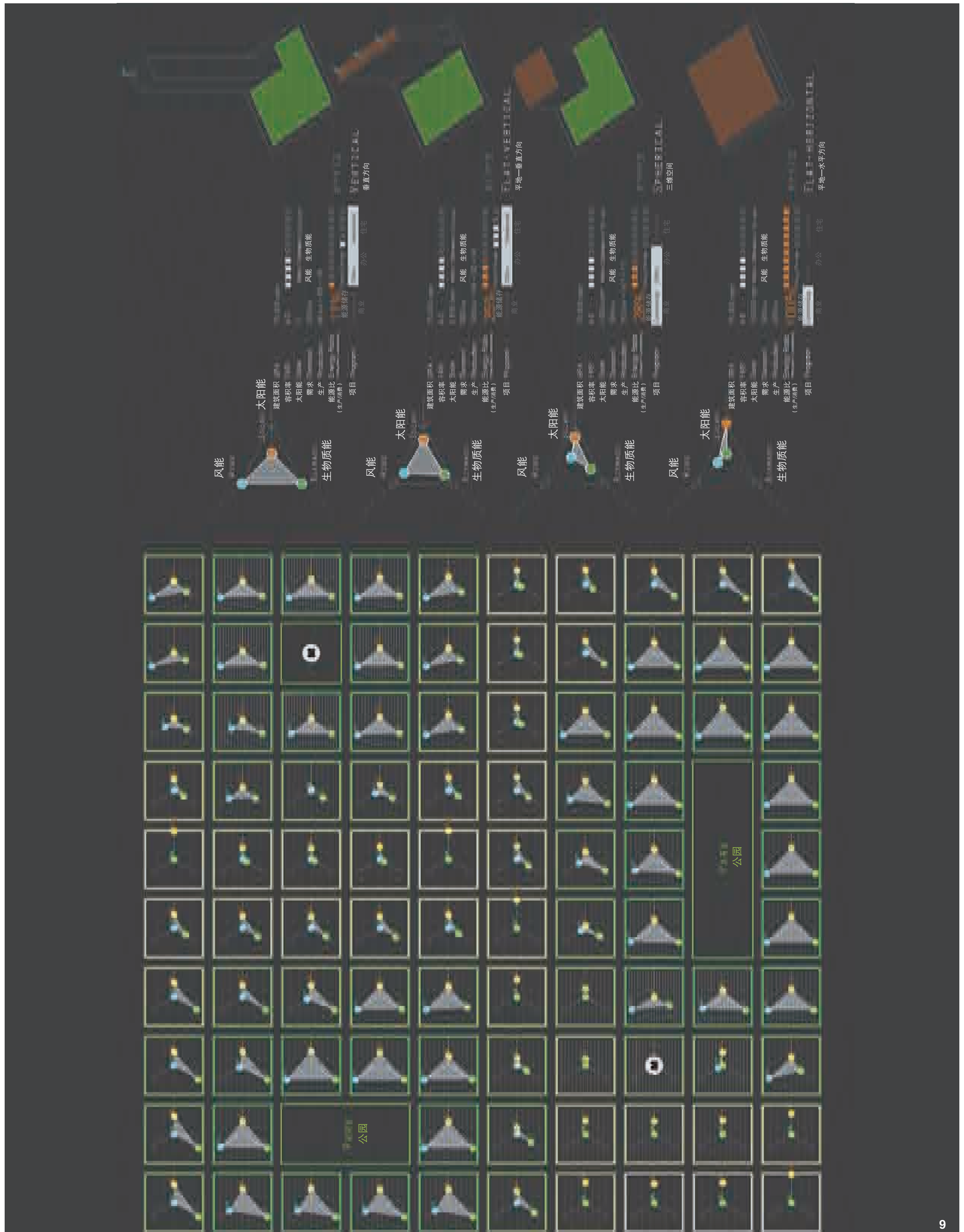
The dynamic, formless character of energy requires a working methodology that is based on scenario-thinking and is capable of engaging both physical and non-physical factors, interrelating layers of information into a complex system; such approach could benefit from the use of computational tools. Through its ability of negotiating among a range of different priorities, parametric design can also overcome the traditional engineering methodology associated with the efficiency of separated systems.

