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清華大學环境学院
School of Environment, Tsinghua University

工业园区可持续水管理创新指南2.0
Guideline for sustainable water stewardship in industrial parks V2.0

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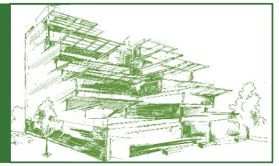
二〇二三年九月Sept. 2023

清华大学环境学院

主要内容

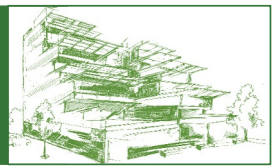
1. 基本概念Concepts
2. 指南简介Brief introduction to the guideline
3. 研究进展Update of the guideline

《工业园区可持续水管理创新实施指南V2.0》

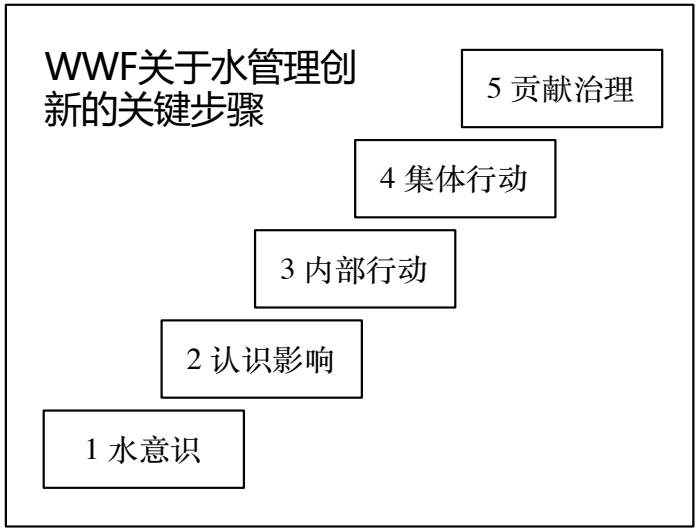


下载链接IDownoad：http://wwfchina.org/content/press/publication/2018/IP%20Guidance_20180402_final_compressed.pdf

什么是水管理创新What is water stewardship?



- Water Stewardship: 最早由国际水管理创新联盟和世界自然基金会共同发起Initiated by AWS and WWF
- 水管理创新的核心：持续改善用水状况，降低企业内部及价值链、供应链相关的水影响

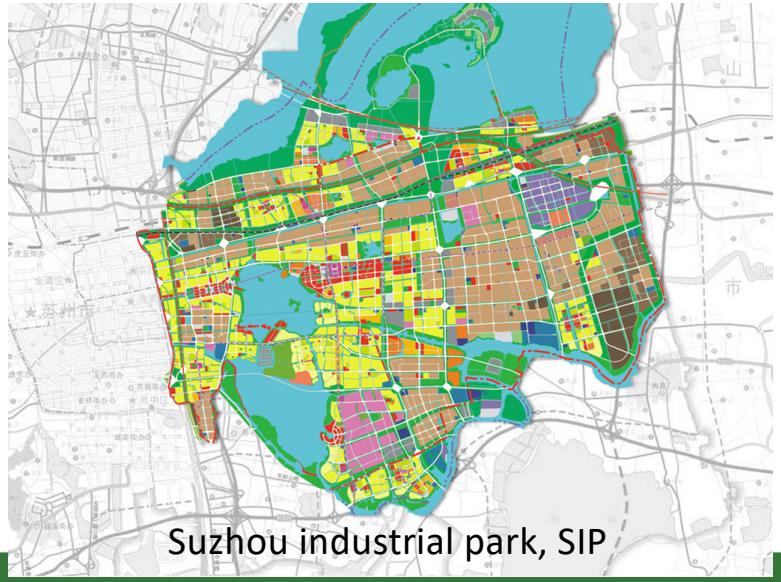


工业园区水管理创新

- 园区多利益相关方共同行动，推进和共享水资源的可持续开发利用
- WWF defines water stewardship for a business as continual improvement of water use and a reduction in the water-related impacts of internal and value chain operations. More importantly, it is a commitment to the sustainable management of shared water resources in the public interest through collective actions with other businesses, governments, NGOs and communities.

什么是工业园区What is an industrial park?

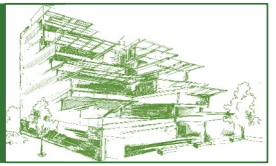
- The industrial park (IP) is a common feature of the global landscape建立工业园区是全球一种普遍的经济现象.
- It is a large tract of land, subdivided, and developed for the use of several firms simultaneously, distinguished by its shareable infrastructure and close proximity of firms (Peddle 1993; UNEP, 1997, Environmental management of industrial estate).
- Synonymous: an industrial estate, industrial area, or industrial zone.
- In China, we have high-tech development zones(高新区), economic-technological development areas (经济技术开发区), and other kinds of industrial parks.



