對外合作組織與機構動態報導

2017/4/14

FOUR FANTASTIC MATERIALS FOUND AT ARGONNE

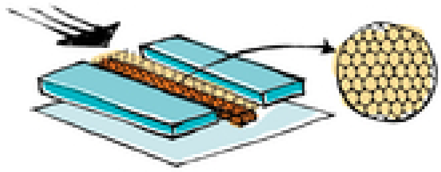
四種在阿岡發現的神奇材料：石墨烯、奈米盾、硼烯、磁荷冰

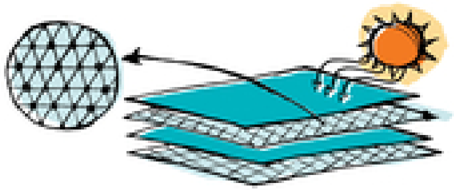
By Katie Elyce Jones • April 3, 2017

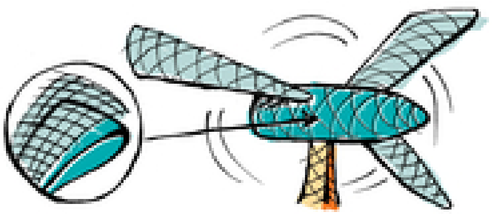
New materials are the seeds for new technologies. Here are four discoveries with never-before-seen properties that could lead to new devices, innovations, or breakthroughs.

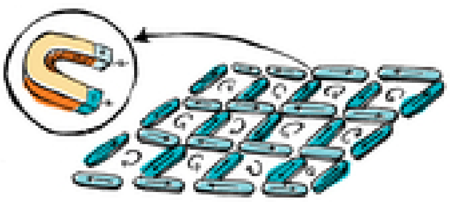
報告摘要(KEY INFORMATION)

1. 新材料是新科技之本。讓我們回顧在阿岡實驗室發現的 4 個重要材料：電子傳遞快——石墨烯、防護性強——奈米盾、堅固不易碎——硼烯，以及節省數據存儲空間——可重寫磁荷冰；種種新材料將會帶來新的構想與突破。
2. 如果科學家能得到原子結構面平移、擠壓的清晰成像，將有助於新興科技之進展，如奈米電子學領域、次世代半導體元件等。IBM 與阿岡實驗室已開發出一套新的成像方法——單角度同調 X 光繞射顯微技術。
3. 3 月 23 日，阿斯特里德公主訪視比利時核能研究中心位於莫爾的生命科學實驗室，公主藉此機會瞭解研究中心年輕研究學者在醫學及太空領域所推動的進展，先進的研究成果將帶來新興的醫學應用。
4. 中國的電動車銷量在 2015 年已經超過 24 萬輛，大約是前年的 5 倍，現已超過美國成為全球銷量最大的國家，銷量快速成長的關鍵是其對內的補助與稅率優惠。中國政府藉促進電動車的銷量以帶動整體運輸產業，同時減少機動車輛排放的空污，並降低目前石油能源過度依賴進口的風險。
5. 阿海琺公司與牛頓研究實驗室簽署合作協議，將讓結合阿海琺檢測專業與牛頓實驗室機器人科技之最先進的非破壞性檢測技術，進入美國核能產業；另外，其機器人維修技術亦將在近期進場。









1. **LIGHTNING-FAST GRAPHENE**
   The first scientists to create graphene, a single layer of carbon atoms, did so by progressively peeling away layers of graphite, the stuff of No. 2 pencils. Despite its origins as pencil ash, graphene is extremely hard and strong, tougher than diamond, and thin and flexible. As a single layer, graphene is a semiconductor, rapidly ushering electrons across its 2-D plane. In fact, electrons can travel up to 100 times faster through graphene than the silicon used in computer chips. Today at Argonne, researchers are exploring this amazing material's potential for electronics and other applications by creating different 2-D graphene structures—sheets, ribbons, scrolls, and more. For one study, scientists are designing circuits of graphene ribbons as thin as 50 atoms wide to take advantage of the super speed of its electrons for faster, more energy-efficient electronics. Specifically, they are observing the circuits' band structure, a directional property of semiconducting materials that must be understood before designing new devices

