

工业化转型发展下城市工业景观的环境再生策略

——上海典型案例调研与比较

STRATEGIC ANALYSIS OF URBAN INDUSTRIAL LANDSCAPE REGENERATION UNDER POST-INDUSTRIALIZATION: A SURVEY AND COMPARISON STUDY OF SAMPLES IN SHANGHAI

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摘要

中国正处于由工业化向后工业化阶段转换的时期，而上海已率先进入后工业化阶段，历史遗留的大量工业景观面临遗产保护、转型升级和环境治理等发展需求。鉴于上海工业发展历史悠久、园区数量巨大且类型多样，本文通过梳理近代工业发展历史，将工业景观再生归纳为遗产类、转型类和优化类三种类型；通过解析相关规范标准设定的建设要求，就基建控制、服务配套与产业升级这三大重点对上海的典型工业景观分类样区进行调研，并讨论各自的环境再生策略。研究表明，遗产类样区需重点应对遗产利用和生态恢复问题；转型类样区需同时关注服务设施的完善、公共空间的塑造，以及循环产业链的构建；优化类样区亟需通过节能减排、立体绿化来提升绿地的生态效益，改善环境品质。不同的工业景观应针对相应的再生类型和具体问题，选取适用的再生策略，以优化环境品质，达成环境、社会和经济相协同的可持续发展。

关键词

工业景观；后工业化；再生策略；城市更新

ABSTRACT

With the nationwide trend of shifting from industrialization to post-industrialization, Shanghai is one of the first cities stepping into the post-industrialization stage. The large amount of industrial landscapes left over from this transition requires heritage preservation, industrial transformation, and environmental conservation. This paper reviewed the long-term modern industry development of Shanghai and divided its various industrial landscapes into three categories of regeneration: heritage revitalization, site transformation, and environmental optimization. After summarizing the existing constructive guidelines and standards, five sample areas of typical industrial landscapes in Shanghai were surveyed in terms of construction control, supporting service improvement, and industrial structure upgrading, with regeneration strategies suggested for each of them. The results show that the sample area for heritage revitalization needs to prioritize heritage reuse and ecological restoration; sample areas for site transformation should reinforce the improvement of service facilities and public spaces together with establishing the recycling industry chain; and sample areas for environmental optimization have to enhance the ecological performance of green spaces by introducing vertical greening along with energy saving and emission reduction for an environmental quality improvement. In conclusion, strategies for each type of regeneration should vary on a case-by-case basis so as to improve its environment and achieve sustainable development with a synergy in environment, society, and economy.

KEYWORDS

Industrial Landscape; Post-industrialization; Regeneration Strategy; Urban Renewal

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- ①

8个近郊工业区即漕河泾微电子工业区、北新泾精细化工区、彭浦重型机械工业企业、五角场机电工业区、高桥石油化工区、庆宁寺造船工业区、周家渡钢铁工业区、长桥煤炭化工区。
- ②

7个卫星城即宝山、吴泾、闵行、金山、松江、安亭和嘉定卫星城。
- ①

The eight suburban industrial parks were Caohejing Microelectronics Industrial Park, Beixinjing Fine Chemical Industrial Park, Pengpu Heavy Machinery Industrial Park, Wujiaochang Electromechanical Industrial Park, Gaoqiao Petrochemical Industrial Park, Qingningsi Shipbuilding Industrial Park, Zhoujiadu Steel Industrial Park, and Changqiao Coal Chemical Industrial Park.
- ②

The seven satellite towns were Baoshan, Wujing, Minhang, Jinshan, Songjiang, Anting, and Jiading towns.

1 引言

随着经济的发展，中国正处于由工业化向后工业化阶段转换的时期，服务业比重持续上升，制造业比重持续下降，产业结构面临深刻转型^[1]。这一变化正同步引发城市工业景观的闲置和污染修复等问题，以及转型升级的需求。随着生产技术的进步和可持续发展理念的不断深入，循环产业链、产城融合、工业遗产地保护与利用等手段逐渐兴起^{[2]-[4]}。城市工业景观的设计应借助各种环境再生策略——即可使环境适应新的发展需求以达到动态平衡机能的策略^[5]——针对性地解决与具体环境相关的历史遗留问题，适应不断提升的建设规范与标准，优化环境品质。

上海是中国最早开埠发展现代工业的城市之一，目前已进入以现代服务业为主、以高端制造业为辅的后工业时代，既有工业区数量巨大、类型全面。在后续规划建设用地零增长的背景下，这些工业区普遍需要进行转换、升级，但因各自的历史与未来发展方向不同，其具体的再生策略也各不相同。本文首先梳理了上海的工业发展历史与当地工业景观的再生类型；而后回顾了相关的建设规范、标准，结合当前的建设要求，选取分属不同再生类别的典型样区进行调研；最后针对各样区的建设问题，讨论适用的景观环境再生策略，以期为面临后工业化转型的城市提供工业景观再生发展的借鉴。

2 研究背景

2.1 上海工业发展历史与工业景观再生类型

上海是中国近代史上最早开放的5个通商口岸之一，自1843年起，华商与外商开始沿码头自由建厂发展轻工业，形成沪东、沪西、沪南三大工业聚集区；新中国成立后，为恢复经济、引导并发展重工业，工业用地呈圈层式向城郊扩张，8个近郊工业区^①和7个卫星城^②为重点建设对象；1990年后，浦东新区开发计划启动，同时中心城区外围工

1 Introduction

With the growth of economy, China is entering its era of post-industrialization with a significant reform of industrial structure, seeing a boom of the service industry and a decline of the manufacturing^[1]. Urban industrial landscapes are in an urgent and increasing need of transformation and regeneration of idle or polluted sites. Meanwhile, concepts such as recycling industry chain, city-industry integration, and protection and reuse of industrial heritage emerge with technological advance and sustainable development^{[2]-[4]}. The design of urban industrial landscapes should employ appropriate environmental regeneration strategies, which could help the environmental improvement adapt to new development needs to achieve a balanced functional upgrading^[5], to address longstanding problems, to meet the updated constructive standards, and to improve the environmental qualities.

The post-industry of Shanghai, a metropolitan benefiting from almost the earliest development of modern industry in China, is pillared by modern service sector, seconded by high-end manufacturing. The existing multi-typed, large-amount industrial parks, however, are necessary to be transformed or updated under Shanghai’s inventory land planning control. With different historical backgrounds and future visions, such sites require diverse regeneration strategies suitable to specific conditions. This paper, thus, expects to provide regenerative references for cities confronting post-industrial transformation problems by reviewing the industrial development of Shanghai and identifying its varied regeneration types of industrial landscapes; investigating typical sample areas of each type after analyzing relevant construction standards and examining current construction requirements; and finally exploring appropriate regeneration strategies for each type of regeneration.