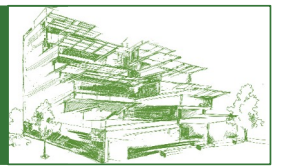
Suzhou industrial park, SIP

A chemical industrial park, SYIA

Profile of some typical industrial parks in China



Industrial Parks Development in China

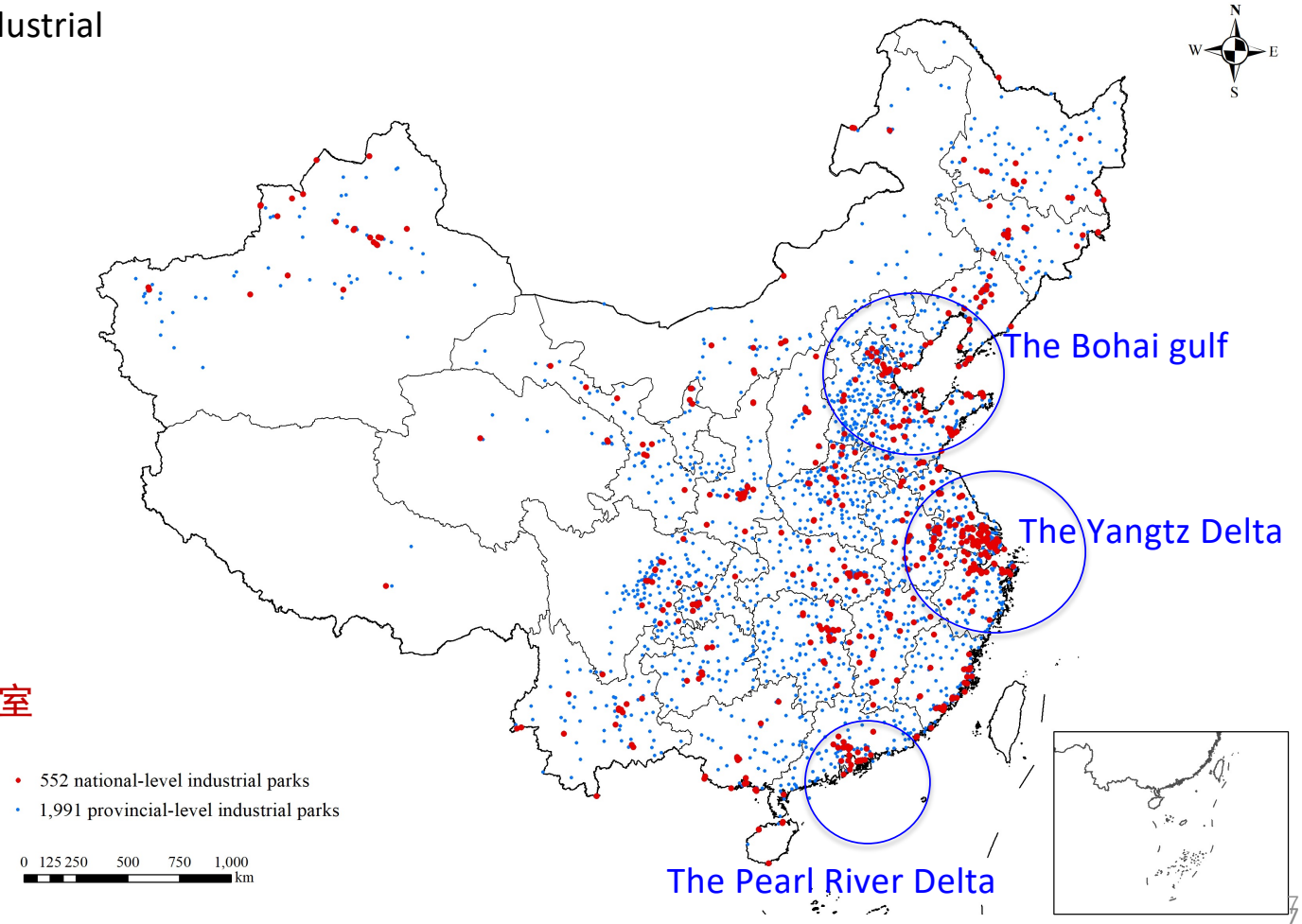


2543: national and provincial level industrial parks国家级和省级园区数量

50%+: contribution of gross industrial output value工业总产值占比

50%+: ratio of manufacturing industry located in industrial parks 工业企业入园率

31%: GHG emissions accounting for total emissions in China园区温室气体排放占全国比例



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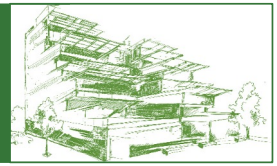
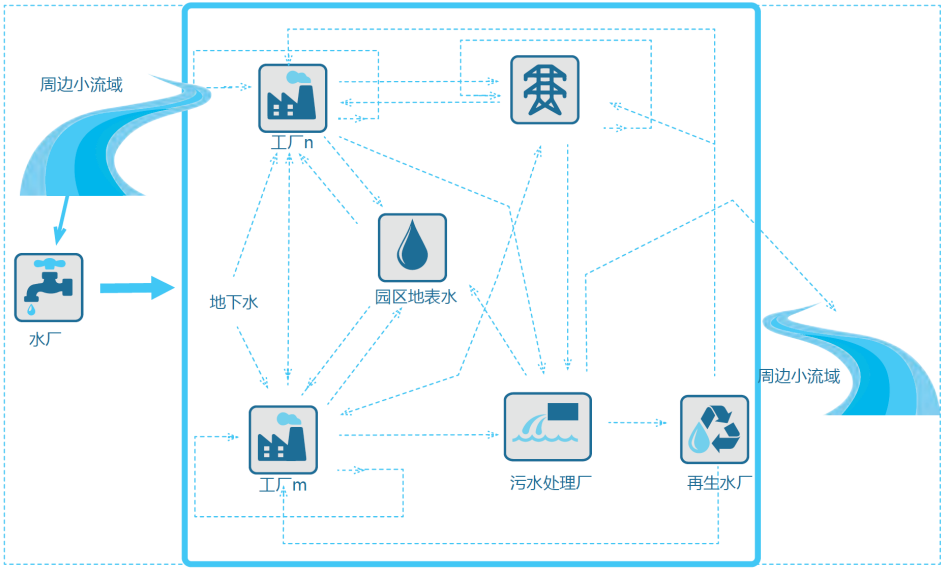
园区水管理创新原则：构建全生命周期水管理体系

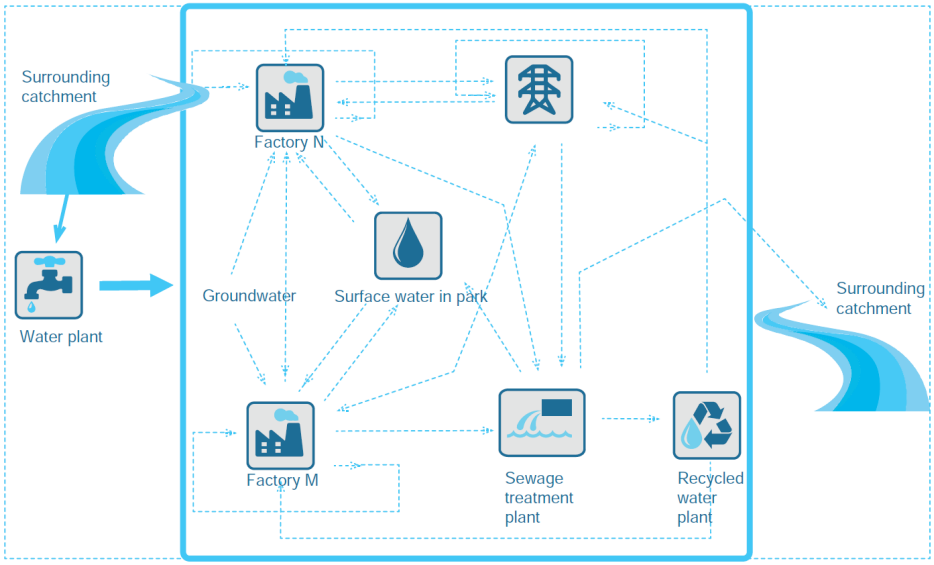
Key principle for WS in industrial park: managing water from the perspective of life cycle thinking



- Life cycle thinking遵循系统思考原理，应用生命周期理念，全面考虑水资源管理及水污染防治各环节
- 构建“供水——用水——废水处理——排放——废水再生回用——污水处理废气治理——污泥处理处置及资源化” 关键环节组成的，全过程水管理体系；water withdraw---water supply---water use---wastewater treatment---reclaimed water reuse---waste gas treatment in WWTP---sludge treatment and energy recovering
- 统筹“水～能”资源，构建能源、环境基础设施共生体系；water-energy nexus, and CHP-WWTP industrial symbiosis
- 从企业、园区、周边小流域三个层面设计一体化水管理创新解决方案integration of plant---park---catchment