2. **PROTECTIVE NANOSHIELD**
   Roughly 80% of the cost of wind energy is tied up in machinery. Exposed to variable and often extreme conditions, turbines need to be tough. Resilient, long-lasting gears, rotors, and other machine parts are important to advancing the future of wind energy. But inevitably, after so many stop-and-go rotations, turbines begin to feel stress in the form of tiny fractures known as micropitting that lead to bigger problems as rotations continue.
   Luckily, Argonne has scientists who specialize in understanding the nanoscale vulnerabilities of mechanical parts and developing protective materials like coatings to reduce the friction that leads to cracks and pits. One such coating, called N3FC, has diamond-like carbon bonds—but instead of being hard as diamond, N3FC is relatively soft, providing a flexible shield that absorbs the impacts of cranking and sliding. 100 million test cycles later—about three times the typical number of test cycles—N3FC-coated parts have not incurred significant micropitting, which is already a pretty amazing track record.

3. **UNBREAKABLE BOROPHENE**
   Something special happens when you take atoms of the carbon-like element boron and spread them into a single layer: you transform a hunk of nonmetallic boron into a brand new 2-D material known as borophene. As the first metallic and lightest 2-D material that also sports a high tensile strength, or resistance to breakage, borophene could lend greater flexibility and durability to electronic devices and solar

cells at a lower environmental cost than industry staples like silicon.
Argonne scientists were the first to create borophene, and did so in a way that is easier and less toxic than previous experiments synthesizing boron-based materials.

4. **MAGNETIC CHARGE ICE**
In the game "20 Questions," a player must guess an object chosen by another player by asking a series of "yes" or "no" questions. Working within similar limits, computers store information based on only two states created by the opposing forces of tiny magnets (represented as 0s and 1s). If you have ever wanted to say "maybe" in 20 Questions, you understand why researchers want to develop technologies that can store information in multiple states: you can reach a complex answer much faster.
Recently, scientists at Argonne developed a 2-D material called "rewritable magnetic charge ice" that can store eight units of information—quite an electromagnetic vocabulary compared to yes and no. After separating magnetic spins and charges to achieve greater control over the magnetic charges, researchers used a local nano-magnet to "tune" eight charge configurations for relaying information. An external magnetic field can also be applied to easily erase and rewrite information, opening up the possibility for new computing functionalities.

SINGLE-ANGLE PTYCHOGRAPHY ALLOWS 3D IMAGING OF STRESSED MATERIALS

單角度同調 X 光繞射顯微技術可產生材料受壓時的 3D 成像

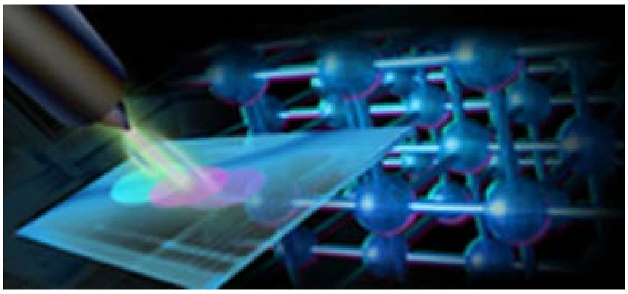
By Jared Sagoff • March 21, 2017

Everyone reacts differently under stress — even the relatively orderly atoms in a crystal. If scientists could get a clear picture of how planes of atoms shift and squeeze under stress, they could make use of those properties to provide emerging technologies, like nanoelectronics and next-generation semiconductor components, with extra speed or functionalities. However, creating this picture requires new techniques for imaging atoms in materials and their behavior in different environments.

In a recent collaborative study from the Institut Fresnel, IBM and the U.S. Department of Energy's (DOE) Argonne National Laboratory, scientists developed a new form of imaging that uses X-ray diffraction patterns, called single-angle Bragg ptychography.

Although Bragg ptychography and especially X-ray diffraction have been around for a while, single-angle Bragg ptychography allows for easier reconstruction of 3D data about how strain affects a material.

"What we needed was a trick to retrieve the missing phases of the diffraction pattern."