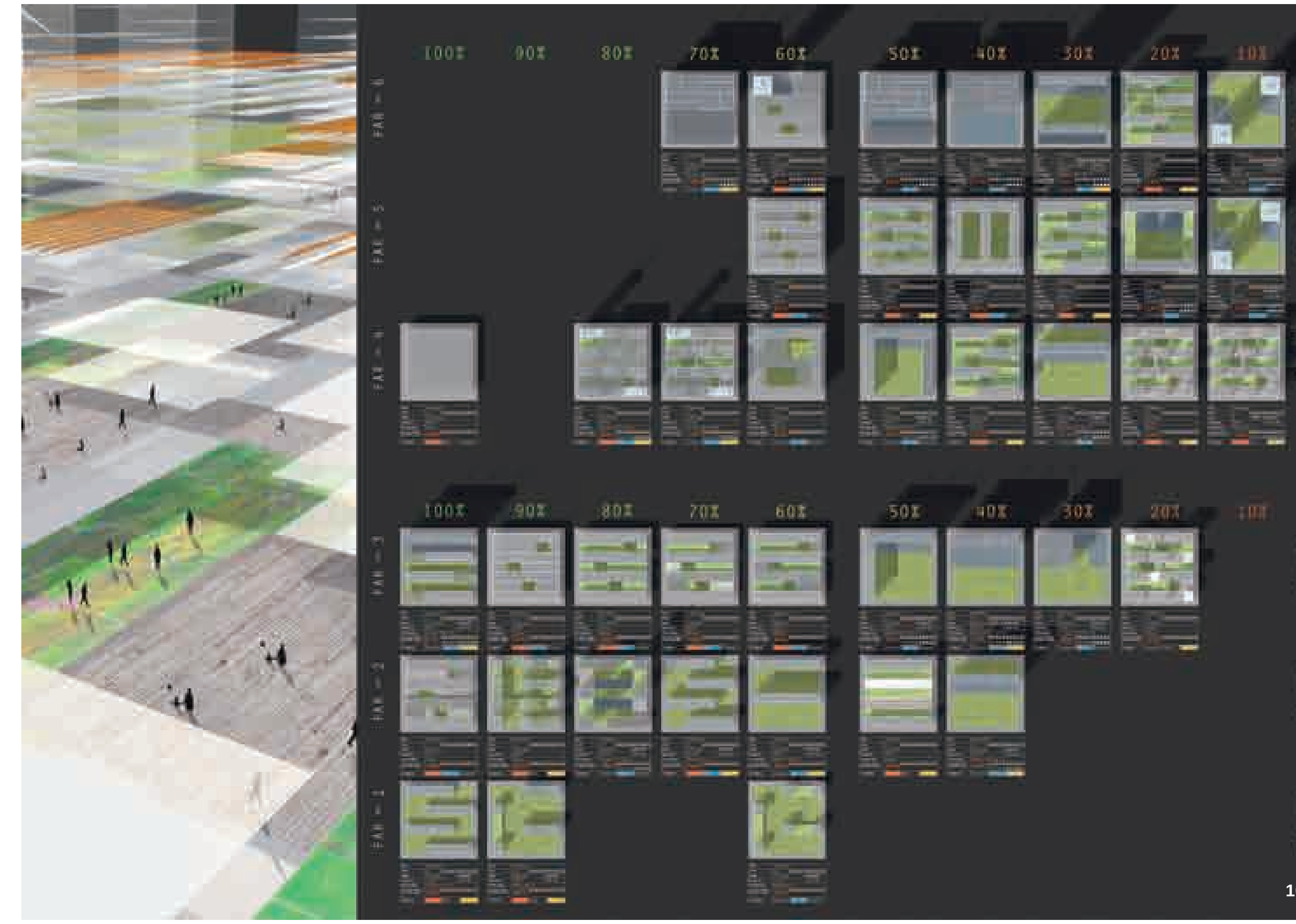
The ultimate precision and rigorous quantitative expression enhanced by computational tools can reveal even the most subtle differentiation and critical thresholds. The transformation of representation from an analytical to a projective instrument will help unfold hidden design opportunities. Once the design parameters are selected and their relationships translated into quantitative formulas, the definition of various prototypes will allow designers to move back and forth between data and space. Flat and formless datasheets could be materialized into their associated spatial conditions and specific goals visualized and evaluated, reintroducing the question of form and space that lies at the core of any design profession (Fig. 6). In a process-based approach, designers are freed up from preconceived ideas and could explore emerging spatial and organizational models. Rather than aiming for a fixed formal vision, design goals would then be achieved through the definition of a relational system and a strict control over the process; the output is adaptable and potentially dynamic. Various scenarios at multiple scales can be foreseen, evaluated and optimized in a continuous loop, providing the adaptability needed for long-term developments while preserving a reasonable degree of design specificity (Fig. 7).