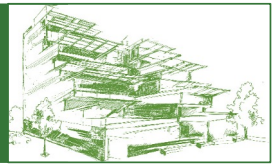


园区水管理创新水相关要素关联示意



Interrelations of Relevant Industrial Park Water Stewardship Factors

工业园区全过程水管理优化的目标Goal of WS in industrial parks

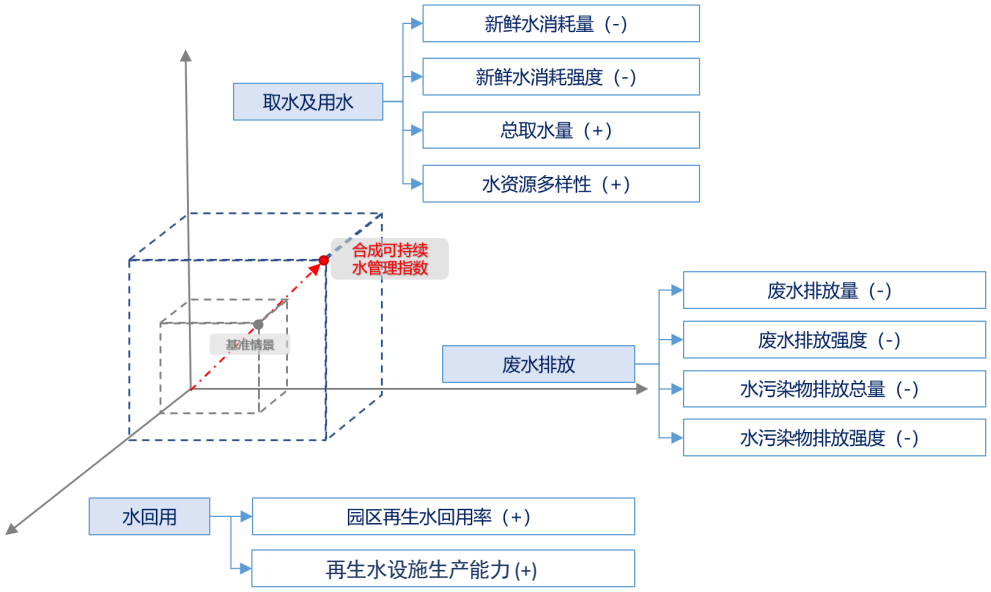


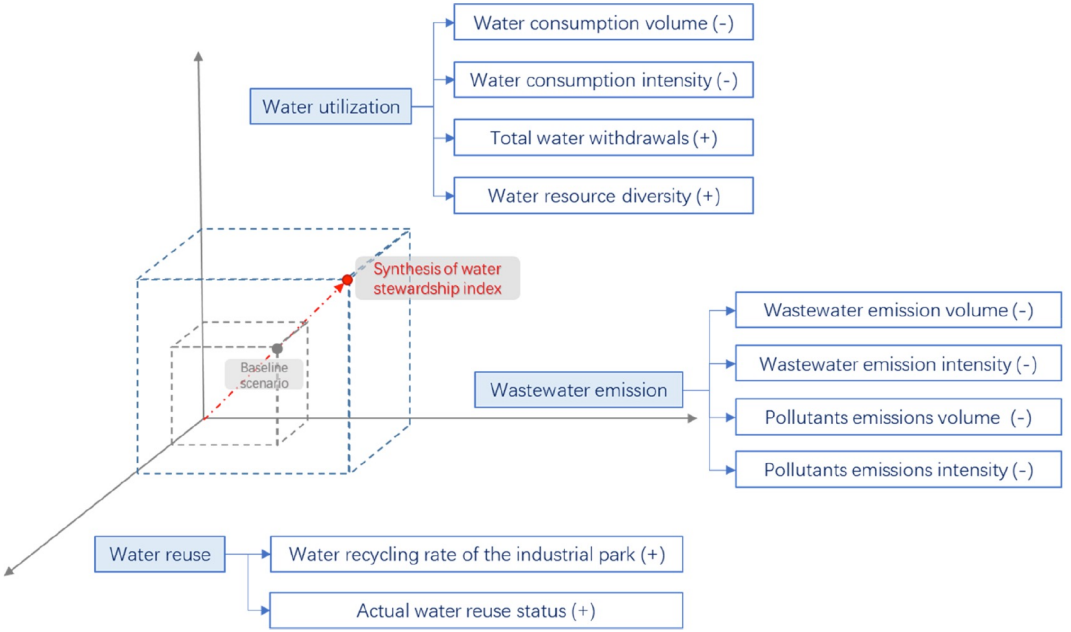
- 以园区管理机构和企业为实施主体Principle facilitators: administrative committee and manufacturing enterprises
- 推动园区实现水资源消耗从相对脱钩迈向绝对脱钩Goals of WS: achieving a leapfrog from a relative decoupling to absolute decoupling of water resource use with economic growth in industrial parks
- 关键举措：推进园区水管理科学化、精细化，控制用水总量，提高用水效率和水资源产出率；开发利用非常规水源；全过程防治水污染、减少废水排放；持续改善水环境质量和生态环境、防范和降低供应链及流域水风险Key measures: delicate management of water use; improving water efficiency and water productivity; exploring unconventional water sources; controlling the cap of freshwater use and wastewater emission; improving water quality and water risks both in supply chain and local catchment.

工业园区水管理创新指南总体架构Framework of WS in industrial parks

	水管理问题识别	成因分析	主要对策	绩效评估
企业	企业层面用水量大、水效率低	企业清洁生产、技术水平、管理水平；水资源成本占比很小	强化源头控制；加强清洁生产，应用新技术改造提升传统产业，强化用水定额/总量管理，加强节约集约用水，循环用水，再生水回用，强化环境管理	1. 管理体系 (1) 管理流程 (2) 管理制度
	企业废水及水污染物排放负荷高	技术水平落后、未实施用水总量、定额控制；环境信息不公开		2. 供水 (1) 用水总量控制 (2) 供水水质保障
园区	水资源供需矛盾	空间布局及产业结构不合理：布局水功能敏感区、高涉水行业占比高	实施基于全生命周期原则及一体化的水管理体系	3. 水资源产出率 (1) 单位工业增加值新鲜水消耗 (2) 单位GDP新鲜水消耗 (3) 单位税收收入新鲜水消耗 (4) 单位工业增加值(或GDP)废水（或污染物COD、氨氮）排放量 (5) 再生水回用率
	集中式污水处理厂稳定运行	WWTP进水组分复杂、水质不稳定，工艺不合理，运行成本高	最严格水资源管理，用水总量管理，调整/优化布局；强化区域产业准入管理；非常规水源开发利用	
	污水处理污泥的处理处置	污水处理污泥未列为危废，全生命周期水监管不到位	强化污水/污染物源头削减，污水分类收集分类预处理，强化监管	
	污水处理厂出水毒性	特征污染物及出水毒性尚未纳入监管范围，检测能力不足	监测能力提升，在线毒性检测，水风险识别及预警，强化污水处理毒性（急性毒性/持久性毒性）及特征污染物监控	
	园区内水体污染	早期污水未处理/处理不足，并向园区内水体排污，初期雨水污染等		4. 环境影响 (1) 常规污染物排放总量 (2) 特征污染物排放总量 (3) 出水毒性影响 (4) 污泥处理处置/综合利用 (5) 地表水环境质量 (6) 小流域承载能力
	企业间水资源循环梯级利用不高	企业之间生产及资源消耗信息不透明，管理机构组织协调不充分	根据不同企业用水、排水的水质差别化需求，构建园区层面一水多用、梯级利用的水资源高效利用模式体系，提高水资源利用率及回收率	
	园区周边小流域污染	污水排放量大，且污染负荷高，难降解物质/出水毒性高	小流域承载能力监测预警，实施生态修复，构建区域生态系统，提高水体自净能力及承载力	

