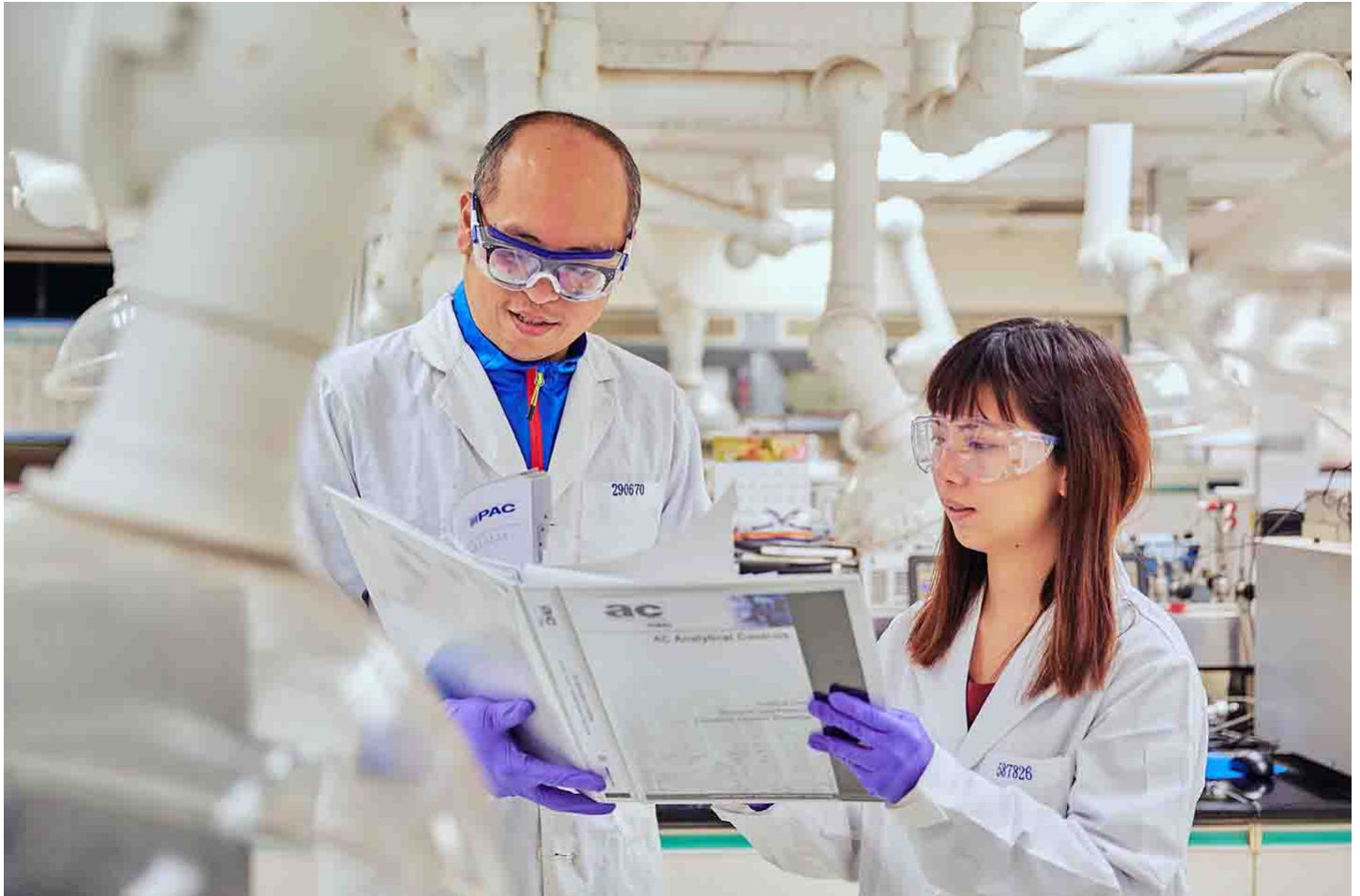




Research & Development



Research and Development

Research and Development (R&D) has been a core value for both technological innovation and corporate sustainability for CPC. Three major institutes are responsible for R&D in their respective areas: the Exploration & Development Research Institute (EDRI) in Miaoli, the Refining & Manufacturing Research Institute (RMRI) in Chiayi and the Green Technology Research Institute (GTRI) in Kaohsiung.