In X-ray diffraction, the atoms within a material "scatter" the incoming X-rays, producing a signal on a detector. Because there are so many overlapping diffraction events happening simultaneously, it can be hard to identify the contribution of a particular small region of the lattice to the overall signal. To compensate for this, scientists use a method called Fourier analysis, which essentially converts the overall signal to a series of waves with peaks and valleys that correspond to the relative intensities of various parts of the signal.

However, just doing regular X-ray diffraction only tells part of the story, said lead author and Argonne materials scientist Stephan Hruszkewycz. "In order to really see and understand the strain in real space, you need information on both intensity and the phase," he said. "What we needed was a trick to retrieve the missing phases of the diffraction pattern."

Phase can be understood by imagining waves lapping onto the shore after someone throws a handful of rocks into a still pond. Measuring the height of waves at the shore as well as their arrival time could allow you to "watch the wave backwards" by reconstructing the positions and sizes of all the rocks when they hit the water. X-ray detectors, however, only measure the height of the waves; phases, i.e. when the wave reaches the shore, must be recovered by other means.

The trick the authors used comes from ptychography, a technique that is able to recover phase information by using redundant sampling from the same region of the crystal. By shifting the X-ray beam only slightly, and by imaging as much as 60 percent of the same real space between beam positions, the team was able to extract information about the phase.

"In essence, by having a lot of the same information encoded in neighboring samples, it constrains the possible configurations of the crystal in real space," Hruszkewycz said.

The real advance, however, came not from information gathered through diffraction, but from the positioning of the beam itself. Because the researchers knew exactly where the beam was positioned and the angle at which the crystal's atomic planes would scatter the X-rays, they were able to extract additional information about how the strain affected the material in three dimensions.

"Most diffraction techniques, including some ptychographic ones, really only give a 2D representation of the sample of interest," Hruszkewycz said. "This technique also makes fewer requirements in terms of the instrument technology than comparable techniques for generating 3D information about materials."

An article based on the study, "High-resolution three-dimensional structural microscopy by single-angle Bragg ptychography," appeared in November in the online edition of Nature Materials.

The work was funded by the U.S. Department of Energy's Office of Science (Office of Basic Energy Sciences). The researchers used the Hard X-Ray Nanoprobe Beamline, which is operated by Argonne's Center for Nanoscale Materials at

Argonne's Advanced Photon Source. Both the Center for Nanoscale Materials and Advanced Photon Source are DOE Office of Science User Facilities.

Argonne scientists Martin Holt and Paul Fuoss also contributed to the study, along with researchers from IBM and France.

SCK•CEN YOUNG RESEARCHERS PAVE THE WAY FOR NEW THERAPEUTIC APPLICATIONS

比利時核能研究中心的年輕學者正推動醫療應用研究的進展

On Thursday 23 March, Her Royal Highness Princess Astrid visited the Life Sciences labs at SCK•CEN research centre, located in Mol. Princess Astrid seized the opportunity to find out more about technological and scientific progress made by the Centre's young researchers when it comes to space and medicine. State-of-the-art research which paves the way for new promising medical applications.

The Belgian Nuclear Research Centre (SCK•CEN) has been a pioneer in international research on the effects of low dose radiation on the human body and the environment for many years. In Belgium, medical applications – mainly imaging but also radiotherapy – are responsible for more than 95% of exposure to unnatural sources of radiation.

"Research conducted at SCK•CEN is essential in order to get a better understanding of the effects of exposure, mainly for foetuses and children, and to reduce the radiation dose absorbed by the patient to a minimum", explains Hans Vanmarcke, head of the Life Sciences department at SCK•CEN and Chair of the UNSCEAR, a scientific committee of the United Nations. "Thanks to these advances, we can evolve towards a personalized medicine where each and every patient is treated based on his genetic profile and his sensitivity to radiation. Consequently, cancer treatments become more efficient while causing less side effects."

These studies enable the development of new radiopharmaceuticals for better diagnosis and better cancer therapy but also better therapy for immune, cardiovascular and neurocognitive diseases. Research which also gains altitude and uses space as its field of exploration.