2 Research Background

2.1 Shanghai’s Industrial Development History and Regeneration Types of Industrial Landscapes

Shanghai was one of the five earliest trading ports in China’s modern history. Since 1843, both local and foreign businessmen were allowed to build factories of light industry along the docks, forming three core industrial clusters locating in eastern, western, and southern Shanghai. After 1949, more and more suburbs were included into industrial land, and eight major suburban industrial parks^① and seven satellite towns^② were created to revitalize the economy and develop heavy industry. In the 1990s, together with the establishment of Pudong New Area,

业区增加较多，形成“1+3+9”^③的集约化产业布局；随着城市土地资源日渐紧缺，自2006年“十一五”规划开始，工业向园区集中，重点发展新兴产业，全面推进产业转型升级。目前，上海共整合形成104个产业园区，在后工业化的背景下，形成了由战略性新兴产业引领、先进制造业支撑和生产性服务业协同的新型工业体系。^{[6]-[9]}

如若以历史的时空视角审视现在或曾经开展生产活动的城市工业景观，在上海从工业化向后工业化转型的过程中，部分工业景观围绕生产功能展开，形成园区景观；另有部分转换功能，成为公园、博物馆等遗产景观；还有部分既包含工业遗产，又具有生产功能，可视为混合型景观，如上海M50创意园等。

这些不同类型的工业景观体现出了三种再生发展方向：1）遗产类再生，即由工业生产景观向观赏游憩和展示类景观转变。这类工业景观主要包括沿黄浦江、苏州河岸分布的早期工业废弃地，它们转换功能，成为公园、博物馆等遗产景观；2）转型类再生，即工业景观为顺应时代发展而进行产业升级和改造更新，多是位于因城市扩张而成为新的城市中心的近郊工业区，依据转型进程还可细分为转型中和转型完成两类；3）优化类再生，主要涉及远郊及浦东的新兴工业区，他们在建设之初已受到循环经济、生态工业园和绿色工业发展理念的影响，但因高品质工业园区建设要求的不断提升，需要纳入新的再生策略，进一步优化环境品质。

在各类城市工业景观中，每个景观一般都自成管理单元；而工业景观的再生分类则面向环境再生策略。在同一景观类型的管理单元中可同时并存多种再生分类，例如，一些旧工业区的再生发展既包含对工业遗产景观的保护，也涉及基于工业区更新的新产业的植入。

2.2 城市工业区建设要求

自1949年以来，中国针对城市工业区的建设出台了一系列规范和标准。首先是对工业区建设进行底线控制的标准，如国家级的《工业项目建设用地控制指标》^{[10][11]}和市级的《上海产业用地指南》^{[12]-[15]}，

industrial zones peripheral to the central city increased, forming the “1+3+9” intensive layout of industrial development^③. In the 11th Five-Year Plan started from 2006, due to the shortage of land resource, scattered industrial plants began to relocate into industrial parks, with an increase of industrial upgrading and a boost in emerging sectors. Up to now, Shanghai has integrated a total of 104 industrial parks and restructured its post-industry that now is led by strategic emerging sectors, supported by advanced manufacturing and production-oriented service sectors.^{[6]-[9]}

Over the centuries from the industrialization to post-industrialization, Shanghai’s industrial landscapes now include the ones subsidiary to industrial parks, the ones preserved as the cultural legacies, such as urban heritage parks and industrial museums, and the ones possessing both production and heritage opportunities (e.g. Shanghai M50 Creative Park).

These industrial landscapes can be categorized into three types for further regeneration: 1) Heritage revitalization, i.e. the regeneration of industrial production sites into urban landscapes for public recreation and exhibition, which are mainly distributed along the banks of Huangpu River and Suzhou River. 2) Site transformation, i.e. the regeneration by ongoing or completed industrial upgrading and transformation to meet current development demands; such sites mainly locate in suburban industrial zones that have become new city centers due to urban expansion. And 3) Environmental optimization, mainly including the regeneration of the recent industrial parks located in the outer suburbs and Pudong New Area to further improve their environment qualities; such sites require innovative regeneration strategies to satisfy the continuously improving construction requirements for quality industrial parks, though having been established under the emerging guidance of recycling economy, eco-innovation, and green growth from the beginning.

In general, urban industrial landscapes are classified by administrative requirements and managed individually, while their types for further regeneration are defined by different strategies. Thus, the industrial landscapes of one single administrative unit may adopt different regenerative strategies. For example, some historical industrial zones renew their sites by both protecting industrial heritages and introducing emerging industries.

2.2 Construction Requirements for Urban Industrial Zones

Since 1949, China has issued a series of regulations and standards to guide urban industrial zone construction. The early ones were the baseline standards, such as the national-level

③ “1+3+9”布局：“1”即浦东新区；“3”即闵行经济技术开发区、漕河泾新技术开发区和上海化学工业区；“9”即康桥工业区、莘庄工业区、金山工业区、松江工业区、青浦工业园区、嘉定工业区、崇明工业园区、宝山城市工业园区和上海市工业综合开发区。

③ The “1+3+9” intensive layout of industrial development consists of 1 newly-planned district (Pudong New Area), 3 new development zones (Minhang Economic and Technological Development Zone, Caohejing Hi-Tech Park, and Shanghai Chemical Industrial Park), and 9 municipal development zones (Pudong Kangqiao Industrial Zone, Xinzhuang Industrial Park, Jinshan Industrial Zone, Songjiang Industrial Zone, Qingpu Industrial Park, Jiading Industrial Zone, Chongming Industrial Zone, Baoshan City Industrial Park, and Shanghai Industrial Comprehensive Development Zone).

表1: 城市工业区建设底线指标 Table 1: Baseline indicators for urban industrial zone construction							
文件名称（颁布年份） Documents (issued year)		《工业项目建设用地控制指标（试行）》 （2004） Construction Land Regulatory Indicators for Industrial Projects (Trial) (2004)	《工业项目建设用地控制指标》 （2008） Construction Land Regulatory Indicators for Industrial Projects (2008)	《上海产业用地指南》 （2004） Shanghai Industrial Land Use Guide (2004)	《上海产业用地指南》 （2008） Shanghai Industrial Land Use Guide (2008)	《上海产业用地指南》 （2012） Shanghai Industrial Land Use Guide (2012)	《上海产业用地指南》 （2019） Shanghai Industrial Land Use Guide (2019)
等级 Level		国家级 National	国家级 National	市级 Municipal	市级 Municipal	市级 Municipal	市级 Municipal
具体指标 Indicators	基建指标 Construction indicators	容积率 FAR	容积率 FAR	建筑容积率 FAR	容积率 FAR	容积率 FAR	容积率 FAR
		建筑系数 Building coverage ratio	建筑系数 Building coverage ratio	—	建筑系数 Building coverage ratio	建筑系数 Building coverage ratio	建筑系数 Building coverage ratio
		—	绿地率 Green space ratio	—	绿地率 Green space ratio	绿地率 Green space ratio	绿地率 Green space ratio
	服务配套指标 Supporting service indicators	行政办公及生活服务设施用地面积所占比重 Land ratio for administrative and service facilities	行政办公及生活服务设施用地面积所占比重 Land ratio for administrative and service facilities	—	行政办公及生活服务设施用地所占比重 Land ratio for administrative and service facilities	行政办公及生活服务设施用地所占比重 Land ratio for administrative and service facilities	行政办公及生活服务设施用地所占比重 Land ratio for administrative and service facilities
	投资回报指标 ROI indicators	—	固定资产投资强度 Investment intensity of fixed assets	投资强度 Investment intensity	固定资产投资强度 Investment intensity of fixed assets	固定资产投资强度 Investment intensity of fixed assets	固定资产投资强度 Investment intensity of fixed assets
		—	—	土地产出率 GDP per unit area	土地产出率 GDP per unit area	土地产出率 GDP per unit area	土地产出率 GDP per unit area
		—	—	—	—	土地税收产出率 Tax yield per unit area	土地税收产出率 Tax yield per unit area

注
表中各类文件请参见参考文献[10]~[15]。

NOTE
All the listed documents are sourced from Ref. [10] ~ [15].