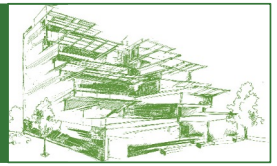
水管理创新指数Water stewardship index (WSI)





$$WatSteInd\ (WSI) = \sum_{j=1}^{12} \left(\omega_j \times Indicator_j\right)$$

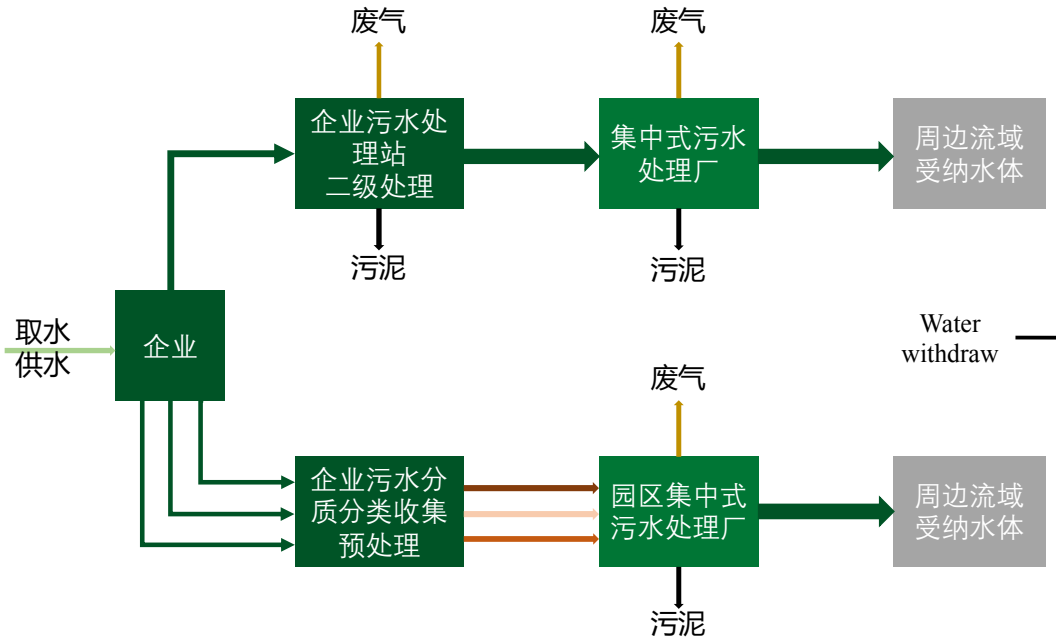
工业园区两种主要排水模式Generalization of two typical wastewater treatment models in industrial parks

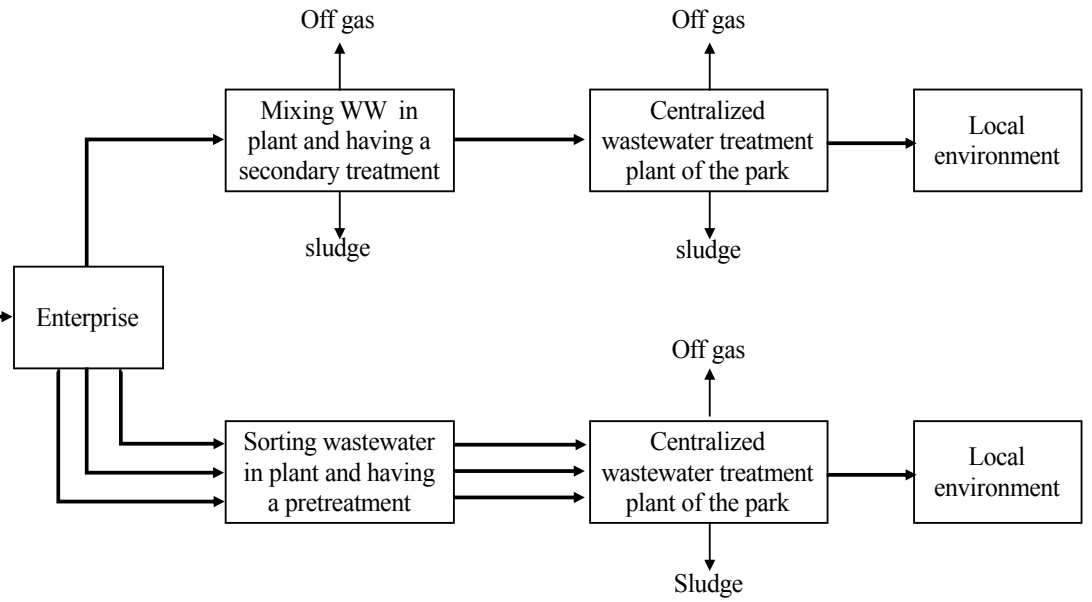


Shareable environmental infrastructure

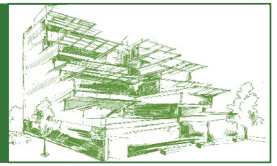
Two typical wastewater treatment models in the Chinese industrial parks

CWWTPs are established in 72% of the Chinese national parks





企业层面推进水管理优化关键行动(V2.0)
Critical Actions of Water Stewardship Implementation for Sites

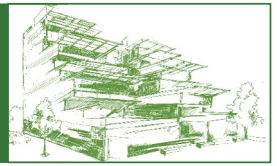


1. 深入分析企业水管理现状做到现状明、底数清；
2. 获高层支持，将水管理创新嵌入日常经营管理；
3. 引导企业开展全过程全要素精细化计量和管理；
4. 应用先进适用节水技术和设备，挖掘节水潜力；
5. 推进水处理由污染控制向低能耗、资源化、能源化、生态安全的绿色转变；
6. 提高再生水处理及回用的绿色化水平；
7. 深入推进清洁生产，削减废水排放总量；
8. 加强化学品管理控制排水特征污染物总量。

1. Status quo analysis of water management
2. Develop Commitment to Water Stewardship
3. Establish the Water Consumption and Drainage Inventory in high spatial-temporal resolution
4. Employing advanced water-efficient technologies and equipment to maximize water-saving potential
5. Facilitating eco-transforming of wastewater treatment towards low energy consumption, resources-energy recovery associated with ecological safety
6. Environmentally friendly reclaimed water reuse
7. Strengthening cleaner production to reduce the quantity of wastewater generation at the source
8. Control the emerging pollutants in wastewater

来源：WWF工业园区水管理创新指南

园区层面水管理优化的关键行动(V2.0)
Critical Actions of Water Stewardship Implementation for parks



1. 评价园区供水、用水、排水、污泥处理处置、再生水回用等现状；
2. 识别制约园区水资源效率、水环境改善主要因素；
3. 识别园区的水风险，以及供应链水风险；
4. 构建园区水管理信息系统；
5. 控制园区及企业用水总量，加强用水定额管理；
6. 构建指标体系，强化项目水效率准入控制；
7. 严格地下水管理和污染防治；
8. 实施工业企业水效领跑者引领行动；
9. 控制排水中特征污染物；
10. 发现培育并固化企业间合作，建立工业生态系统；
11. 水能统筹构建能源—环境基础设施间共生；
12. 园区产业结构优化。

来源：WWF工业园区水管理创新指南

1. Status quo analysis of life-cycle water management
2. Assessment of water efficiency/water quality and the bottlenecks
3. Identifying waster risks both in local areas and those along the supply chain
4. Establishment of a water stewardship information system
5. Control the cap of water use both in total quantity and in quota per unit of product;
6. Reinforcing threshold of water efficiency for newly developed manufacturing products;
7. Preventing underground water pollution;
8. Facilitating Water/Energy Efficiency Leader Initiative
9. Control emerging pollutants in wastewater treatment plant
10. Uncovering and facilitating industrial symbiosis to enrich eco-industrial system in industrial parks
11. Development of water-energy nexus by symbiotic cooperation between energy-environmental infrastructure
12. Upgrading industrial structure in industrial parks

