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城市轨道交通“绿智融合”的发展新趋势

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2020 年 3 月 12 日，中国城市轨道交通协会发布了《中国城市轨道交通智慧城轨发展纲要》；2021 年 12 月 9 日，国务院印发了《“十四五”现代综合交通运输体系发展规划》；2022 年 8 月 18 日，中国城市轨道交通协会发布了《中国城市轨道交通绿色城轨发展行动方案》。国务院、中国城市轨道交通协会先后发布的文件表明，“绿智融合”是新时代中国城市轨道交通发展的新趋势。

《中国城市轨道交通智慧城轨发展纲要》提出了“智慧城轨”建设蓝图以及“智慧城轨”的八大体系，其中智能运维是切合当下行业迫切需求且已经形成技术创新应用的发展亮点之一。以基础设施智能运维为例，未来发展趋势是通过智能感知体系的建设及智慧平台的应用，打造覆盖“感知—分析—评价—决策”全流程的智能运维体系，形成包含综合检测车、搭载式检测设备、电驱检测平台、便携式检测设备和智能运维平台等在内的“检测装备 + 载具 + 平台”的谱系化智能运维体系。其中感知端的核心设备是新一代智能化综合检测列车，该列车可兼容不同限界条件及多种供电制式，可应用于互联互通的运营线网，实现等运营速度、等轴重下的轮轨、弓网、隧道、通信、信号等全断面、一体化检巡，实现多专业的综合分析和系统病害的精确定位与评估；智能运维平台涵盖基础数据管理、检测分析管理和运维综合管理三个中心，具有线网级、多专业基础设施数据资产管理、检测数据智能化分析、数据多维度可视化展示、基础设施状态评价与预警告警、运维作业流程闭环管理等功能。

《“十四五”现代综合交通运输体系发展规划》指出：全面推进绿色低碳转型，推广低碳设施设备，鼓励在交通枢纽场站，以及公路、铁路等沿线合理布局光伏发电及储能设施。城市轨道交通在规划、设计、建设以及运营等各环节均有较大的节能空间。

绿色化主要涵盖“开源”和“节流”两个方面。“开源”方面主要是指新能源应用。根据城市轨道交通用地与用能特点，可以充分应用分布式光伏发电技术，利用车辆段、停车场、车站及其附属建筑的屋顶等可用场地发展光伏发电，并将电能优先用于满足城市轨道交通建筑自身的用电需求，以及将光伏发电接入牵引网。另外，地源/空气源热泵、氢能源等新能源也具有较好发展潜力。“节流”方面主要是指低碳节能技术应用。目前中压能馈装置、飞轮储能装置、双向变流技术、新型电力储能装置等技术和装置都已获得应用。在未来的新线建设和运营中，建设阶段可采用 BIM（建筑信息模型）、装配式建造等技术以及高强低耗建筑材料；采购装备时可优先选用集成多种低碳技术的绿色简统化车辆；设计供电系统时，可将车站建筑设计为“光伏 + 储能/蓄电池 + 直流配电 + 智能充电桩”的柔性用电建筑；构建运维体系时，应包括能源管理控制平台，建立系统能耗管理机制。

“绿智融合”是城市轨道交通发展的新趋势，应统筹谋划，重视顶层设计，坚持自主创新，攻克智慧化、绿色化的关键核心技术，并加强上下游产业协同，进一步推进“智慧城轨”技术与“绿色城轨”技术的深度融合，以智慧赋能城市轨道交通绿色低碳发展目标，最终实现城市轨道交通行业的高质量发展。

Commentary

New Development Trends for 'Green-Smart Coalescence' in Urban Rail Transit

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On March 12, 2020, the China Association of Metros released the 'Development Outline of Smart City Urban Rail Transit in China.' On December 9, 2021, the State Council issued the 'Development Plan of Modern Comprehensive Transportation System in the 14th Five-Year Plan.' On August 18, 2022, the China Association of Metros unveiled the 'Action Plan of China

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Urban Rail Transit Green Urban Rail Development.′ These documents successively released by the State Council and the China Association of Metros demonstrate that ′Green-Smart Coalescence′ is the new development trend for China urban rail transit in the new era.