这类标准的控制指标可分为基建指标、服务配套指标和投资回报指标（表1），其中基建的基本指标为建设强度（以建筑系数与容积率为代表），服务配套的基本指标为服务设施用地面积占比，之后逐步增加了控制环境品质的绿地率和土地产出率，完善了基建和投资回报方面的要求。其次是引导工业区建设向高品质环境方向发展的规范标准，主要包括颁布于2015年的国家级的《国家生态工业示范园区标准（HJ 274-2015）》^[16]及颁布于2017年的市级的《上海市工业园区循环化改造实施方案编制指南（试行）》^[17]，关注于园区内产业结构和企业生产方

Construction Land Use Regulatory Indicators for Industrial Projects^{[10][11]} and the municipal-level Shanghai Industrial Land Use Guide^{[12]~[15]}, covering construction, supporting service, and ROI (return on investment) indicators (Table 1)—Among them, the indicators on construction mainly indicate development intensity, which are represented by the building coverage rate and FAR (floor area ratio), and the ones on supporting service are by the area ratio of facility and amenity; construction and ROI indicators were later completed with standards on green space ratio and GDP per unit area. More recently, environmental-protection standards were stipulated to guide the upgrading of industrial structure and production mode, including the Standard of National Demonstration Eco-Industrial Parks (HJ 274-2015) in 2015^[16] and the municipal-level Implementation Planning Guide for the Recycling Reform of Industrial Parks in Shanghai (Trial) in 2017^[17]. While ensuring the productivity of resources, these standards use a series of indicators not only to regulate resource consumption and waste

表2：工业区高品质环境的主要建设要求 Table 2: Main construction standards for high-quality industrial parks						
文件名称 Documents	总体要求 General requirements	指标分类 Category indicators				
国家生态工业示范园区标准（HJ 274-2015） Standard of National Demonstration Eco-Industrial Parks (HJ 274-2015)	循环经济、生态工业、清洁生产 Recycling economy, eco-industry, clean production	经济发展 Economic growth	产业共生 Industrial symbiosis	资源节约 Resource conservation	环境保护 Environmental protection	信息公开 Information transparency
上海市工业园区循环化改造实施方案编制指南（试行） Implementation Planning Guide for the Recycling Reform of Industrial Parks in Shanghai [Trial]	经济持续发展、资源高效利用、环境优美清洁、生态良性循环、统筹规划园区创建 Economic sustainable development, efficient utilization of resources, beautiful and clean environment, ecological recycle, systematical industrial park planning	—	—	资源产出、资源消耗 Resource productivity and consumption	废弃物排放 Waste discharge	运行管理、特色 Operation management and features

注
表中文件请参见参考文献[16][17]。

NOTE
The listed documents are sourced from Ref. [16] and [17].

式的转型升级，在保障资源产出的同时，通过多个指标控制园区内的资源消耗及废弃物排放，促进企业生产资料的减少与资源的循环利用（表2）。

综合而言，对以生产功能为核心的转型类和优化类再生实践来说，基建控制、服务配套与产业升级是目前政策层面所重点关注的。就遗产类再生而言，这类工业景观的改造涉及用地性质的改变，相应的基建控制和服务配套的具体要求会发生较大的改变。例如，历史风貌建筑会加以保留但转变使用功能，并应公共性使用而增加更多的服务内容和面积；同时绿地率指标会应新的用地要求有所提高^{[18]–[20]}（表3）。

3 上海工业景观再生现状分类调研

3.1 工业景观再生分类典型案例及样区选择

研究团队针对遗产类、转型类和优化类这三种再生类型的工业景观，选择了5处较为典型的案例，即杨浦滨江工业带、漕河泾新技术开发区、市北高新技术服务业园区、上海外高桥保税区和上海国际汽车城零部件配套工业园区，针对其中遗产类再生方向中既往工业用地

discharge in the parks, but also to promote the concepts of “reduce, reuse, and recycle” (Table 2).

Generally, regulating the construction, improving supporting service, and upgrading industrial structure are the major policy concerns for the transformation- and optimization-oriented regeneration that centers on ensuring the productivity of land use. As for the heritage-revitalization regeneration, the requirements concerning the construction regulation and supporting service may alter significantly due to land use changes. For instance, more public spaces may be supplemented to the preserved historical buildings to provide new services; the green space ratio standard will be improved according to the new land use requirements^{[18]–[20]} (Table 3).

3 Survey of the Regeneration of Industrial Landscapes in Shanghai

3.1 Typical Cases and Sample Area Selection of Industrial Landscape Regeneration

This study selected 5 typical cases of the 3 types for further regeneration of industrial landscapes in Shanghai—Yangpu Riverside Industrial Belt, Caohejing Emerging Technology Development Zone, Shibei High-Tec Park, Shanghai Waigaoqiao Free Trade Zone, and Automotive Components Supporting Park of Shanghai International Automobile City—which vary from 3 to 10 square kilometers in area. Then the study identified 5 sample zones (2 square kilometers on average)—for the heritage revitalization type, this study focused on the areas with a great number of industrial features; for the transformation- and optimization-oriented cases, this study selected the areas dominated by the

表3：转型后的工业用地与部分其他用地的附属绿地占比对比
Table 3: Comparison on subsidiary green space ratio among different land uses

文件名称（颁布年份） Documents (issued year)	城市绿化规划建设指标的规定（1994） Regulations of the Planning and Construction Indicators for Urban Greening (1994)		上海市绿化条例（2017修正版） Regulations of Greening in Shanghai (2017 Revision)		城市绿地规划标准（征求意见稿）（2018） Urban Green Space Planning Standard (Exposure Draft) (2018)	
等级 Level	国家级 National		市级 Municipal		国家级 National	
规划要求 Planning standards	绿地类别 Green space category	附属绿地占比 Subsidiary green space ratio	绿地类别 Green space category	附属绿地占比 Subsidiary green space ratio	绿地类别 Green space category	附属绿地占比 Subsidiary green space ratio
	工业企业单位附属绿地 Subsidiary green space to industrial enterprises	≥ 20%（产生有害气体及污染的工厂≥ 30%） ≥ 20% (≥ 30% for the factories that produce noxious gas or pollution)	新建工业园区及工业园区外新建工业项目的附属绿地 Subsidiary green space to newly-built industrial parks and to scattered newly-built industrial projects outside the parks	≥ 20%（新建产生有毒有害气体 的项目≥ 30%） ≥ 20% (≥ 30% for newly-built projects that produce noxious gas)	工业用地绿地率 Green space ratio for industrial land	≥ 20%（产生有害气体及污染的 工厂≥ 30%） ≥ 20% (≥ 30% for factories that produce noxious gas and pollution)
	仓储单位附属绿地 Subsidiary green space to storage land	≥ 20%	仓储项目的附属绿地 Subsidiary green space to storage projects	≥ 20%	物流仓储用地的规划绿地率 Planned green space ratio for logistics and storage land	≥ 20%
	学校、医院、疗养院所、机关团体、公共文化设施、部队等单位附属绿地 Subsidiary green space to schools, hospitals, nursing homes, government organizations, public cultural facilities, military units, etc.	≥ 35%	新建学校、医院、疗休养院所、公共文化设施的单位附属绿地 Subsidiary green space to new schools, hospitals, nursing homes, and public cultural facilities	≥ 35%	公共管理与公共服务设施用地的规划绿地率 Planned green space ratio for public management and public facility land	≥ 35%
					公用设施用地的规划绿地率 Planned green space ratio for public facility land	
	商业单位附属绿地 Subsidiary green space to commercial places	≥ 20%	—	—	商业服务业设施用地的规划绿地率 Planned green space ratio for commercial and service facility land	≥ 20%（宜大于35%） ≥ 20% (better > 35%)
	新建居住区绿地 Green space in new residential areas	≥ 30%	新建居住区内绿地 Green space in newly-built residential areas	≥ 35%	规划新建居住用地的绿地率 Green space ratio for the planned newly-built residential areas	≥ 30%
	—	—	成片改建、扩建居住区的绿地 Green space in large-scale reconstructed or extended residential areas	≥ 25%	旧城居住用地的绿地率 Green space ratio for built residential area	≥ 20%