The EDRI primarily focuses on the analysis of domestic and foreign geological/stratigraphic data for the evaluation of oil and gas reserves, technological development on exploration, drilling and extraction methodology, environmental

monitoring, geothermal resource development and carbon sequestration. The RMRI plays a leading role in the R&D of high value-added petrochemicals, the promotion of the circular economy, pollution control, the improvement of refinery structure or configuration, and resolving on-site production problems. The GTRI is dedicated to R&D related to biofuels, renewable energy and green materials, and is responsible for pilot production on advanced projects.

CPC's expenditure on R&D in 2021 amounted to about NT\$3.666 billion. The R&D achievements are described below:

Exploration & Development Research Institute

- Re-evaluated Oryx fields' Original Oil in Place (OOIP) and reserve based on an updated reservoir structure and 3D geological models.
- Evaluated the feasibility of contract extension for Block 17 in Ecuador.
- Conducted an analysis of the petroleum system of the Roebuck Basin on the North Western Australian shelf.
- Conducted an analysis of the impact of COVID-19 on the shale oil and gas industry in North America.
- Planned a road map for carbon capture, utilization and Storage (CCUS) technological development in cooperation with the RMRI and conducted a preliminary assessment of the domestic potential carbon storage sites.
- Established casing materials screening technology for the Matsao area, in Yangmingshan, and collected information on strategies for overcoming acid geothermal fluid among different countries.
- Assisted the LNG Project & Construction Division in analyzing mud samples from Datan algal reef at the LNG Terminal Reservation Area.
- Assisted the Lubricants Business Division in investigating the soil and groundwater samples from the Longtan Oil Depot.

Refining & Manufacturing Research Institute

- Developed new production processes, including the introduction and evaluation of a new light diesel engine motor oil formulation to meet the European Automobile Manufacturers Association (ACEA) C3 5W/30 standards; the development and application of CPC amorphous soft-carbon in electric-vehicle batteries electrochemical/mechanical hybrid shear exfoliation graphene of artificial graphite; environmentally-friendly precision machinery cutting oil; the on-site application of chemical oxidation technology in Xinguang Community; the development of styrene recycling technology; the establishment of alicyclic polycarboxylate hydrogenation technology; the planning of the trial production process for refined bitumen; and the development and application of magnetic filters and packing technology.
- Completed the performance evaluation of commercial gasoline and diesel, heavy-duty diesel engine testing, gasoline and diesel fuel additive cleaning performance tests, and the promotion of natural gas heating value integration and stove specification unification standardization for environmental protection.
- Completed groundwater soil remediation and detection services in refinery polluted sites; airborne volatile organic compounds (VOC) monitoring; VOC recovery of gasoline filling exhaust; health risk assessment; and planning for special waste-liquid pretreatment and waste-water recycling to meet the environmental regulations and the requirements of environmental impact assessments.
- Continuous surveillance of the effect of stray electric currents from the Kaohsiung and Taipei MRT systems on pipelines, and assistance in diagnosing refinery boiler pipe problems in order to ensure pipeline safety.
- Successful conversion of CPC's own heavy oil through a self-developed proprietary refining process to exploit a long-life amorphous soft carbon material with the great potential to be used in the anodes of lithium ion batteries.
- Implementation and operation of Smart & Green e-station: completed the planning and construction of the "Taoyuan Jiadong Smart & Green Demo e-Station,"; deployed mobile LiFe battery storage modules for not only the verification of CPC's own soft carbon materials, but also for the potential application in emergency rescue in distress areas; conducted ongoing solar power generation and the verification of the Smart EMS (Energy Management System) at the "Chiayi Xinyi Smart & Green Demo e-Station".