The astronaut is our laboratory technician

The daily dose of ionizing radiation is much higher in space than on earth and this has a direct impact on astronauts and bacteria in space. To be able to take up major challenges and to enable long-term space missions (for example to Mars), SCK•CEN researchers are working jointly with the European Space Agency and an international expert consortium on the development of a microbe-based waste recycling system called MELiSSA and able to produce oxygen, water and food in space.

For ten years, researchers of the Centre have been preparing a space experiment involving spirulina, an intriguing cyanobacterium capable of producing oxygen and food. In November, a device called 'photobioreactor' will fly to the International Space Station (ISS) to test the behavior of spirulina. The project will give us crucial information about oxygen production thanks to an active bacterial culture lasting several weeks in microgravity and space radiation conditions.

"It is a world first!", claims Natalie Leys, head of the Microbiology department at SCK•CEN, enthusiastically. "Our space projects are regularly chosen for sending experimental packages in the ISS. All of the collected data allow us to better understand how the human body and bacteria function and to use the results for therapeutic and biotechnological applications on earth."

Focus on three young researchers and their work

Space research also contributes to the scientific education program of the SCK•CEN Academy, offering teachers and students of high school and universities the opportunity to visit the labs and to carry out experiments there. "Thanks to this promising research and to our cutting-edge installations, we are welcoming many students and young researchers from all over the world every year", explains Sarah Baatout, head of the Radiobiology department at SCK•CEN. "Our large expertise and broad knowledge of the subjects enable us to make progress both within science and medicine."

REVIEW OF CO2 EMISSION CUTBACKS WITH ELECTRIC VEHICLES IN CHINA

中國的電動車如何降低碳排放量

LU Zheng, Senior Economist, Energy Data and Modelling Center

IEE JAPAN

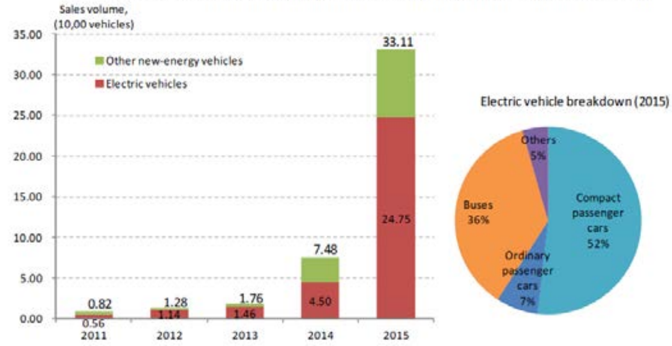
Electric vehicle sales in China surpassed 240,000 vehicles in 2015, a roughly five-fold increase over the previous year, putting China ahead of the US as the global leader. Key factors behind rapid expansion of electric vehicles in China are subsidies and tax incentives for electric vehicle purchases and exemption of electric vehicles from number-plate regulations in Beijing, Shanghai, and other major cities. By promoting adoption of electric vehicles, the Chinese government mainly aims to develop the automobile industry, as well as alleviate air pollution stemming from auto exhaust gas. And it can also be expected to contribute to energy security through reduction of oil usage in light of China's reliance on imports for over 60% of its oil needs.

At the same time, many observers are doubtful about the CO2 cutback effect of wider adoption of electric vehicles in China with its heavy reliance on coal in power generation. This report reviews the introduction situation of electric vehicles in China and consider whether wider adoption of electric vehicles in China contributes to cutbacks in CO2 emissions in light of the forecast for China's power source composition based on our " IEEJ Asia and World Energy Outlook 2016" released in October 2016.

Trend in electric vehicle introduction in China

The number of electric vehicles sold in China has risen sharply in recent years with an increase from about 8,000 vehicles in 2011 to 247,500 vehicles in 2015 that works out to an average annual growth rate of over 150%. Production and sale of electric vehicle continued to expand in 2016. Cumulative sales volume for Jan-Nov 2016 was already over 300,000 vehicles, rising about 80% versus the previous year. The Chinese government's plan presents goals for production and sale of new-energy vehicles1, which mainly consist of electric vehicles, of at least 2 million vehicles per year and cumulatively 5 million vehicles by 2020.