The Overlapped City: Redefining Energy Landscapes in the Post-fossil Era

Energy production in the post-fossil era will be dominated by renewables, whose low power density requires dramatically larger to produce enough energy to meet

7. 设计过程 © Chen Chen
8. 重叠城市设计概念 © Chen Chen
7. Design process © Chen Chen
8. Concept of The Overlapped City © Chen Chen





our demand, as shown in Figure 4. On the other hand, renewable energy production can take place at a range of scales. They are more compatible with urban conditions and more flexible with spatial application than fossil fuel based energy production. Their distributed production pattern could take advantage of micro grid, a more efficient, resilient distribution. Current cities, which are solely energy consumers, are facing both the challenge and the opportunity of accommodating energy production within their footprints. This challenge will be further intensified with the ambition of managing urban growth in more compact models of development.

Historically, political, religious and geographic agents have defined our cities. In the new era, the logic of energy production and distribution will start having a significant impact on the spatial organization of the urban growth. This project explores the morphology of resilient post-fossil cities across three scales: redefining urban boundaries and urban clusters, energy infrastructure framework and a new set of urban codes. The concept of "The Overlapped City" tries to generate spatial synergies between energy and other urban parameters in the three scales (Fig. 8).

The testing site is in west Houston, the fastest growing urban area in the US, with a rich potential for renewable energy production. Landscape elements on site such as stream, ponds and forest are recognized and preserved. A potential ecological network could be established generating a linear system connecting all the adjacent ecologic elements. The ecological network serves as a buffer zone as a way to define urban growth. A series of maps recognize existing landscape elements on site to project the location of open spaces. Proximity to public transits and open spaces both leads to higher density.

Parametric tools help recognize the different energy potentials associated with various massing strategies (the four categories of envelopes determined by their geometric features have embedded patterns that define different productivity level in terms of energy) (Fig. 9). A series of dynamic relationships