- Optimized gasoline, diesel and petrochemical raw material production processes, and offered advisory services to resolve on-site problems and to enhance operational efficiency, in order to achieve energy-saving goals.
- The technology transfer of newly-formulated CPC Marilube, Guoguang brand low-alkali marine motor oil, environmentally-friendly metalworking fluid, and long-life equipment oil.
- Development of CPC Racing CVT; Mirage PRO CVTF; CPC Superpower C3/SN Fully Synthetic Motor Oil 5W/30; CPC Racing C3/SN Fully Synthetic Motor Oil 5W/30; CPC Racing MB SN Fully Synthetic Motor Oil 5W/40; and American Petroleum Institute (API) ST 0W/20 passenger car engine oil and related products.
- Improved the dielectric properties of traditional substrate resin materials to meet the requirements of high frequency/speed transmission of 5G communication and successfully entered ton-scale pilot production. The resulting novel resin material has been certified by copper clad laminate (CCL) manufacturers for subsequent downstream promotion.
- Development of bio-based and bio-degradable plastics in compliance with the national plastic restriction policy. Bio-based plastics use biomaterials as feedstocks, while bio-degradable plastics can undergo further microbial decomposition to carbon dioxide and water. For bio-degradable plastics, CPC focused on polylactic acid (PLA) in the short-term and the more-environmentally-friendly polyhydroxyalkanoates (PHAs) in the long-term, in order to reduce pollution caused by synthetic plastics. Regarding the selection of feedstocks, non-food types, such as lignocellulose, methanol or natural gas, are among CPC's priority for the mutual benefit of economic development and environmental protection.
- Development of novel biomaterials, including whitening and antimicrobial ingredients in cosmetics/medical products, in order to break into the retail market with cosmetics made from CPC's own materials.

Green Technology Research Institute

- Established an Operations and Maintenance Center for PV Systems (OMCPVS), responsible for developing technologies for independent operation/management and

the promotion of PV system installation. The OMCPVS currently ensures the stable operation of more than 230 sites installed with roof-type PV systems, with a total capacity of 11.337MW.

- Operation of Smart & Green e-station: with the integration of solar PV, fuel cell and lithium titanate (LTO) batteries, the Tainan-Qianfeng gas station was transformed into a "Smart and Green Demo e-station." By collecting local climate data and environmental information, a big data system was developed which was used to build the solar PV power forecasting model. The Hualien-Guangfu gas station is another "Smart & Green Demo e-Station," which deployed a 25kWh mobile LTO energy storage system and an energy management system (EMS) with an online inspection function of energy storage system in order to improve safety management.
- A 1200F super-capacitor (charge and discharge between 1.35V to 2.7V at 40A with a capacity retention of 80% over 20,000 cycles) was developed, and the verification of 48V super-capacitor module was carried out.
- Conducted ongoing field verification of high and low temperature fuel cells for distributed power generation, and established a monitoring system and a big data database to conduct data collection, analysis and further applications.
- Received the "18th National Innovation Award" with "The development of high-safety and fast-charging lithium titanate energy storage materials," while the LTO demonstration plant with a thousand-ton per year scale is currently under construction. Proprietary new low-cost LTO materials have been sold to a battery company to be used in an LTO battery system as an emergency power backup in buildings.
- Completed the core technology development of electric bus battery system by using self-produced LTO materials, and successfully integrated and manufactured the first LTO electric bus and energy storage and charging system. The LTO electric bus passed the six critical performance tests through the Automotive Research & Testing Center.
- Developed a new low-carbon emission polyol-based polyurethane material for thermal insulation coatings which was then applied to the roof of oil tanks to reduce the average liquid temperature inside and roof VOC emissions, emphasizing the efficacy of practicing bio-low-carbon concept and reduction of corrosion spreading.

- Completed the automation of a batch-type pilot process for soft carbon production. The yield and capacity were both improved while also effectively suppressing particulate emission. The resulting soft carbon materials met the targeted specifications.
- Awarded with 2021 EU Seagiculture Innovation Gold Award with the topic "Cultivation of seaweeds using the cold seawater drainage from the Yongan LNG terminal to fulfill the circular economy for energy and water." The Development of seaweed extracts can enhance the growth of Human Follicle Dermal Papilla Cells, which has great potential for the future development of scalp care products.
- Developed the biorefinery production process for 5-Hydroxymethylfurfural (5-HMF) in compliance with national restrictions on plastics, and completed the continuous trial production equipment setup at laboratory-level and solvent/catalyst testing.

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