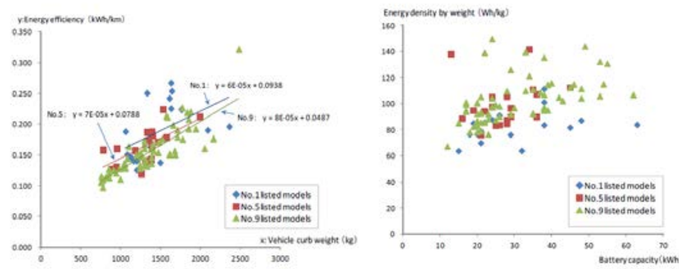
Figure 1: Sales of new-energy vehicles (mainly electric vehicles) in China



Almost all electric vehicles sold in China are currently domestic-made vehicles from local car manufacturers. The breakdown of electric vehicles sold in 2015 was passenger cars at about 60% and buses at just under 40%. Compact cars with a curb weight of 1,000kg or less accounted for around 90% of passenger cars.

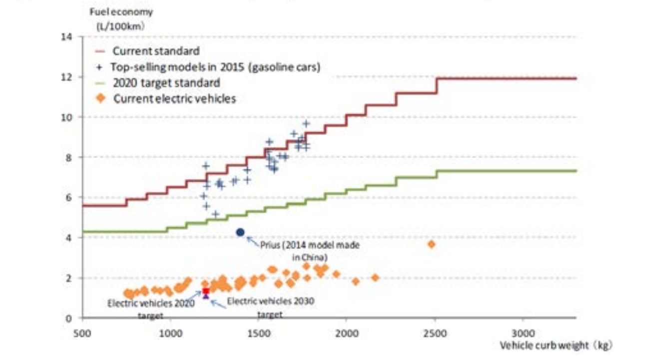
The Chinese government disclosed the lists of new-energy vehicle models on exemption from vehicle purchase tax nine times during August 2014 to November 2016. Energy efficiency improves with each release as seen in a graph of energy efficiency for electric vehicles (passenger cars) listed in the 1st (August 2014), 5th (September 2015), and 9th (November 2016) releases (Figure 2). While the energy density per unit of weight for battery systems has been steadily increasing too, the Chinese government's plan targets a level of at least 200Wh/kg2 by 2020 and steep improvements are necessary to reach the goal. Furthermore, many of the leading electric vehicles in terms of sales volume have a maximum speed in the 80km/h range, and considerable room still exists for enhancing performance.

Figure 2: Energy efficiency and battery performance of Chinese electric vehicles (passenger cars)



The Chinese government is strengthening fuel-economy standards for automobiles3 and seeks improvement of the target standard for 2020 (corporate average fuel economy) by about 30% versus the current level. Fuel economy of electric vehicles currently available in the market is 1/4-1/3 of gasoline vehicles using simple conversion of electricity to gasoline on a calorific value basis, and increased sales of electric vehicles provide an important means of curtailing corporate average fuel economy amid limited leeway to improve fuel economy in gasoline vehicles.

Figure 3: Passenger vehicle fuel economy and gasoline-converted fuel economy of electric vehicle in China



China's power source composition and outlook

The level of CO2 emissions at the power-generating stage (electricity's CO2 emission coefficient) strongly affects results in comparison of electric vehicles and gasoline vehicles by the unit of CO2 emissions. This section looks at the electricity CO2 emission coefficient in China.

China's electricity generation is 5,666 TWh in 2014, according to IEA data. This included 4,115TWh from coal-fired facilities, or 73% of the total, and 115TWh from natural gas-fired power plants and 10TWh from oil-fired o power plants. Fossil fuel-fired electricity accounted for a 75% share of total output. Coal, natural gas, and oil used to generate electricity were 925 million ton oil equivalent (Mtoe), 21Mtoe, and 2.3Mtoe respectively. CO2 emissions from consuming these fuels amounted to about 3.72 billion tons4. These values put China's CO2 emission coefficient at the power generation end in 2014 at 656 gCO2/kWh. Additionally, the CO2 emission coefficient at the final consumption level was 788gCO2/kWh after factoring in consumption within the power plant and electricity lost in transmission.