The ′Development Outline of Smart City Urban Rail Transit in China′ presents a blueprint for the construction of ′Smart urban rail′ and outlines eight major systems, among which IOM (intelligent operation-maintenance) stands out as a prominent development focus, closely aligned with the industry urgent needs and marked by notable technological innovations. Taking infrastructure IOM as example, the future development trend revolves around the establishment of an IOM system that covers the entire process of ′perception, analysis, evaluation, and decision-making′ through the construction of an intelligent sensing system and the application of a smart platform. This involves creating a systematic approach to IOM that includes a spectrum of ′inspection equipment + carriers + platforms.′ Core equipment on the sensing end includes the next-generation intelligent comprehensive inspection train. This train is compatible with various clearance conditions and multiple power supply formats, making it suitable for interoperating networks. It enables comprehensive inspections and patrols across all sections, including wheel-rail, pantograph-catenary, tunnels, communications, and signals, under conditions of uniform operating speeds and axle loads. It achieves comprehensive analysis across multiple disciplines and precise localization and assessment of system faults. The IOM platform encompasses three centers: basic data management, inspection and analysis management, and comprehensive operation-maintenance management, offering functions such as network-level, multi-disciplinary infrastructure data asset management, intelligent analysis of inspection data, multi-dimensional data visualization, infrastructure status assessment, early warning and alarm, and closed-loop management of operation-maintenance processes.

The ′Development Plan of Modern Comprehensive Transportation System in the 14th Five-Year Plan′ points out: green and low-carbon transformation shall be comprehensively advanced, low-carbon facilities and equipment shall be promoted, and it is encouraged to rationally layout photovoltaic power generation and energy storage facilities at transportation hubs, as well as along corridors such as roads and railways. Urban rail transit has significant energy-saving potential at each stage of planning, design, construction, and operation.

Green transformation mainly encompasses two aspects: ′energy generation′ and ′energy conservation.′ Regarding ′energy generation,′ the focus is on the application of new energy sources. According to the characteristics of urban rail transit land use and energy consumption, distributed photovoltaic power generation technology can be fully utilized. This involves developing photovoltaic power generation on available sites such as vehicle depots, parking lots, stations, and their associated buildings. The electricity should be prioritized to meet the electricity demand of the urban rail transit buildings themselves and connect photovoltaic power generation to traction grid. In addition, geothermal/air-source heat pumps, hydrogen energy, and other new energy sources also have good development potential. On the ′energy conservation′ front, the emphasis is on the application of low-carbon energy-saving technologies. Currently, technologies and devices such as medium-voltage energy feedback devices, flywheel energy storage devices, bidirectional inverter technology, and new types of power storage devices have all been applied. In the construction and operation of new lines in the future, during the construction phase, technologies such as BIM (building information modeling) and prefabricated construction, as well as high-strength, low-consumption building materials, can be used. When procuring equipment, priority can be given to green, simplified vehicles that integrate multiple low-carbon technologies. When designing power supply systems, stations can be designed as flexible electricity buildings with ′photovoltaics + energy storage/batteries + direct current distribution + smart charging stations′. In the construction of the operation-maintenance system, an energy management control platform should be included, and a system energy consumption management mechanism should be established.

′Green-Smart Coalescence′ is the new trend in urban rail transit development. It should be approached with comprehensive planning, a focus on top-level design, a commitment to independent innovation, and the overcoming of key core technologies related to intelligence and sustainability. Furthermore, there should be strengthened coordination between upstream and downstream industries. This will facilitate deep integration of ′Smart urban rail′ and ′Green urban rail′ technologies, ultimately empowering urban rail transit with smartness to achieve green and low-carbon development goals. This approach will ultimately lead to the high-quality development of urban rail transit industry.

(**Translated by ZHANG Liman**)