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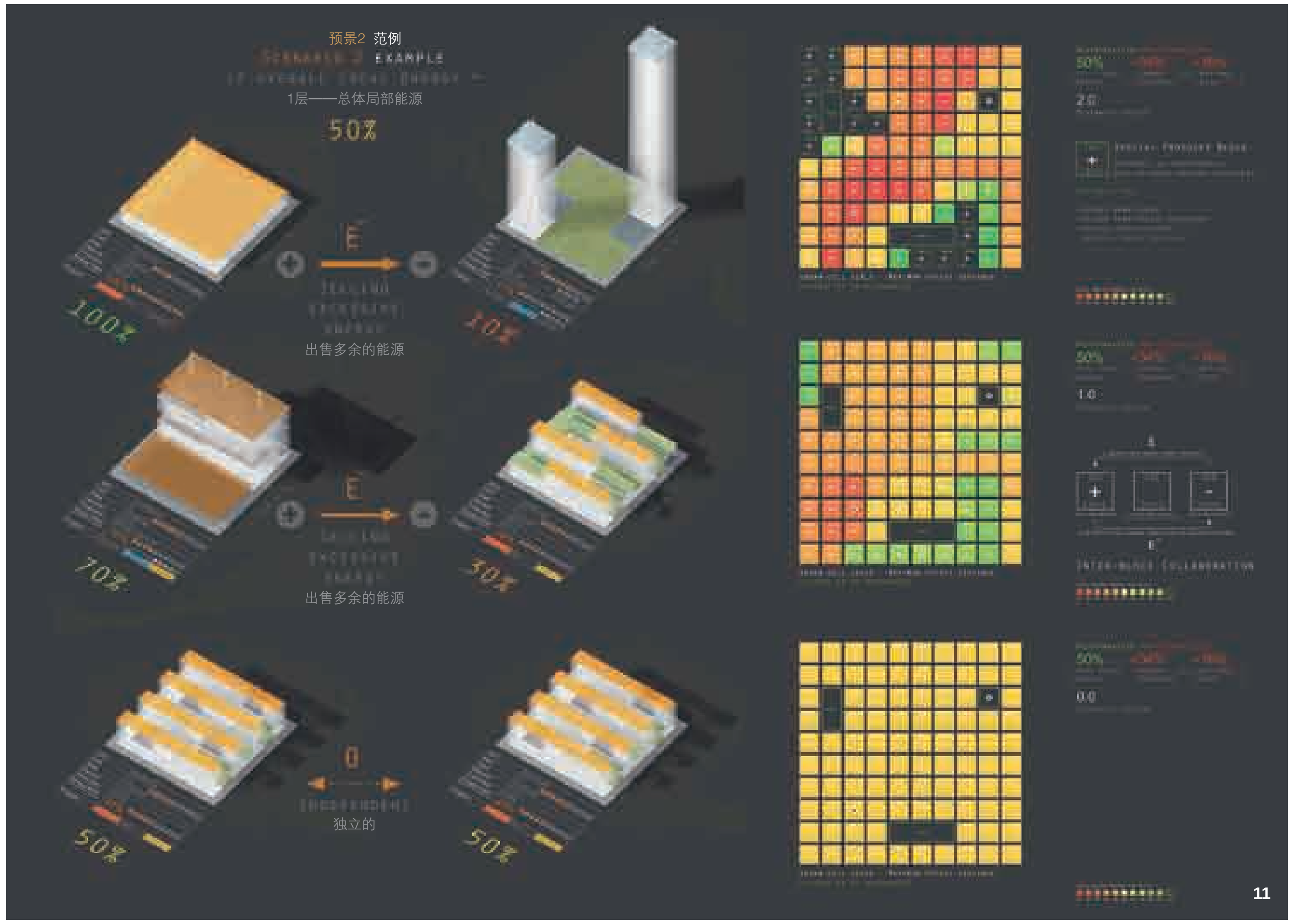
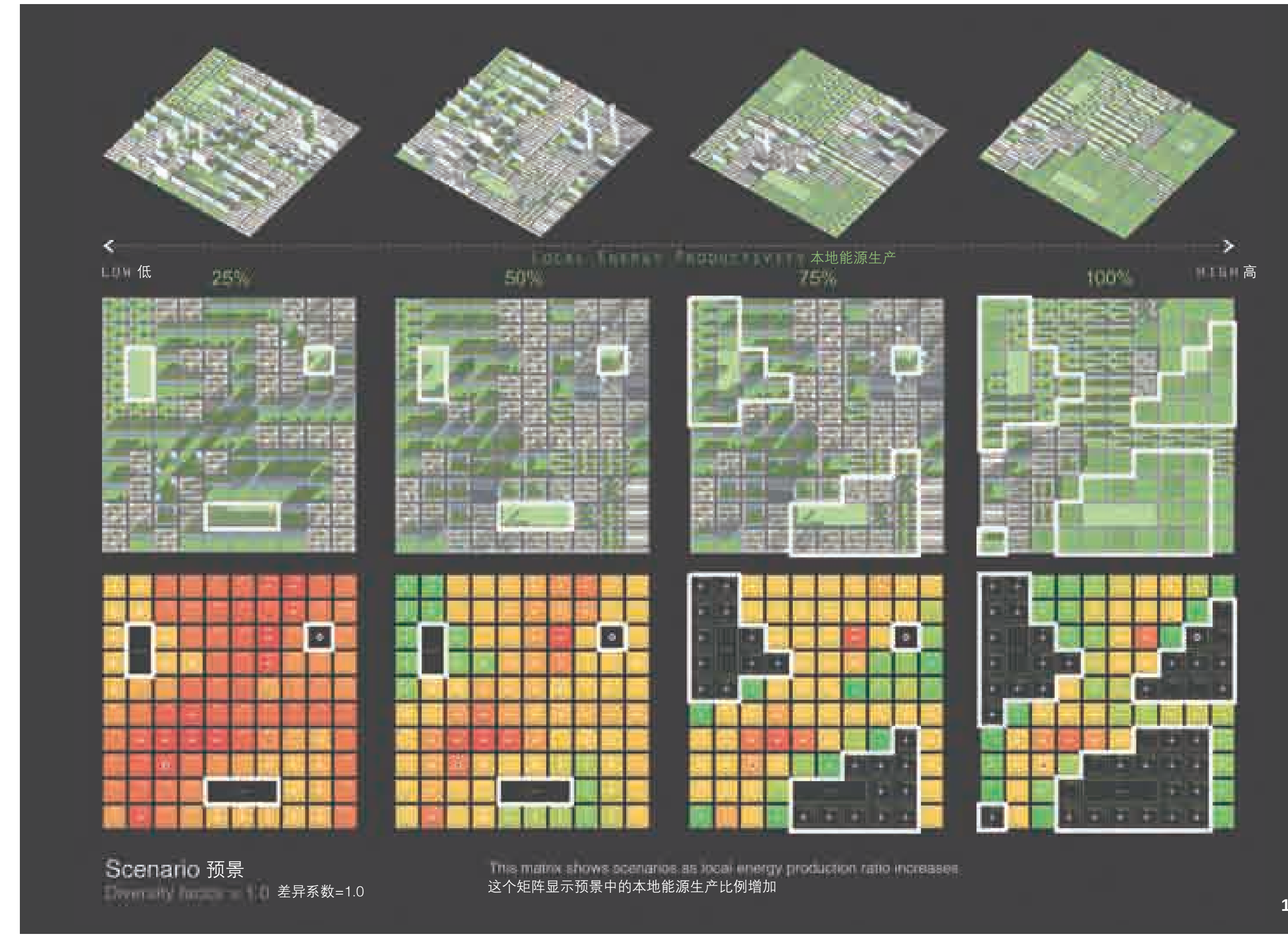
10. 城市类型学矩阵 © Chen Chen
9. Overall energy production potential © Chen Chen
10. Urban typology matrix © Chen Chen