China is steadily expanding installations of non-fossil energy power generation, and the No.13 five-year plan (2016-20) presents goals of 58GW, 340GW, 210GW, and 110GW accumulated installed capacities for nuclear power, hydropower, wind power, and solar power by 2020 respectively. Our "IEEJ Asia and World Energy Outlook 2016" released in October 2016 indicates decline in the share of coal in China's power supply composition from 64% in 2020 to 57% in 2040 in the reference case that reflects past trends as well as energy and environment policies that have been introduced so far. While natural gas-fired power generation is slated to increase, the share of fossil fuel-fired power generation shrinks to 69% in 2020 and 66% in

2040. The electricity CO2 emission coefficient on the final consumption basis decrease to 691gCO2/kWh in 2020, a 12% drop from the 2014 level, and 601gCO2/kWh in 2040, a further 24% decline (vs. 2014), thanks to upturn in power generation efficiency and decline in power transmission loss.

In the Advanced Technology case (Adv. Tech.) that assumes robust energy and environmental policies and technology advances in non-fossil fuel power generation, the share of fossil fuel-fired power generation narrows to 64% in 2020 and 51% in 2040, and the electricity CO2 emission coefficient on the final consumption basis moves to 648gCO2/kWh in 2020 (-18% vs. 2014) and 461gCO2/kWh (-42% vs. 2014).

Figure 4: China's electricity generation by energy source

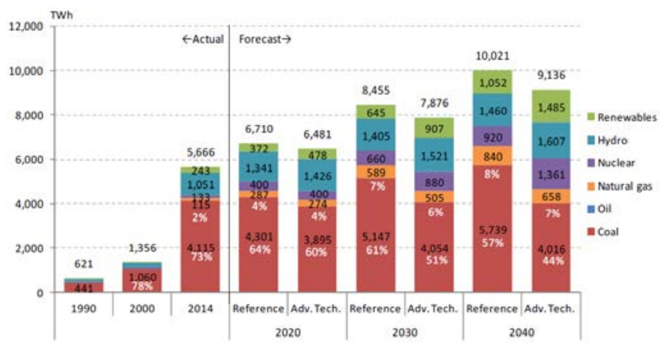
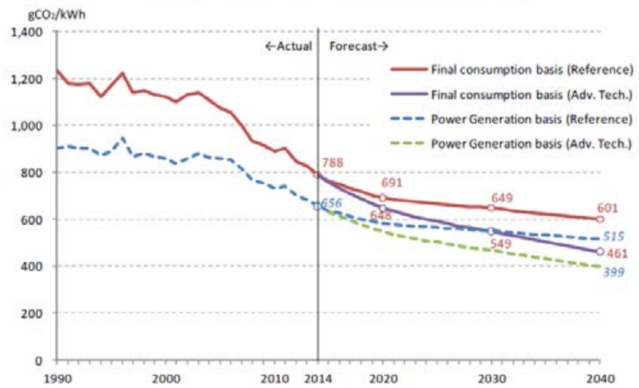


Figure 5: China's CO_2 emission efficient for electricity



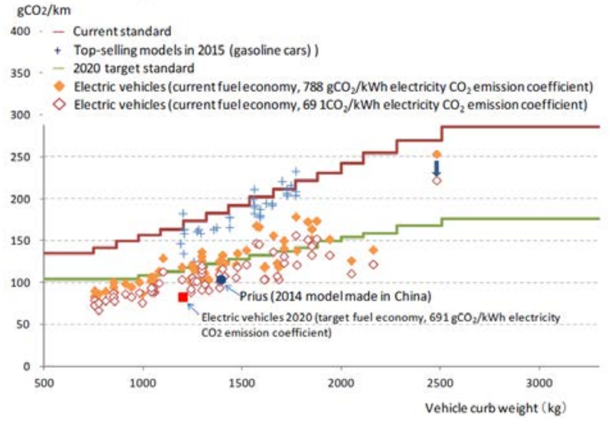
CO2 emissions unit for electric vehicles in China

Figure 6 presents results from calculating the electricity CO2 emissions unit for electric vehicles in China based on fuel-economy values from Figure 3 utilizing the above-mentioned electricity CO2 emission coefficients at the final consumption level. The CO2 emissions unit for current electric vehicles has an estimated range of 76-253gCO2/km in the case of the 2014 electricity CO2 emission coefficient (788gCO2/kWh). Many models have a lower value than existing gasoline passenger cars. However, few models exceed the target standard for 2020 and values are larger than for hybrids.