注

- 表中各类文件请参见参考文献[18]~[20]。
- 《城市绿地规划标准（征求意见稿）（2018）》已正式变更为《城市绿地规划标准（GB/T51346-2019）》，于2019年12月1日生效（参见参考文献[21]）。但因本文撰写时正式稿尚未发布，且正式稿中缺少量化指标参照，故仍参考征求意见稿中的指标要求。

NOTES

- All the listed documents are sourced from Ref. [18] ~ [20].
- The Urban Green Space Planning Standard (Exposure Draft) (2018) was further revised and officially adopted as the Urban Green Space Planning Standard (GB / T51346-2019) on December 1, 2019 (Source: Ref. [21]). But considering that the latter version was not released during the writing of this paper and it does not include relative quantitative indicators, this study adopted the standards from the 2018 draft as quantitative references.



集中的区域及转型类和优化类再生方向中以产业用地^④为主的区域, 分别从3~10km²不等的总占地范围内提取2km²左右的局部重点样区, 参考相关建设要求进行现状调研(表4, 图1)。其中优化类再生案例因引入物流等现代产业, 用地性质和构成与传统工业区有显著差别, 故选择了以物流仓储用地为主的上海外高桥保税区和以工业用地为主的上海国际汽车城零部件配套工业园区分别研究。

3.2 调研项选择及数据来源

基于上述对部分建设要求的分析可知, 基建控制、服务配套与产业升级是三个着重关注的方面。以此为基础, 结合环境再生策略应对环境、社会和经济层面的问题, 兼顾调研的可操作性、可复制性及非重复性, 选取了以下调查项目:

1) 产业用地中的附属绿地占总用地面积的比例: 该调查项目用于集中反映三类样区的建设强度状况。在工业项目中, 建筑系数即项目

industrial land^④— to investigate their current situation in accordance with relevant construction requirements (Table 4, Fig. 1). Specifically, two cases, i.e., Shanghai Waigaoqiao Free Trade Zone (with logistics and warehouse dominated land use) and the Automotive Components Supporting Park of Shanghai International Automobile City (with industrial dominated land use) were chosen for optimization-oriented regeneration, considering the significant differences in land use between traditional industrial zones and the new ones with emerging industries, e.g. logistics industry.

3.2 Field Survey and Data Sources

In view of that regulating construction, improving supporting service, and upgrading industrial structure are the major concerns in the regeneration of industrial landscapes, this study surveyed 3 aspects of the sample areas as follows, taking the feasibility, replicability, and originality into account:

1) The ratio of subsidiary green space: The ratio can reflect the construction intensity of the sample areas. Though the building coverage rate—the ratio of the area covered by buildings and structures to the total land area^[22]—is a main

用地范围内各种建、构筑物占地面积总和占总用地面积的比例^[22]。对于总面积一定的用地，建筑系数与附属绿地占总用地面积的比例存在较为明确的数量关系，故可利用附属绿地占比代替各类标准中的建筑系数指标来进行讨论。在本研究中，各样区的附属绿地占总用地面积的比例根据上海市测绘院的测绘图测算获得。

2）服务设施密度：该调查项目用于考察三类样区的配套服务情况，主要通过统计各类服务设施数量并根据样区面积转换为设施密度进行比较。依据《上海市控制性详细规划技术准则（2016年修订版）》^[22]，公共设施用地按中类分为行政、商业服务业、文化、体育、医疗卫生、教育科研设计、文物古迹、商务办公和其他公共设施9类；考虑到研发类企业往往集中进驻园区的商务办公用地，因此在统计服务设施类别时未纳入商务办公用地，仅参照其余8类设施用地，分为行政、商业、文化、体育、医疗、教育、文物和其他用地。各样区产业用地上的设施数量分别根据各区政府网站公开的用地性质及借助20m精度的百度地图搜索各类服务设施点获得。

3）产业类型及是否具有构建循环产业链潜力：该调查项目用于考察转型类和优化类样区的产业升级状况，其中循环产业链是针对产业转型升级后生产工艺仍会产生废弃物的样区专设的考察项目。因各个样区内涉及的单位较多，难以一一获得其投资强度、土地产出率和具体生产方式的准确信息，故借助产业门类考察高新产业的引入情况。

index in various standards, the ratio of subsidiary green space can be a substitute since it often has certain proportions with the building coverage rate. In this study, the ratio was sourced from the maps by the Shanghai Surveying and Mapping Institute.

2) The density of service facility: This indicator examines the supporting services in the sample areas in the amount and density of varied service facilities. According to the Technical Guidelines for Regulatory Planning in Shanghai (2016 Revision)^[22], the land use for public facilities can be classified into the administrative, commercial service, cultural, sporting, medical and healthcare, educational / research / design, cultural relics, business and office, and other typologies. This research adopted 8 of these typologies except the business and office since such places often accommodate R & D enterprises. The facility number of varied land use typologies in each sample area was accessed from the government’s data release and with Baidu maps of a 20-meter accuracy.

3) The industry type and the potential for establishing recycling industry chain: These factors were used to examine the sample areas’ upgrading capability in transformation- and optimization-oriented regeneration, and whether the upgraded industry satisfy recycling requirements (waste discharge or not in this study). Considering the large amount of enterprises located in each sample area, it is hard to collect detailed information on their

表4：工业景观环境再生分类案例选择
Table 4: Selected cases of industrial landscape types for further regeneration

工业景观类型 Industrial landscape types for further regeneration		工业景观（及所选样区） Industrial landscapes (and selected sample areas)	典型性说明 Reasons for the selection
遗产类 Heritage revitalization		杨浦滨江工业带（样区一） Sample Area 1 from Yangpu Riverside Industrial Belt	位于上海工业最早起源地之一的沪东工业区，多数重工业地区现已转型，主要发挥商务办公和旅游休闲功能 A belt located in the East Industrial Zone, one of the original industry areas in Shanghai, where most of the heavy industries have been transformed for business and recreational uses
转型类 Site transformation	转型完成 Completed	漕河泾新兴技术开发区（样区二） Sample Area 2 from Caohejing Emerging Technology Development Zone	为20世纪50年代所建的近郊工业区之一，自20世纪80年代以来，逐渐由重工业区转型为以电子信息为主的高新技术产业开发区 One of the suburban industrial zones established in the 1950s and transformed from a heavy industrial zone to a high-tech zone dominated by the electronic information industry since the 1980s
	转型中 Undergoing	市北高新技术服务业园区（样区三） Sample Area 3 from Shibei High-Tec Park	位于20世纪50年代所建的彭浦近郊工业区内，正由重工业区向以大数据产业基地为核心的高新技术园区转型 A park located in Pengpu suburban industrial zone established in the 1950s and transforming from a heavy industrial zone to a high-tech park for big data enterprises
优化类 Environmental optimization		上海外高桥保税区（样区四） Sample Area 4 from Shanghai Waigaoqiao Free Trade Zone	设立于20世纪90年代的以国际贸易产业、加工制造业及现代物流业为发展重点的园区 A trade zone established in the 1990s for international trading, processing, and manufacturing industries, as well as modern logistics
		上海国际汽车城零部件配套工业园区（样区五） Sample Area 5 from Automotive Components Supporting Park of Shanghai International Automobile City	创建于20世纪90年代的以汽车零部件产业为特色的现代化工业园区 A modern industrial park established in the 1990s and featured by the automotive components supporting industry