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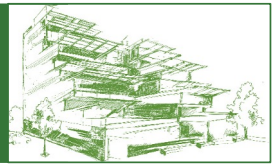
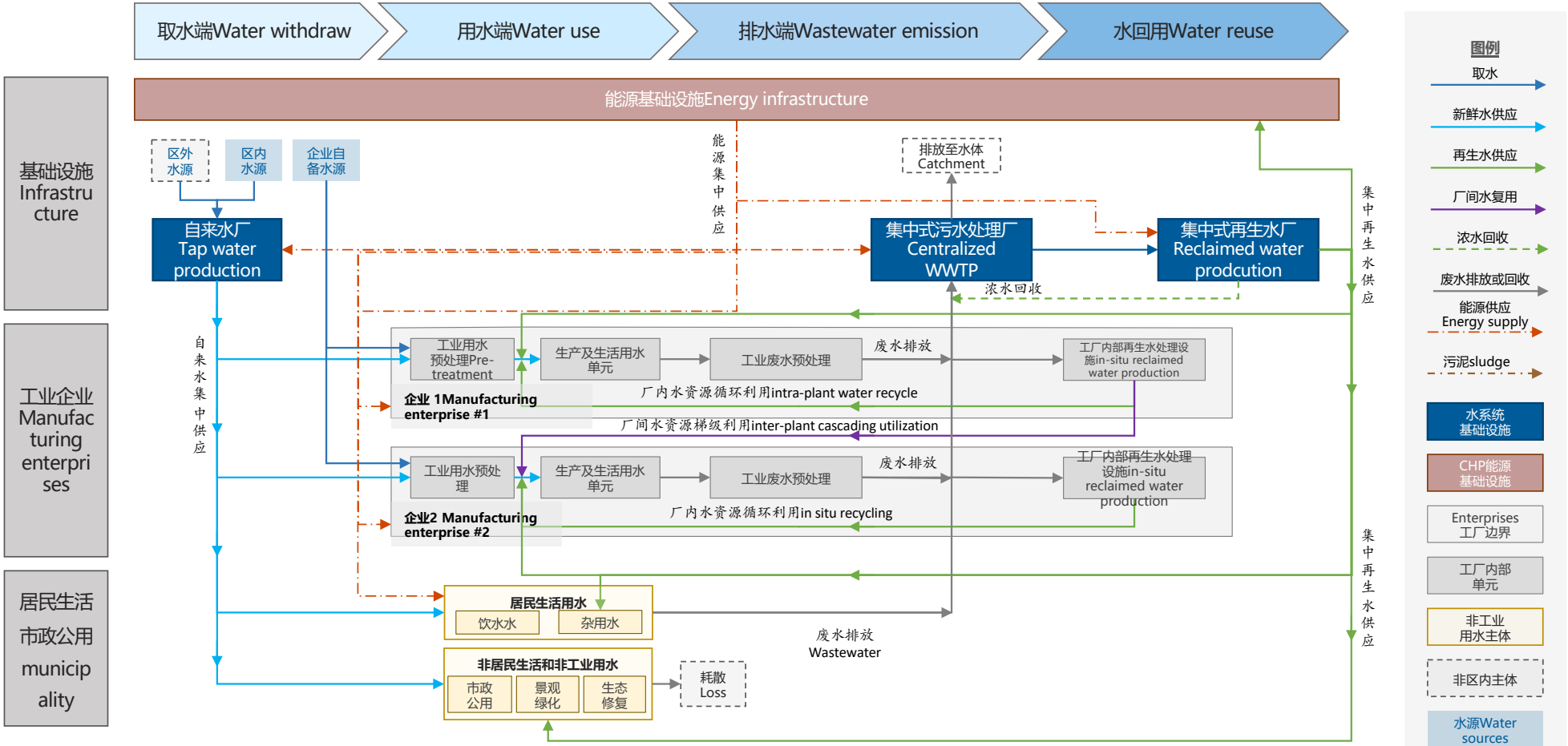
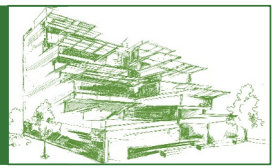
从多维度认知园区水系统：水流向、多层级、多利益相关方
Water flow and multi-stakeholders

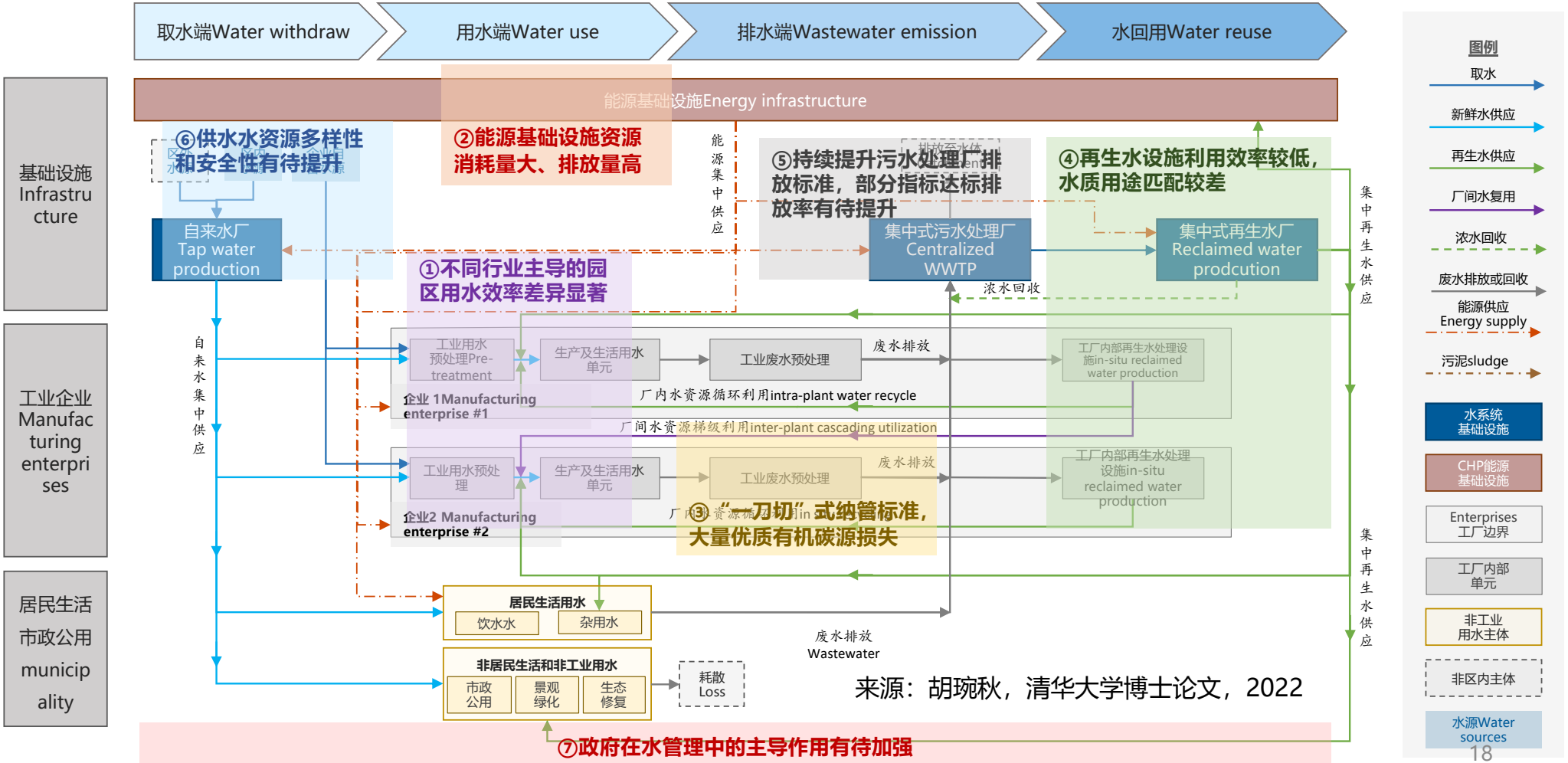




来源：胡琬秋，清华大学博士论文，2022

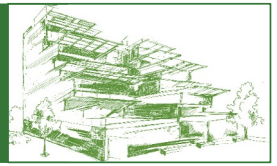
识别园区水管理中关键挑战，提出针对性的解决措施
Major challenges for sustainable WS in industrial parks

