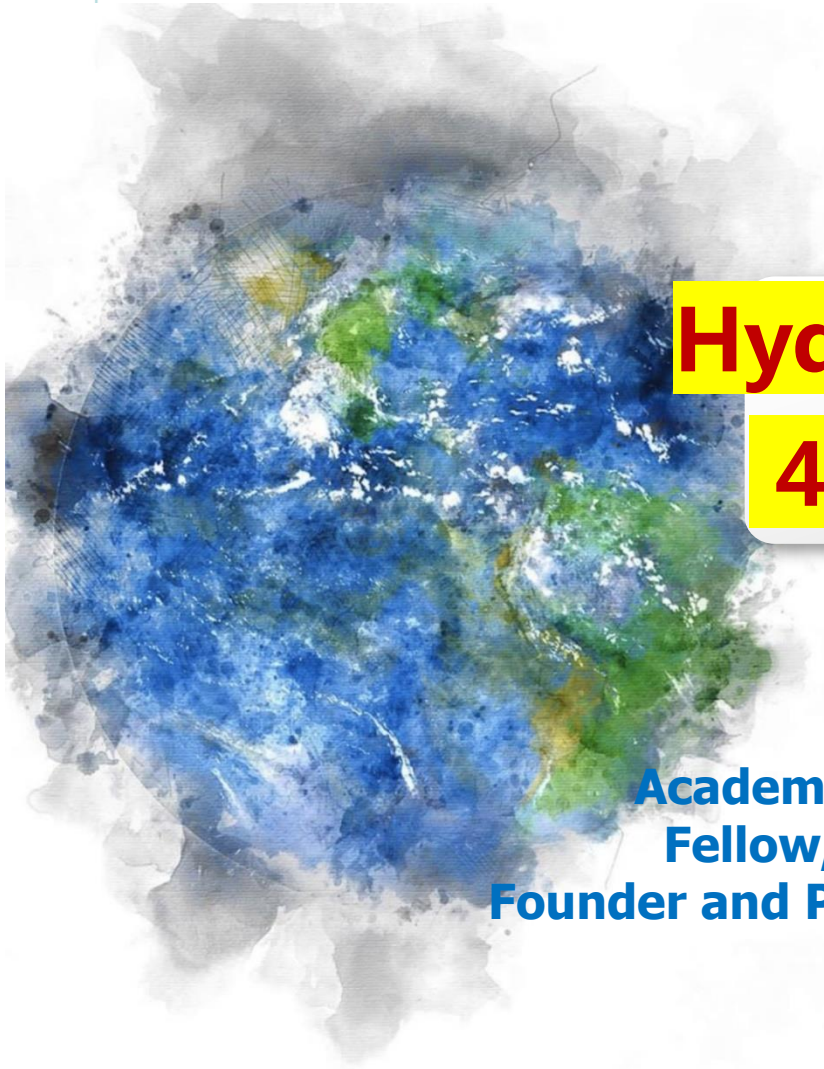
Hydrogen Economy Conference 2020



Hydrogen Energy Promotes 4th Industrial Revolution

Professor C. C. Chan

Academician, Chinese Academy of Engineering
Fellow, Royal Academy of Engineering, U.K.,
Founder and President, World Electric Vehicles Association
University of Hong Kong