各样区的产业门类主要通过查阅企业查询网站中的园区信息，并根据《国民经济行业分类（GB/T 4754—2017）》^[23]将各企业归入对应大类获得。

构建循环产业链可通过园区整体工业共生及基础设施的共享，实现能源的梯级利用、废弃物及副产品的循环利用，并通过企业内部的生产管控从源头减少资源能源消耗量、提高资源转化效率，最终在产业集聚、资源能源消耗和环境污染排放最集中的区域实现绿色发展，解决当前的资源环境困局^[24]。一条完整的循环产业链应当包括生产者企业、消费者企业及分解者企业，分别负责研发设计、生产、销售，以及资源的回收和再利用^[3]，中间由物流、商贸、信息服务业者进行沟通（图2）。表5中根据以上三者的定义，结合《国民经济行业分类（GB/T4754-2017）》，列出了常见的生产者、消费者、分解者和中间者企业门类，据此可推断各样区的产业类型是否能构建循环产业链。

3.3 调研结果

各样区的调研结果如表6所示。

4 分类样区再生策略分析

4.1 遗产类再生策略

样区一再生后的用地类型为公共绿地、公共文化设施用地、商业用地、行政办公用地、教育科研用地等^[26]，各类附属绿地占比要求较再生前有所提高；同时，当工业用地转变为具有公共性的用地时，除保护工业建筑遗产为文物类设施外，还需要配置更为完善的文化、运动、商业等服务设施，并应对工业建筑的拆除和改造、工业污染治理等问题。

浦江两岸具有大量工业区遗存，对于工业区的普查与评估不应仅关注工业建筑实体，也需重视建筑以外的工业设备与构筑物所形成的独特景观环境。此外，工业用地所承载的生产历史、技术管理、产

investment scale, GDP per unit area, and production mode. This research investigated the inventory information of hi-tech industries according to the database of enterprises and by matching them to the categories from the latest official classification of industries, i.e. the National Industries Classification (GB/T 4754-2017)^[23].

The recycling industry chain of an industrial park could be established through the industrial symbiosis and infrastructure sharing for the cascade use of energy and the recycle of wastes and by-products. Meanwhile, to address the current dilemmas of resource shortage and environmental deterioration, a source control of the energy consumption and productive efficiency during the production of enterprises within the industrial areas of intensive-layout, high-energy-consumption, and heavy-pollution would greatly contribute to the regional green development^[24]. A complete recycling industry chain should include “producer” enterprises for research, design, and production, “consumer” enterprises to take charge of sale, and “decomposer” enterprises to help with resource recycling and reusing^[3]; the material and information flows are supported by logistics, commercial, and information service enterprises, as intermediary servers (Fig. 2). Accordingly, Table 5 lists the enterprise categories as common producer, consumer, decomposer, and intermediary servers, referring to the National Industries Classification (GB / T4754-2017), to help evaluate the industry’s potential for establishing recycling chain in the sample areas.

3.3 Survey Results

The survey results of each sample area are shown in Table 6.

4 Regenerative Strategies for Sample Areas of Varied Types

4.1 Strategies for Heritage-Revitalization Regeneration

After its regeneration, the land typologies in Sample Area 1 now are public green space, public cultural facility, commercial, administrative, and education and research land, etc.^[26], each requiring a larger ratio of subsidiary green space than before. When industrial lands are transformed for public uses, more cultural, sporting, commercial service facilities should be introduced to protect industrial heritages as cultural relics, and address problems such as building demolition and reconstruction and industrial pollution remediation.

Considering the large amount of industrial heritages along the waterfront of the Huangpu River, a sweeping survey and assessment is required on both the industrial structures and the unique landscapes what they have shaped. For this type of regeneration, design strategies for the site’s commercial, cultural, and tourist places should be integrated with its intangible cultural

2. 循环产业链构成示意图
2. Diagram of the structure of recycling industry chain

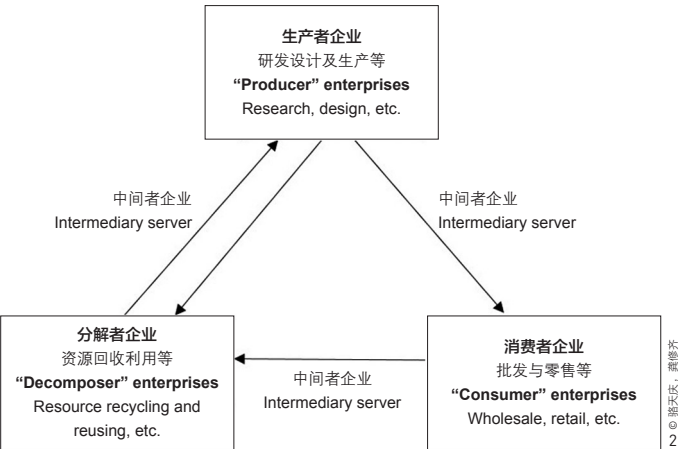


表5：适宜构建循环产业链的产业类型及示例 Table 5: Industry categories suitable for establishing a recycling industry chain		
	产业门类 Industry category	产业大类 First-level category
生产者 Producer	C.制造业（必须包括废弃资源综合利用业） C. Manufacturing (must including comprehensive reuse of wastes)	汽车制造业、通用设备制造业、废弃资源综合利用业 Automobile manufacturing, general equipment manufacturing, comprehensive reuse of wastes
	M.科学研究和技术服务业 M. Research and technical services	研究和试验发展、科技推广和应用服务业 Research and experimental development, technique promotion, and application services
消费者 Consumer	F.批发和零售业 F. Wholesale and retail	批发业和零售业 Wholesale and retail
分解者 Decomposer	N.水利、环境和公共设施管理业 N. Water conservancy, environmental and public facility management	生态保护和环境治理业、公共设施管理业 Ecological and environmental protection, and public facility management
	O.居民服务、修理和其他服务业 O. Neighborhood services, repair services, and other services	机动车、电子产品和日用产品修理业 Vehicle, electronic product, and daily necessity repair services
中间者 Intermediary server	G.交通运输、仓储和邮政业 G. Transportation, storage, and postal services	装卸搬运和仓储业 Handling and storage
	I.信息传输、软件和信息技术服务业 I. Information transmission, software, and information technology services	互联网和相关服务、软件和信息技术服务业 Internet and related services, software, and information technology services
	L.租赁和商务服务业 L. Leasing and business services	租赁业和商务服务业 Leasing and business services