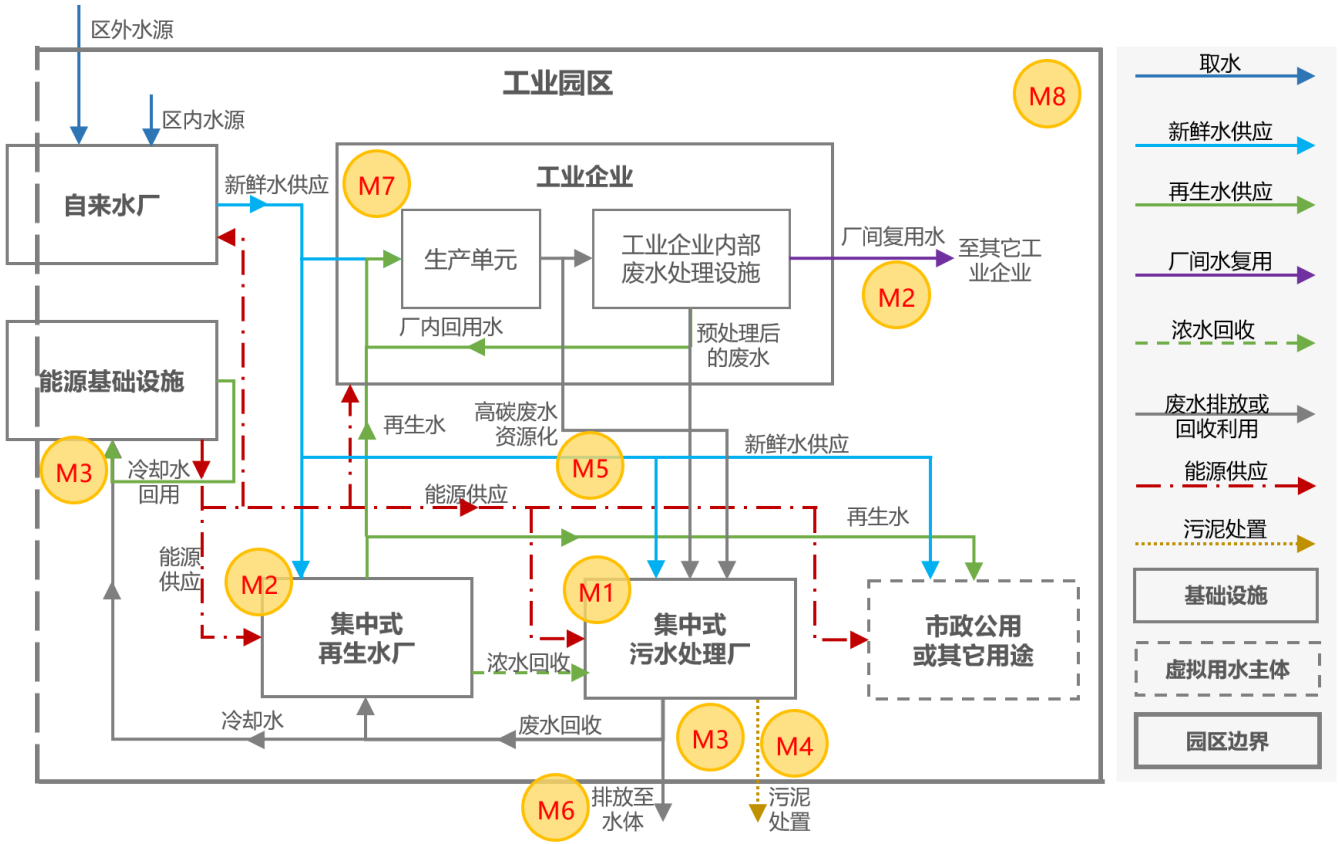




来源：胡琬秋，清华大学博士论文，2022

提升园区水管理创新指数的策略Measures to improve the WSI and overall environmental efficiency of the water utilization system in industrial parks

