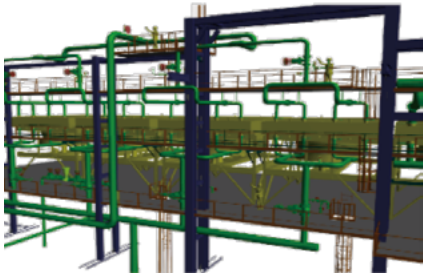
■Green technique practices and results

Techniques	Measures	Applications or results
Energy-saving and water-saving for processes	● Update process techniques or adopt optimal process designs ● Recycle waste heat generated during the process to produce steam for reuse	● Increase equipment efficiency and productivity ● Improve energy efficiency and save energy required for production
Energy-saving for the rotary machinery	● Optimize rotary machinery systems to improve transmission efficiency	● High efficiency motor: the electricity efficiency can be increased by 5% to 15% ● Using inverters: Achieve better control over process systems, lower machinery maintenance cost, lower noise output, and increased adaptability to system changes
Energy-saving for electrical engineering	● High-performance transformers: Use amorphous transformers to minimize loss of no-load iron cores. ● High-efficiency lighting: Utilize LED energy-saving lamps to improve energy efficiency. ● Renewable energy: Utilize solar energy, wind energy, among others, to transform natural energy into energy.	● Transformers: Increase performance while extending service life and reduce greenhouse gas emissions. Substantial energy consumption can be minimized in production processes, and materials can be reused. ● Lighting: Minimizing environmental light pollution and reducing greenhouse gas emissions. ● Renewable energy: Make full use of natural forces to reduce dependence on traditional non-renewable energy power, and effectively reduce carbon emissions.
Option specifications of the Equipment / Material	● Optimization design of the pressure vessel specification. ● The modification of the structure & material for the cooling tower.	● Inclusion of design specification with ASME Sec VIII Div.2 for big size pressure vessel or tower to reduce the thickness resulting in less material quantity and CO_2 emission. A prime example is the GCGV MEG project for ExxonMobil in the US. ● Replacing RC with FRP for the structure material of cooling tower, resulting in less material quantity/construction schedule & manpower and CO_2 emission. A prime example is the LPIC EPC 1 project in Oman.
Air pollution prevention	● Hydro-desulfurization and selective catalytic reduction (SCR) ① ● Using elements of denitrification, desulfurization, and dust removal to comprehensively treat all pollutants between the exhaust emission port and the chimney.	● Decrease emissions of various air pollutants, including particulate matters (PM2.5) ● The concentration of exhaust gas (SO_2, NO_X and particles) can become lower than that from the traditional exhaust gas treatment methods ● Achieve the standard for best available control techniques ● Decrease annual NO_X emission by more than 246,000 metric tons
Wastewater treatment	● Advanced dual-layer gas gathering up-flow anaerobic sludge blanket method ● Process techniques and membrane bioreactor (MBR) ② ● Electro Dialysis Reversal (EDR) technique in industrial wastewater recovery ③	● Over 70% of the COD removal rate, 60% of the methane contained in the biomass gas is sent to the boiler in the plant as fuel. ● Improve wastewater treatment performance ● Reduce risks during water shortages
Vibration control	● Set up a vibration group based on task orientation, including experts in various fields such as process, equipment, piping, civil engineering, etc., to assist projects and customers to deal with various vibration phenomena.	● Ensure that equipment, pipelines, and structures conform to vibration
Equipment noise control	● Use mufflers, sound-proof shields, and acoustic barriers. ● Equipment suppliers are required to conduct noise tests and provide test reports. ● Analyze the plant area using engineering software and visualize the noise distribution. ● Analyze the Pressure Safety Valve (PSV) noise with recommendations for noise abasement measures.	● The overall noise in the plant is within the permissible limit, which also minimizes the negative impact of the workplace environment on operators. ● Analyze the feasibility of replacing unnecessary implementation of the silencers by the single or dual hearing protection devices according to the PSV relieving scenarios to reduce CO_2 emissions by decreasing the steel amount, which has been applied in LNG and petrochemical projects in Thailand, India, and Malaysia.
Application of low-emission valves	● Low-emission valves with a leakage specification of 100 ppm are used instead of the general valves above 1,000 ppm.	● Effectively lowering the fugitive emission of valve operations, minimizing the impact of VOCs ④ to the staff and the environment
Green construction ⑤	● Green design, permeable pavement, and green vegetation cover design, and utilization of green building materials.	● Reclaimed water recycling project: The total amount of carbon sequestration in the 40-year life cycle reached 124,763 kg, 35,683 kg better than the greening reference value (89,080 kg).
Plant arrangement value engineering (VE) applications ⑥	● Optimize the arrangement of equipment, structures, piping, and other objects and minimizing the distance between units.	● Effectively save the amount of steel structure and concrete used, reduce the consumption of energy resources and greenhouse gas emissions.
Life cycle cost analysis and applications	● Introduce software for life-cycle cost analysis (EEA) ⑦	● Enhance the scientific basis and sustainable concept of proposals
Project real-time information dashboard	● Establish a shared information platform system	● Real-time and synchronous inspection of the execution status of project engineering, procurement, construction, and commissioning; and make project execution information more transparent and easier to manage.
Engineering equipment information integration and application	● Formulate standardized equipment control operation process and powerful equipment control systems	● Appropriate equipment can be delivered to construction sites in time to meet the requirements of quality and scheduling needs of construction sites.