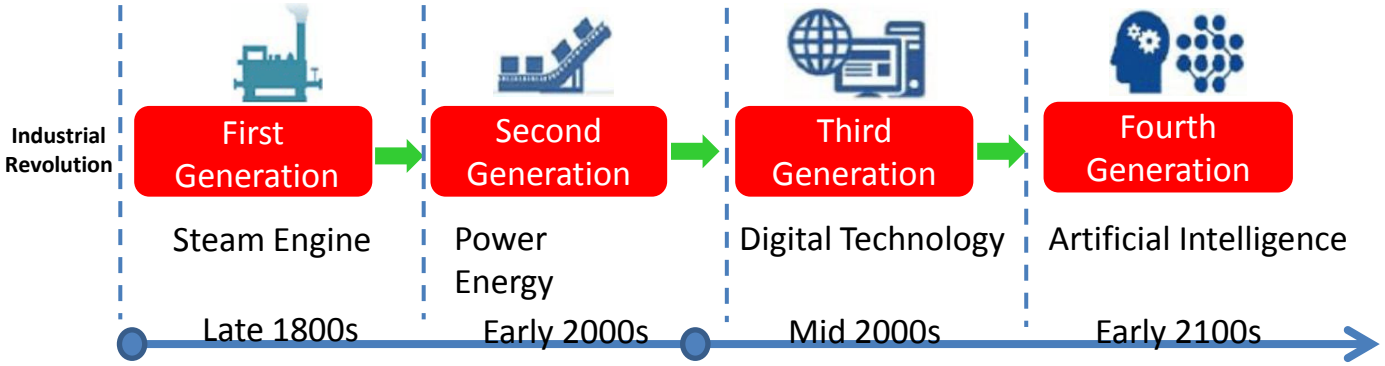
Hong Kong 23 November 2020

Core Content

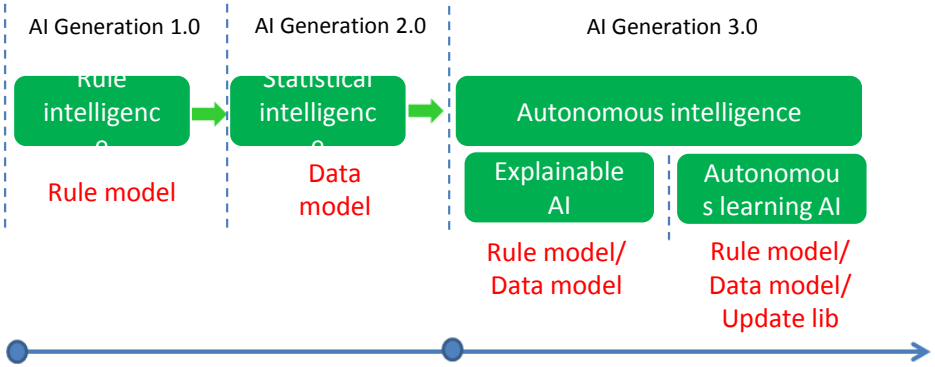
4th Industrial Revolution – Digital Economy – Energy Revolution

- Innovation
- 3 Revolutions and 4 Integration
- **Development of Hydrogen Technology**
- Summary

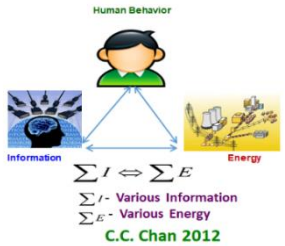
Artificial Intelligence AI role in 4th revolution



- Smart grid based on control theory
- Internet of Energy powered by data
- Integration of four networks driven by knowledge and intelligence



Integration of Four Nets and Four Flows ---
The Driving Force of the Fourth Industrial Revolution



- The core of fourth industrial revolution is artificial intelligence.
- Digital economy is to achieve high-quality economic development through digitalized knowledge and information.
- The fourth industrial revolution will disruptively change the lives of us and future generations, and recreate the economy, society, culture and environment on which mankind depends.
- It requires disruptive strategic holistic thinking and breaks through traditional linear thinking.
- The integration of four nets and four flows is a breakthrough holistic thinking that replaces linear thinking. It links the energy revolution, information revolution, and automobile (mobility) revolution, and integrates the humanity net of the superstructure with the energy net, information net, and transportation net of the economic foundation. Hence to achieve disruptive economic and ecological benefits.

Innovation Driven

Innovation Sources & Environment

- Conceive is the soul of innovation
- **Creativity is the source of innovation**
- **Talent is the basis of innovation.**

Innovation ecology and environment is the key to success：

1. Freedom, openness, cooperation, tolerance;
2. Fair market competition;
3. IPR Protection;
4. Network and big data support.