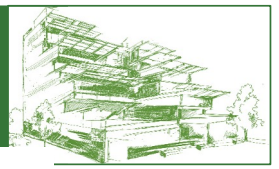


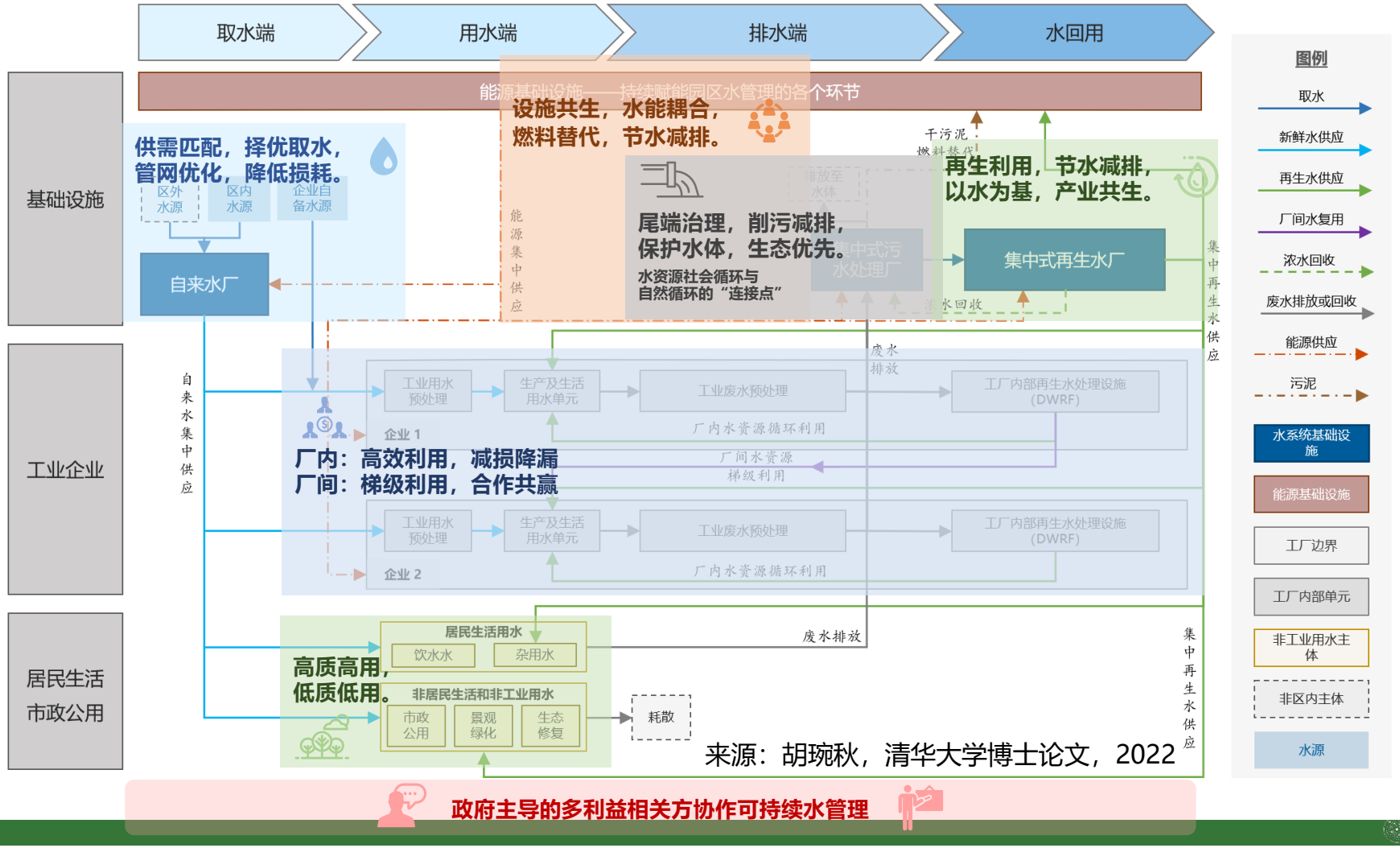


M1	集中式污水处理厂提标改造
M2	再生水系统综合管理
M3	基础设施产业共生
M4	污泥资源化利用

M5	污水资源化利用
M6	水系统监测能力提升
M7	工业企业清洁生产审核
M8	定期实施可持续水管理评价

全流程-多层级-多利益相关方协作的园区可持续水管理概念框架



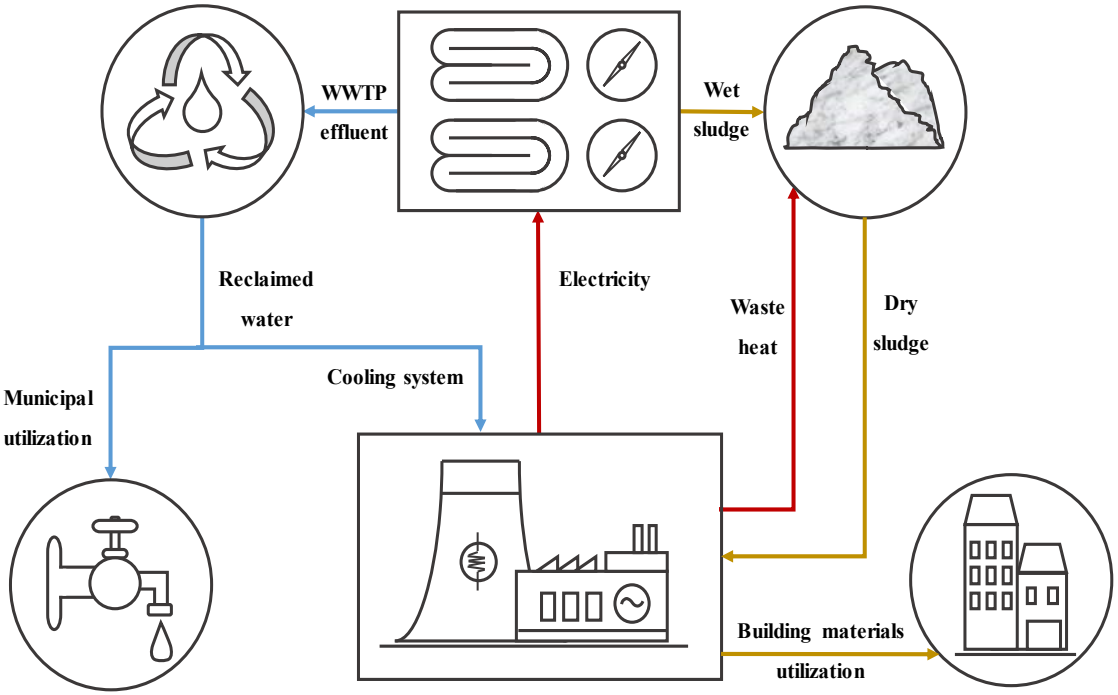


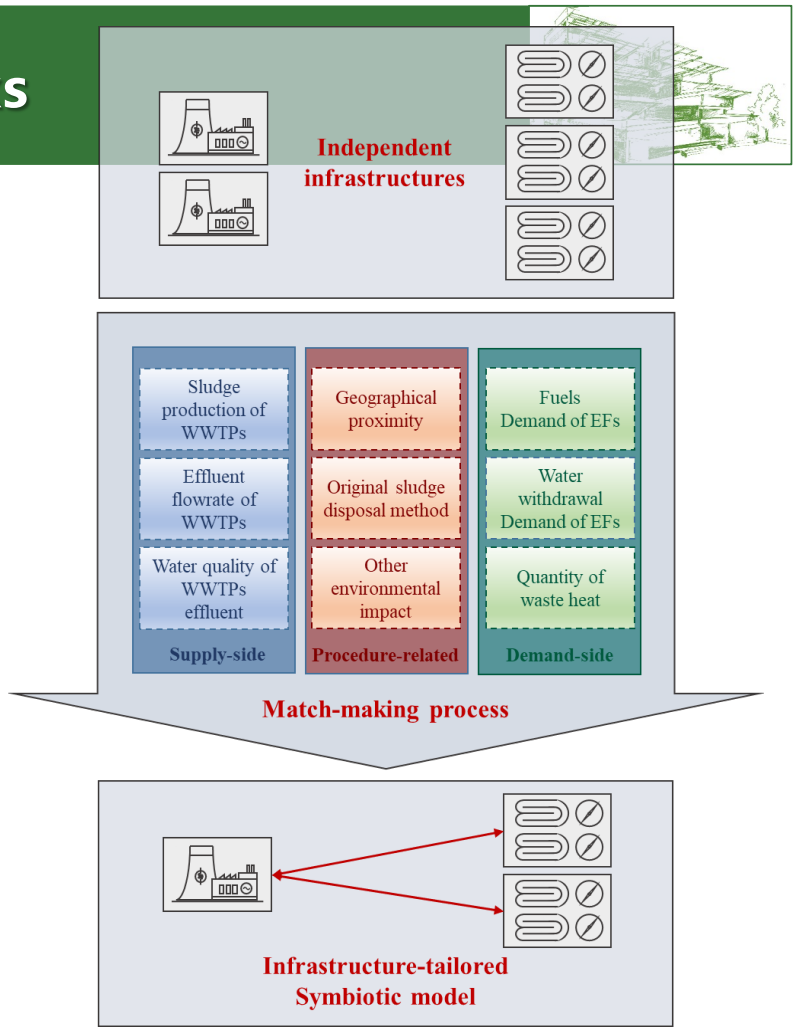
来源：胡琬秋，清华大学博士论文，2022

政府主导的多利益相关方协作可持续水管理

能—水统筹water-energy nexus in industrial parks

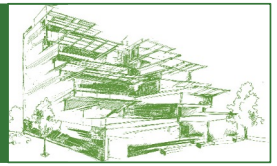
构建能源环境基础设施间共生体系
Industrial symbiosis among energy-environmental infrastructures



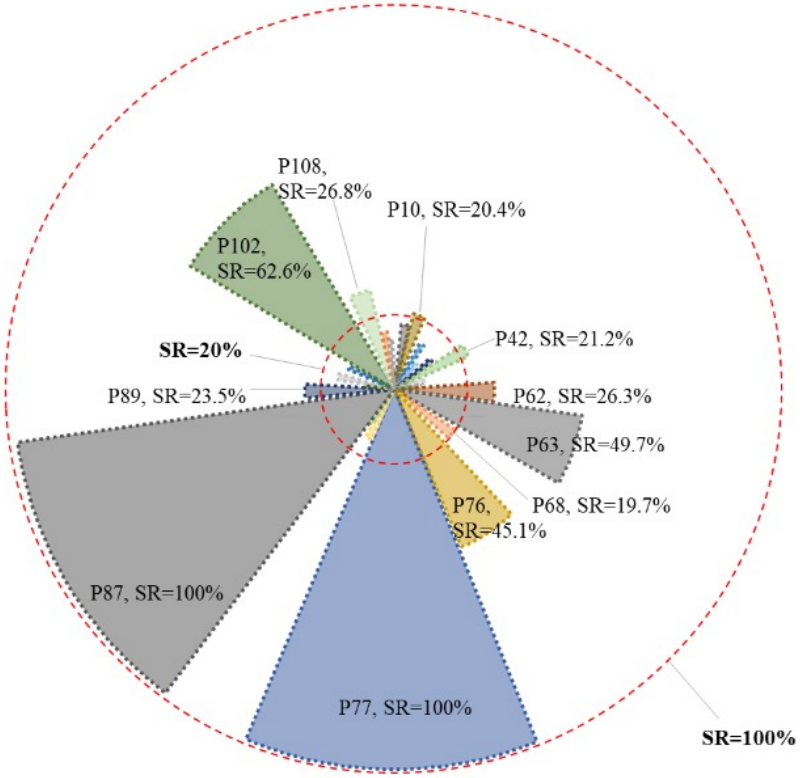


Schematic diagram of the stepwise establishment of infrastructure-integrated symbiosis model