links the traditional parameters of density and height with the energy productivity of each block, as a way to motivate developers to maximize their local energy production (Fig. 10). The design of urban typologies is articulated following the concept of "overlapped city" — maximizing active surfaces and overlapping multiple programs in compact urban areas.

A policy of inter-block energy balance incentivizes the citizens to maximize their local energy production and reduce their reliance on the centralized energy supply, making the new city work as a resilient ecosystem. In such context, different degrees of flexibility can be allowed in order to adapt to the market economy. New patterns of energy specialization arise, defining the blocks that are more prone to production and the ones that are more prone to consumption (Fig.11). Through a system of energy "trading" a cluster meets its overall energy production target through the compensation among the different blocks and the creation of additional energy sources within the green corridors, forming an energy ecosystem in equilibrium (Fig. 12).

The system will develop in phases and in a polycentric manner, in order to adjust and optimize the scheme as more settlements are accommodated and technologies of renewables improve. Starting from easier goals of local energy coverage, the city gradually achieves more and more energy independence and resilience, reducing its reliance on fossil fuels overtime (Fig. 13). As a result of the new urban code, some new interesting and highly diverse spatial conditions and relationships arise, disclosing the potential of this approach to create new paradigms of urbanization. A variety of radically different scenarios are therefore generated, tested and evaluated. LAF

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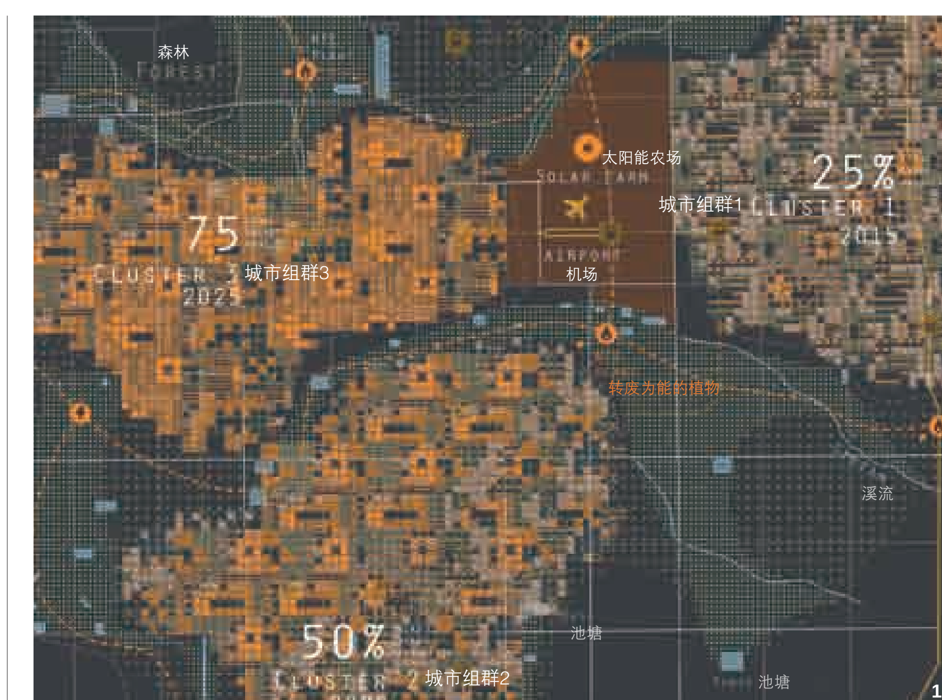

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