业工人的集体记忆等非物质文化遗产的价值也极其重要^[31]，在再生设计时，可结合商业、文化和游览等功能予以体现；对于工业用地常见的土壤及水污染问题，则可根据污染物的性质和污染程度的不同，采取相应的物理技术、化学技术、生物技术和植物修复技术^[32]。

样区一中的杨浦滨江南段示范段改造尤其借鉴意义。这一改造挖掘了原上海船厂、上海杨树浦自来水厂、上海第一毛条厂、上海烟草厂、上海电站辅机专业设计制造厂、上海杨树浦煤气厂、上海杨树浦发电厂、上海第十七棉纺织总厂和定海桥的历史特色，形成“八厂一桥”的9段特色公共空间，以栓船桩、混凝土系缆墩和码头工人雕塑等穿插于其中，保留了老码头的物质与非物质记忆，以垂直绿化、雨水花园、遗址公园等手段进一步提高场地的生态价值^[33]，形成自然与人文共同发展的整体系统。

heritages, including production history, technical management, and collective memory of workers^[31]. When dealing with common soil and water pollution problems, physical, chemical, biological, and phytoremediation techniques can be employed according to specific pollution reasons and levels^[32].

In Sample Area 1, the South Demonstration Section of the Yangpu Riverside Public Space which has finished industrial transformation may especially inspire other similar cases. The created 9 sections recall people’s memory about the site’s history with scattered bollards, concrete cleats, and a sculpture of stevedores, showing respect to its tangible and intangible cultural heritages preserved from the previous “eight factories and one bridge,” namely Shanghai Shipyard, Shanghai Yangshupu Waterworks, Shanghai No. 1 Wool Factory, Shanghai Tobacco Factory, Shanghai Power Station Auxiliary Machine Design and Manufacturing Factory, Shanghai Yangshupu Gasworks, Shanghai Yangshupu Power Plant, Shanghai No. 17 Cotton Textile Main Factory, and Dinghai Bridge. Meanwhile, practices of vertical greening, rain gardens, heritage parks, etc. further improve the ecology of the site^[33], forming an integrated system of the nature and culture.

表G：各样区调研结果汇总表
Table 6: Research results of each sample area

	样区区位 Sample area location	产业用地中的绿地情况 Green space in the industrial land	行政办公及生活服务设施 Administrative and public facilities
样区一 Sample Area 1			
样区二 Sample Area 2			
样区三 Sample Area 3			
样区四 Sample Area 4			
样区五 Sample Area 5			

- 样区范围
Sample area

附属绿地
Subsidiary green space

公共绿地
Public green space

产业用地
Industrial land
- 行政类设施
Administrative facilities

商业类设施
Commercial facilities
- 文化类设施
Cultural facilities

体育类设施
Sporting facilities

医疗类设施
Medical facilities

教育类设施
Educational facilities
- 文物类设施
Cultural relics

其他设施
Other facilities

行政办公及生活服务设施用地
Administrative and public facilities

续表见下页 / Continued

表G：各样区调研结果汇总表
Table 6: Research results of each sample area

	基建控制指标 Construction control indicators		服务配套指标 Supporting service indicators									产业升级指标 Industry upgrading indicators		
调查项目 Research Aspects	面积 Area (km²)	产业用地中 附属绿地的占比 Subsidiary green space ratio in industrial land	行政办公及生活服务设施 Administrative and public facilities									产业门类 Industry category	主要产业 Main industry	是否具有构成 循环产业链的 潜质 Potential to establish a recycling industry chain
			密度 (个/hm²) Density (piece of facility per hm²)	行政 (个) Number of administrative facilities	商业 (个) Number of commercial facilities	文化 (个) Number of cultural facilities	体育 (个) Number of sporting facilities	医疗 (个) Number of medical facilities	教育 (个) Number of educational facilities	文物 (个) Number of cultural relics	其他 (个) Number of other facilities			
样区一 Sample Area 1	1.44 (改造完成部分: 0.43) 1.44 (transformation completed: 0.43)	已改造: 21.3% Transformation completed: 21.3%	已改造: 1.02 Transformation completed: 1.02	2	23	0	4	0	0	15	0	—	—	否 None
样区二 Sample Area 2	1.95	24.0%	0.34	14	46	2	3	2	0	0	0	C, M, F, N, I, L	电子信息 Digital information	否 None
样区三 Sample Area 3	2.26 (改造完成部分: 1.27) 2.26 (transformation completed: 1.27)	已改造: 22.3% Transformation completed: 22.3%	0.72	4	83	2	0	2	1	0	0	C, M, F, O, I, L	高新技术服务业 High-tech services	否 None
		改造中: 9.91% Under transformation: 9.91%	0.40	5	34	0	0	0	1	0	0			
样区四 Sample Area 4	2.96	17.1%	0.14	1	39	0	0	0	0	0	0	C, M, F, G, I	贸易、加工、仓储及交易 Trading, processing, storage, and transaction	否 None
样区五 Sample Area 5	1.60	18.2%	0.43	2	60	3	0	0	1	0	2	C, F, G, O	汽车制造 Automobile manufacturing	否 None

注

1. 样区一范围参考自文献[25]中该区域原为工业地块的范围；样区一更新后的用地参考自文献[26]；样区二的用地参考自文献[27]；样区三的用地参考自文献[28]和百度地图；样区四的用地参考自文献[29]；样区五的用地参考自文献[30]。
2. 产业升级指标中的产业大类具体为：C—制造业（未包括废弃资源综合利用业），M—科学研究和技术服务业，F—批发和零售业，N—水利、环境和公共设施管理业，I—信息传输、软件和信息技术服务业，L—租赁和商务服务业，O—居民服务、修理和其他服务业，以及G—交通运输、仓储和邮政业。

NOTES

1. The boundary line of Sample Area 1 was referred to its previous industrial land boundary, sourced from Ref. [25]; the updated land use of Sample Area 1 was sourced from Ref. [26]; the land use of Sample Area 2 was sourced from Ref. [27]; the land use of Sample Area 3 was sourced from Ref. [28] and Baidu map; the land use of Sample Area 4 was sourced from Ref. [29]; and the land use of Sample Area 5 was sourced from Ref. [30].
2. Letters in the industry categories under the industry upgrading indicators represent respectively C for Manufacturing (excluding comprehensive reuse of wastes), M for Research and technical services, F for Wholesale and retail, N for Water conservancy, environment, and public facility management, I for Information transmission, software, and information technology services, L for Leasing and business services, O for Neighborhood services, repair services, and other services, and G for Transportation, storage, and postal services.