Freedom of Enquiry

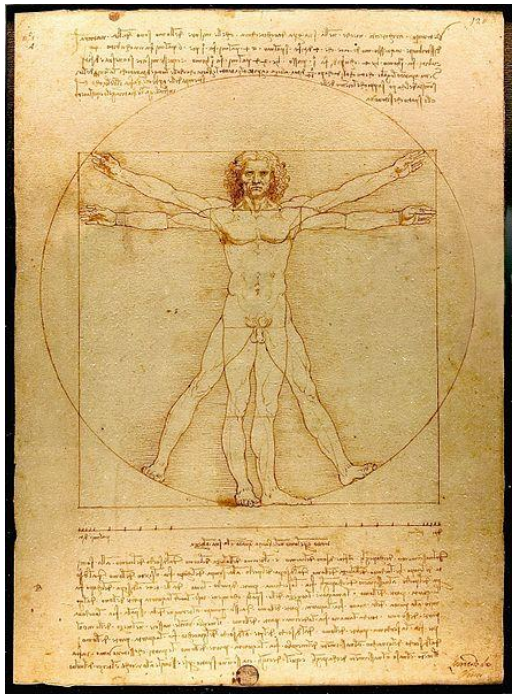


The spirit of Raphael's School of Athens and the principle "I love my teacher, but trust the truth more".

The beginning of the cultural movement of the Renaissance



David, by Michelangelo, an example of high renaissance art



Leonardo da Vinci`s Vitruvian Man, an example of the blend of art and science during the renaissance

Multi Dimensions Thinking

- ***Holistic Thinking***
- ***Mathematic Model & Big Data***
- ***Causal & Related Relationships***
- ***Closed Loop Thinking***
- ***Cycle Thinking***







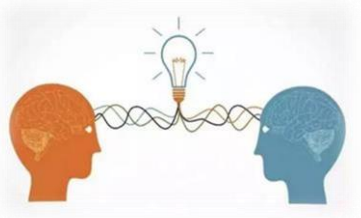
Characteristics of innovation

- **Foresight**
- **Uniqueness**
- **Cutting Edge**

- **How to industrialize innovation achievements**

Science, Engineering, Technology

- Science seeking the truth. WHY?
- Engineering is Integration of Science, Technology & Management. HOW?
- Technology is skill









Engineering Philosophy

System Integration

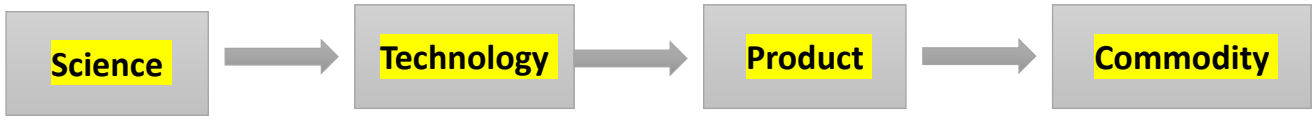
1) Objectives
2) Holistic Thinking
3) Creative Thinking
4) Divide and Conquer, Combine and Rule
5) Human Factors
6) Team Work

Objectives, Thought, Methodology, Implementation

Engineering = Science + Technology + Management

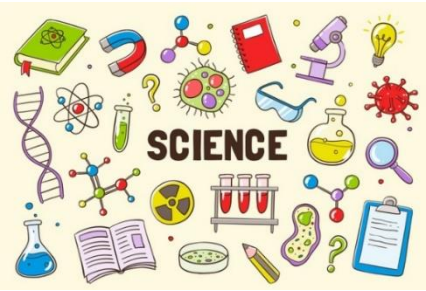
Experience & Practice

From Research to Commodity



Due to different cognition and value orientation, there are barriers in the above each transition

Key of success: Technology, Talent + Policy + Industry, Market + Finance



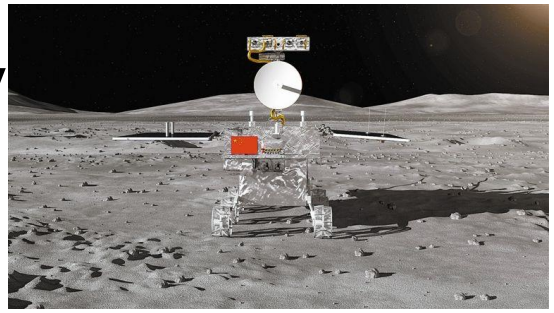






Characters of Science & Technology

- Science without National Boundary
- Scientist has motherland
- Science is endless
- Science is easy to reach consensus





Market & Technology

- Core technology cannot be bought in the market
- Market Exchange & Technology Exchange
- Focus on both core technologies, industries, and domestic and international trades