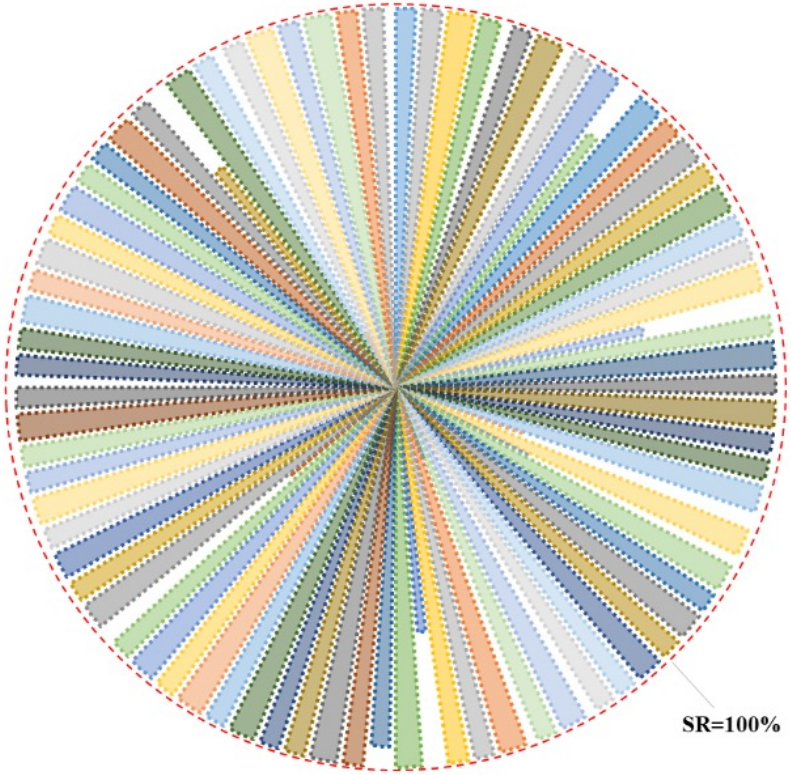
园区“能—水”统筹构建基础设施间共生体系water-energy nexus in industrial parks



基于111个国家级园区252 个WWTPs 和308 个能源基础设施分析，节水潜力和节能潜力分别为73%和7%。

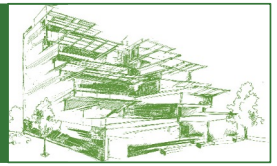


Sludge-to-energy potentials



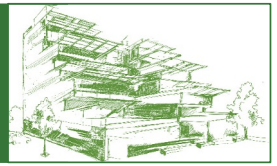
Water substitution potential

园区水管理的基本问题——量、质、价Monitoring the quantity, quality, and cost of water use in industrial parks



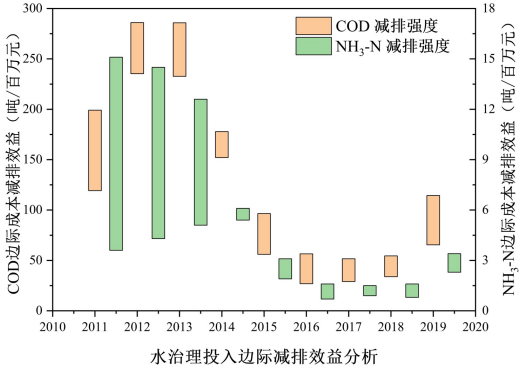
1. 园区每年用排水全过程的费用有多高?
2. 企业是否清晰地知道用了多少水，全流程水质变化及用水成本?
3. 水管理的重要基础工作——水平衡测试

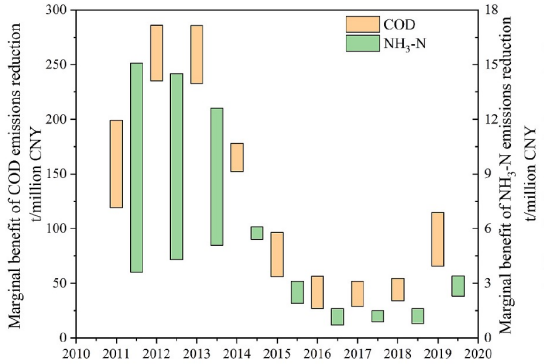
园区水管理的基本问题——量、质、价Monitoring the quantity, quality, and cost of water use in industrial parks



每百万元末端治理投入：

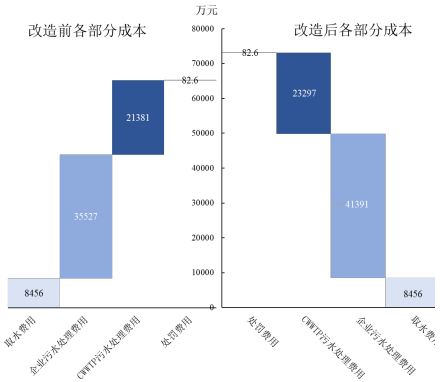
削减COD：65.5–114.5 吨；削减NH_3-N：2.3–3.4 吨





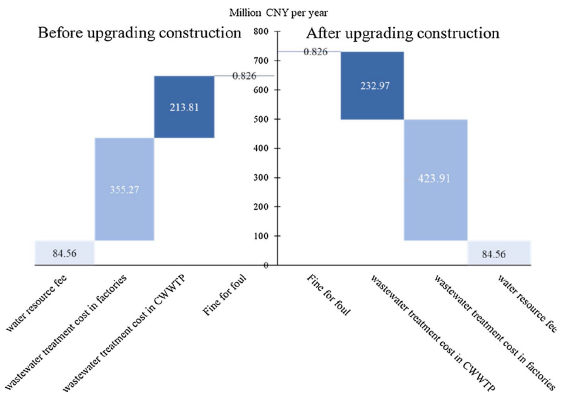
TN提标前成本

吨水处理成本27.3元/吨



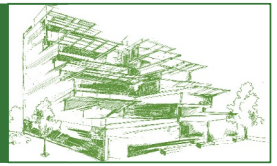
提高TN排放标准

吨水处理成本30.4元/吨



- 污染末端治理的成本已然非常之高，某化工园区年末端治理成本高达13亿元，占产值2.3%；
- 末端治理边际效应锐减，2011-2019年每单位经济投入COD、氨氮的减排量分别下降43%和70%，末端治理难以为继。

“十四五”国家重点建设一批节水型园区示范试点Central government facilitating a series of demonstration programs targeting sustainable water stewardship in industrial parks



2019年以来，中央政府相继发布了80余项与绿色低碳循环相关政策文件，提出一系列节水型园区示范试点行动或目标。

国家重点建设的节水型园区示范试点

工业废水近零排放示范园区；工业节水标杆园区

海水淡化示范工业园区；工业废水循环利用示范园区