4.2 转型类再生策略

样区二和样区三两个转型类再生案例均对整体环境进行了改造更新，所选样区的附属绿地占用地面积的比例分别达到了24%和22.3%，均已符合相关要求。同时，从调研结果可知，两个案例的服务设施类型较为单一，商业设施多为便利店和餐饮店，教育设施及文体设施均较少。在服务设施密度上，由于样区三改造时间更近、对服务类设施的布

4.2 Strategies for Site-Transformation Regeneration

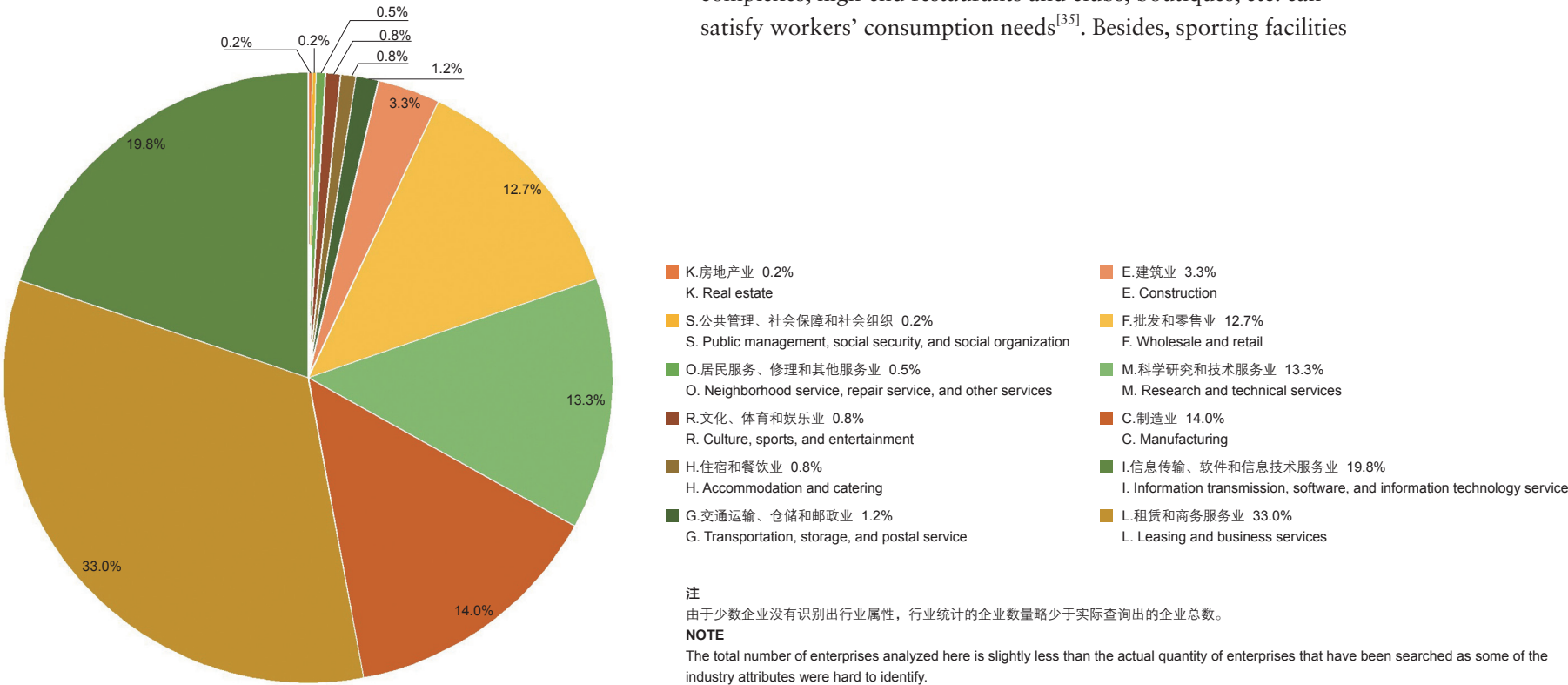
Sample Areas 2 and 3 are cases aiming at transforming and updating the overall environment, where the ratio of subsidiary green space reaches 24% and 22.3% respectively, both meeting the official requirement. However, these two sites are facing the shortage and low-diversity of service facilities. The survey results show that most of the commercial facilities are convenience stores and restaurants, while the educational, cultural, and

置更为全面，其改造完成部分的服务设施密度（0.72个/hm²）比样区二（0.34个/hm²）高出近一倍。此外，原污染性工业用地使用致使场地存在污染遗留问题。从产业结构来看，两个案例都剥离了污染较大的产业，向研发类高新技术产业转型，但并未向循环产业链的方向探索。根据针对样区三内改造完成地块上的产业门类统计可知，租赁与商务服务业占比33.0%，信息技术服务业占比19.8%，相加超过半数；制造业仅占14.0%（图3）。虽然仍保留制造业，但并无处理废弃物的废弃资源综合利用业，水利、环境和公共设施管理业也未有配套。因此，其产业转型和升级实质上是污染的外输转移，并未真正做到生产物质的闭环，难以达成环境再生目标。

随着研发类高新技术产业的引入以及与城市功能的融合，劳动人群由单一的劳动密集型人口变为包含了知识型、技术型在内的多层次人口，二者间的活动需求存在较大的差异^[34]，因而需构建符合其需求的服务设施及公共空间。例如，在文化教育设施方面，可构建行业协会、信息交流中心，以及书店、培训机构等技术交流场所；在商业设施方面可配套商业综合体、餐厅会所与精品主题商店等，满足园区内

sporting facilities are scarce. In terms of facility density, the completed part of Sample Area 3 (0.72 piece of facility/hm²) is almost twice as dense as Sample Area 2 (0.34 piece of facility/hm²) due to its being well re-planned more recently. For another problem of historically remaining pollutions, both cases made little efforts to develop a recycling industry chain, eliminating the high-pollution industries and embracing R & D high-tech industries though. In Sample Area 3, according to the statistics of industrial categories within the areas that finish transformation, leasing and business services account for 33.0% and information technology services for 19.8% (Fig. 3). The manufacturing takes a smaller percentage of 14.0%, but it still lacks upgraded supporting services in waste treatment and reutilization, not to mention water conservancy or environmental and public facility management—its production waste is still treated out-site. In a word, the failure of establishing a recycling loop would lead to a failure in environmental regeneration.

With the introduction of R & D high-tech industries into this type of sample areas, the working population is being diversified, especially seeing an increase of knowledge-based and skilled workers; this change requires the parks to accommodate new service facilities and more public spaces for workers' various activity demands^[34]. For example, cultural and educational facilities and organizations such as industry associations, information centers, bookstores, and training institutions could help drive profession exchange between workers. Commercial complexes, high-end restaurants and clubs, boutiques, etc. can satisfy workers' consumption needs^[35]. Besides, sporting facilities



3. 样区三产业统计分析
(数据来源:企业前瞻网数据库)

3. Statistic analysis of the industries in Sample Area 3 (data sourced from the Qianzhan Database)

高消费人群的商业服务需求^[35];在体育设施方面应新增篮球场等多种健身设施等,鼓励在职者、在居者关注自身健康。

服务设施的布局应以增加可达性、可辨识性和吸引力等为目标,与工作空间及资料室、会议室、展览室等辅助设施相结合,为员工提供休闲、娱乐和交流机会。如将公共交往空间与休闲中庭、地面绿化和屋顶花园等相结合,全方位进行布置设计^[36]。由于多样的公共空间设置会侵占地面绿地,需借助立体绿化加以弥补,从而充分利用空间资源,提高生态效益。

同时,在借助技术手段对既往工业污染进行修复治理的同时,还应注重构建循环产业链,利用高新技术对废物进行再利用,鼓励资源回收利用企业的产业化,将上一级产业的废料作为下一级产业的产品原料,实现资源和能源的再利用和良性循环,真正达到少投入、高产出、低污染和零排放^[37]。

4.3 优化类再生策略

与其他案例相比,样区四与样区五的建设强度较大,附属绿地占总用地面积的比例分别仅为17.1%和18.2%,未达到相关要求。由于工业园区的建设时间较近,且仍在承担必要的生产职能,样区内的产业难以通过升级转型实现再生目标;此外,厂房无法拆除改建,且存在大量的堆场或机械操作空间,故而难以直接增加绿地,需借助立体绿化补偿地面绿化。

以上两个样区内的企业多通过机械化操作进行生产,员工较少,因此对生活服务类设施的需求较少。目前样区内建于生产性建设用地上(如工业用地和物流仓储用地)上的服务设施多为厂家零售点,商业用地则用于集中布置餐馆、市场或小卖部,基本可满足员工的生活需求,整体设施水平无突出问题。

相比转型类案例,优化类案例样区内的产业相对单一。例如,样区四是以贸易服务业为主导的产业集群^[38],在更大范围的产业链中承担贸易物流角色;样区五则是专业化、规模化的汽车生产集群,缺乏以

like basketball courts could encourage workers to take physical exercise and have a healthier lifestyle.