Meanwhile, if the electricity CO2 emission coefficient drops to the level in the reference case (691gCO2/kWh; -12% vs. 2014), the CO2 emissions unit for electric vehicles has an estimated range of 67-2253gCO2/km, even at the same energy efficiency as currently. Many models are below the 2020 target standard, though values are roughly on par with hybrid vehicles.

If the electricity CO2 emission coefficient declines to the level in the technology advancement case (648gCO2/kWh in 2020 and 549gCO2/kWh in 2030) and energy efficiency in electric vehicles rises on track with the roadmap, the CO2 emissions unit for electric vehicles (1,200kg vehicle curb weight) falls to 78gCO2/km in 2020 and 53gCO2/km in 2030,putting it at less than half of gasoline vehicles at the target standard for 2020.

Figure 6: CO_2 emissions unit for electric vehicles in China



Conclusions

Coal-fired power occupied a share of over 70% of China's power generation composition in 2014, the electricity CO2 emission coefficient on the final consumption basis was high at 788gCO2/kWh. Currently, from the perspective of reducing CO2 emissions, electric vehicles do not exhibit much of an advantage over gasoline vehicles and have a higher CO2 emission unit than hybrid vehicles. Nevertheless, China is likely to make significant advances in lowering carbon content in power generation, in this context wider adoption of electric vehicle will substantially lower CO2 emissions in China, with the consistent improvement in the efficiency of electric vehicle.

AREVA PARTNERS WITH NEWTON RESEARCH LABS TO PROVIDE INDUSTRY-FIRST COMPREHENSIVE ROBOTIC EXAM TECHNOLOGY

阿海珐公司與牛頓研究實驗室合作，將全面檢測機器人技術引入產業

CHARLOTTE, N.C., March 21, 2017

AREVA forward-looking energy

AREVA NP signed an exclusive agreement with Newton Research Labs, Inc. to make Newton's non-destructive evaluation (NDE) inspection technology available to the U.S. nuclear industry. The combined service will be the most advanced NDE tank inspection and robotic repair service currently available in the nuclear industry.

With this partnership, AREVA NP becomes the exclusive U.S. supplier for Newton's "Inspector" robot technology for tank inspections. This semi-autonomous, underwater robot surveys the floor of a borated water storage tank without the need to drain or remove the tank from service. This allows utilities to complete these inspections faster and more efficiently, ensuring the continued safe operation of the nuclear power plant. Inspector robots can map and inspect more than 90 percent of a tank floor; this includes inspecting within close proximity to the tank's wall edge.

"AREVA NP is an industry leader in providing phased array ultrasonic techniques and equipment for nuclear plant examinations," said Craig Ranson, senior vice president of the Installed Base Business Unit in the United States. "Our proven inspection expertise combined with Newton's robotics ingenuity will help us provide improved methods to enhance maintenance and safety in the nuclear energy industry."

"The Inspector has a track record of success inspecting in-service water storage tanks both during outages and off-outage," said Eric Yates, sales manager of Newton Labs. "We are excited to work with AREVA NP to continue offering this comprehensive inspection and repair service, and we will work together to develop new ways to improve plant operations."

First deployed in 2014, Newton's Inspector robots are a field-proven solution that allow for complete remote inspections in empty or full water tanks during operations or off-peak seasons. They employ a combination of autonomous machine vision navigation and direct operator guidance to accurately identify and map tank floor weld locations. This is followed by a detailed inspection on a per-plate basis, providing XYZ coordinate locations of any identified flaws in the tank floor using a phased array ultrasonic test. Using on-board sensors, locations of any identified defects are pin-pointed to within 1/8th of an inch (3 mm), allowing for a precision return for further inspection or repairs.

AREVA NP's inspection services agreement with Newton Labs combines the expertise of both firms: NDE testing and analysis by AREVA NP, and optical inspection, underwater laser scanning and robotics by Newton. The agreement is exclusive to North America, with global consideration on a case-by-case basis.