Techniques	Measures	Applications or results
Building information and modeling techniques applications	● Use Revit's 3D to construct models for civil engineering and construction projects and related building materials, as well as to develop interface programs.	● Improve the quality of engineering design, provide accurate drawings, labor, and materials, and extend the application to construction management, thereby minimizing waste of materials and effectively controlling the project schedule.
Automated piping arrangement and electrical pipeline design	● Develop automated design systems for planning and design of system control wiring path	● Improve work efficiency, minimize human design errors, shorten processing time, improve the quality of prints, and saving labor costs.
3D laser scan applications	● Construct point cloud in digital models to reconstruct physical objects or environments into accurate 3D models.	● Applied to plant expansion engineering in an oil refinery in Thailand and a petrochemical plant in Saudi Arabia.
Application of mobile devices in construction sites	● Incorporate engineering management into mobile construction site operations	● Accelerate the operation process of construction management review, input, query and so on. ● Applied to sulfur plants, power plants, flare gas recovery system plants, and EVA plants ⑧
Precast concrete technique	● Reinforced concrete bars are cast first under stringently controlled environment in the factory	● Advantages include high durability, low repairs and maintenance requirements, short installation time, high cost-effectiveness, quieter and cleaner construction sites, and high fire-resistance grading.
Modular construction applications	● Modular designs for construction details; dynamic simulation of the hoisting process of modular construction using CTCI's innovative 4D software.	● Implement a safe and viable installation sequence to shorten the installation time, increase construction quality, minimize work aloft, prevent occupational hazards, and reduce the need for labor in welding. ● Applied to naphtha crackers and sulfur plants
Precast piping and installation applications	● Formulate construction plans with piping section precast system, add barcode label function for obtaining information such as production, warehouse management, and installation data.	● Share design drawings and discussions with remote project teams in real-time, increase the efficiency of construction site management, reduce construction errors, and save on construction cost.
Technical application of wireless instruments	● Replace traditional wired instruments with wireless instruments	● Lower plant construction cost ● Successfully incorporate wireless corrosion detection instruments in overseas RFCC plants ⑨

Notes

① SCR = Selective Catalytic Reduction
② MBR = Membrane Bioreactor
③ EDR = Electro Dialysis Reversal
④ VOCs = Volatile Organic Compounds
⑤ The data is calculated according to the "Green Building Design Technical Specification."
⑥ VE = Value Engineering
⑦ EEA = Carrier Engineering Economic Analysis
⑧ EVA = Ethylene Vinyl Acetate
⑨ RFCC = Residual Fluid Catalytic Cracker

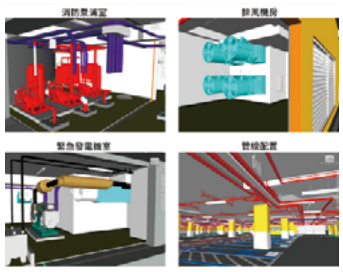


Parametric 3D automatic piping

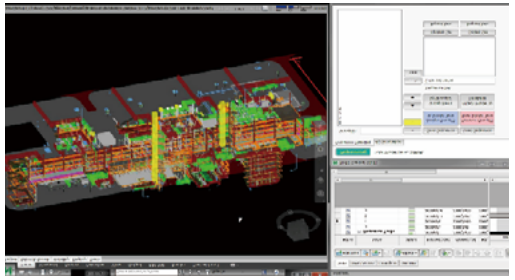
Modular applications to constructions

3D laser scanning applications

MRT Railway



Building Information Modeling (BIM)



Construction process simulation