For a higher accessibility, a clear identity, and great attractions, all these service facilities can be distributed within working spaces and along with auxiliary facilities such as reference rooms, meeting rooms, and exhibition spaces to provide workers with opportunities for leisure, recreation, entertainment, and communication. For these purposes, design measures like integrating recreational atriums, ground greening, and roof gardens into public spaces^[36] can be employed. Considering the possible loss of green space caused by being occupied by diverse public spaces, strategies such as vertical greening could be introduced to realize an optimal use of space and broader ecological benefits.

Together with environmental remediation techniques to polluted lands, the recycling industry chain should be established to promote the industrialization of high-tech resource recycling enterprises. Such an industry chain can form a virtuous cycle of resource and energy reuse that the production waste from the upstream industries could become the raw materials for the downstream industries, helping achieve the goal of low input, high output, low pollution, and zero discharge^[37].

4.3 Strategies for Environmental-Optimization Regeneration

Compared with other cases, Sample Area 4 and 5 have a higher construction density, whose subsidiary green space accounts only for 17.1% and 18.2% respectively, both below the official standard. Dilemmas for these two sample areas lie in that they are both newly-built parks and planned to undertake certain production functions, making it unlikely to take another industrial transformation or upgrading for site regeneration; also, the area of green space would be little increased as the existing plant layout and working field can be hardly adjusted, to which vertical greening might become a solution.

The mechanized production of enterprises in Sample Areas 4 and 5 requires fewer workers than others, which means less demands for daily service facilities. At present, the service facilities within the productive construction land (e.g. industrial, logistics, and warehouse land) are mainly retail outlets, and most restaurants, markets, and kiosks are located on the commercial land, which are sufficient for workers' daily life.

The industrial categories in these optimization-oriented cases are less diverse than those in site-transformation cases. For instance, Sample Area 4 accommodates an industrial cluster dominated by trading services^[38] which supports trade logistics in a wider-range industry chain; Sample Area 5, a cluster of automobile enterprises, accommodates fewer R & D and recycling industries.

研发和回收利用为主导的产业，亟需向循环产业链方向进行探索^[39]。用于单一产业集中建设和生产的场地亦需要通过绿地生态效益的提升来改善环境问题。样区四的物流职能致使区域内库房和堆场集中分布，硬质下垫面多、雨洪问题突出，可结合屋顶绿化、植草沟、滞留沟和雨水花园等低影响开发设计，减少径流污染，促进雨水的滞蓄和回收；样区五存在较多容易产生污染的汽车生产企业和部门，在小区域生态系统不足以消除场地污染的情况下，可与区域背景相结合，将场地的生态需求融入到区域生态服务中解决^[32]。

从长远来看，拓展单一产业的上下游生产环节、构建循环产业链是工业景观优化和环境再生的根本策略。此类策略已在国际上有较多先例，例如，日本北九州生态工业园由综合环境联合体、试验研究区和循环区三部分组成，其中综合环境联合体由大企业参股设立资源再生企业，对来自全国各地的报废汽车、废旧家电及建筑垃圾等废弃物进行规模化收集和再生处理，最大限度地降低循环成本，最终构建了互补的生态工业链^[40]。样区五可借鉴北九州生态工业园的经验，一方面引进汽车研发设计类企业，提高自主创新能力；另一方面引进废弃物回收利用等资源再生企业，与生产研发共同组成完整的产业链。

5 结论与展望

处于工业化转型发展时期的上海工业景观可通过遗产类、转型类和优化类三种环境再生策略进行改造升级。由相应的典型案例分析可知，不同再生类型的工业景观所面临的具体问题存在差别，应采取不同的针对性策略：遗产类的样区一需重点关注遗产利用和生态恢复问题；转型类的样区二和样区三除考虑既往工业用地的污染治理问题外，还需关注服务设施的完善和公共空间的塑造；优化类的样区四和样区五需借助立体绿化提升绿地生态效益，进而改善环境品质。对于具有生产功能、产业转型升级后生产工艺仍会产生废弃物的转型类与优化类案例，均需推进循环产业链的构建，从根本上减少污染，实现节能减排，达成环境、社会和经济的协同发展。

Both of them need to develop their own recycling industry chain^[39]. The construction and production of such single-industry clusters may also lead to severe environmental problems which can be coped with by the improvement of green spaces' ecological performances. Specifically, the concentration of warehouses and storage yards in Sample Area 4 brings about the prevailing use of impervious pavements that has caused more frequent flooding events, which could be resolved by Low Impact Development measures, e.g. roof gardens, grass swales, water retention ditches, and rain gardens, to reduce runoff pollution and recycle the stormwater. Sample Area 5 is challenged with pollution caused by automobile manufacturing that is hard to be removed by the onsite ecosystem, which thus should be dealt with by ecological planning means at a larger regional scale^[32].

In the long run, a single industry's landscape optimization and environmental regeneration would greatly rely on the collaboration between up- and down-stream enterprises and the establishment of recycling industry chain. One of the successful international precedents is the Kitakyushu Eco-Town in Japan, which is composed of an environmental protection joint venture, a pilot R & D area, and a recycling area. The joint venture includes resource recycling enterprises invested by large enterprises and conducts mass collection and reuse of scrap automobiles, home appliances, and construction waste from the whole nation, ultimately helping build an industry chain of symbiotic enterprises with a sound cost-effectiveness^[40]. This experience may provide reference for Sample Area 5 to introduce more R & D and resource recycling enterprises dedicated to innovative automobile design and resource recycling business.

5 Conclusion and Prospects

In conclusion, the industrial landscapes of Shanghai in this post-industrial era can be regenerated via heritage revitalization, site transformation, or environmental optimization. Strategies for each type of regeneration should vary on a case-by-case basis: Sample Area 1 needs to prioritize heritage reuse and ecological restoration; Sample Areas 2 and 3 should reinforce the improvement of service facilities and public spaces together with the control and remediation to the existing industrial pollution problem; and Sample Areas 4 and 5 have to enhance the ecological performance of green spaces by introducing vertical greening for an environmental quality improvement. For the cases of transformation- and optimization-oriented regeneration that may continue causing production waste, a recycling industry chain is encouraged to reduce pollution and conserve energy at source and finally realize a synergetic development in environment, society, and economy.

未来，中国工业园区在后工业化发展的过程中仍有很长的路要走，需准确把握再生方向，选取适用的工业景观再生策略，以缓解环境压力，提高环境品质。**LAF**

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In the future, China's industrial parks will be geared with suitable strategies to the needs of industrial landscape regeneration for a post-industrial growth with broader environmental benefits. **LAF**

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