Importance of Trading

- Fair and open
- Compliance with WTO
- Compliance with ISO9000 standard



陈清泉院士科创中心
C.C.Chan Academician Science & Technology Innovation Center

Academicians' Innovation Centres in Germany, Sweden, Canada and Korea



Academicians Innovation Centre in Germany activities, Chinese Minister of Science and Technology H.E. Mr. Wang Zhigang and Academician C.C. Chan with German and Chinese Scientists 2018



Academicians Innovation Centre in Sweden with Chinese Ambassador H.E. Gui Congyou and Academician C.C. Chan with the Swedish Minister of Enterprise and Innovation H.E. Ibrahim Baylan 2019s2019



Inaugural of Academicians Innovation Centre in Canada, Academician CC. Chan with Canadian Officers and Scientists 2018



Inaugural of Academicians Innovation Centre in Korea, Academician C.C. Chan with the Advisor of President Moon Jae-In, Prof. Kim Se Ok and Korean Scientists 2017

The Integration of
3 Revolutions: Energy, Automobile and Information
4 Networks and 4 Flows
3R4I

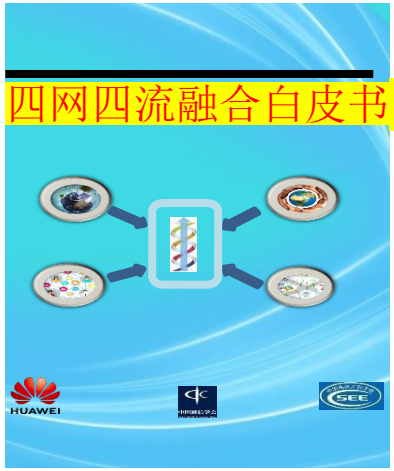
Four Networks: 4N

- **Energy Network**
- **Information Network**
- **Transportation Network**
- **Humanity Network**

Four Flows: 4F

- **Energy Flow**
- **Information Flow**
- **Material Flow**
- **Value Flow**

Preface of Integration of 4 Nets 4 Flows White Paper by C.C.Chan



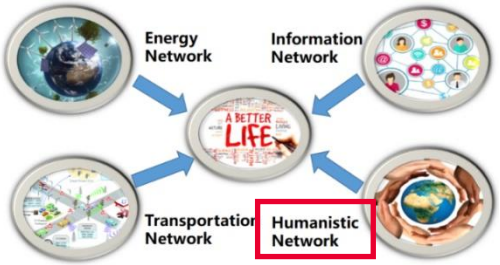


Prof. C.C.Chan
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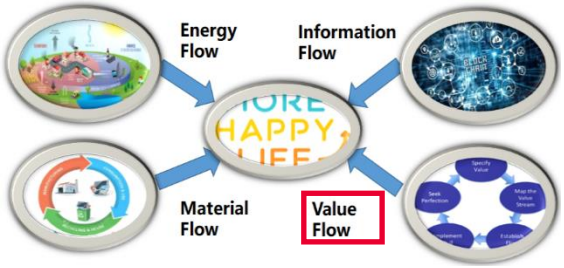
- Digital productivity is a typical feature that distinguishes the fourth industrial revolution from the previous three industrial revolutions. It needs to be supported by the economic foundation and superstructure.
- Energy network, information network, and transportation network are the three pillars of the economic foundation, while the humanistic network is an important part of the superstructure.
- Through the integration of four networks (energy network, information network, transportation network, humanities network) and four flows (energy flow, information flow, material flow, value flow), the proactive initiative of human can be combined with energy revolution, information revolution, and transportation (mobility) revolution.
- Through establishing a new production relationship formed by the human-machine-physical system, the huge productivity from big data of the fourth industrial revolution can be further explored, which grows exponentially upon the sum of the total productivity of the previous three industrial revolutions.
- The fourth industrial revolution will disruptively change the lives of us and future generations, and reshape the economy, society, culture and environment on which mankind relies. We need use groundbreaking strategy to deal with the fourth industrial revolution by going beyond traditional linear thinking. The fusion of four networks and four flows is a breakthrough of using circular thinking to replace linear thinking.

Definition of Fusion for Four Nets and Four Flows

Four Nets

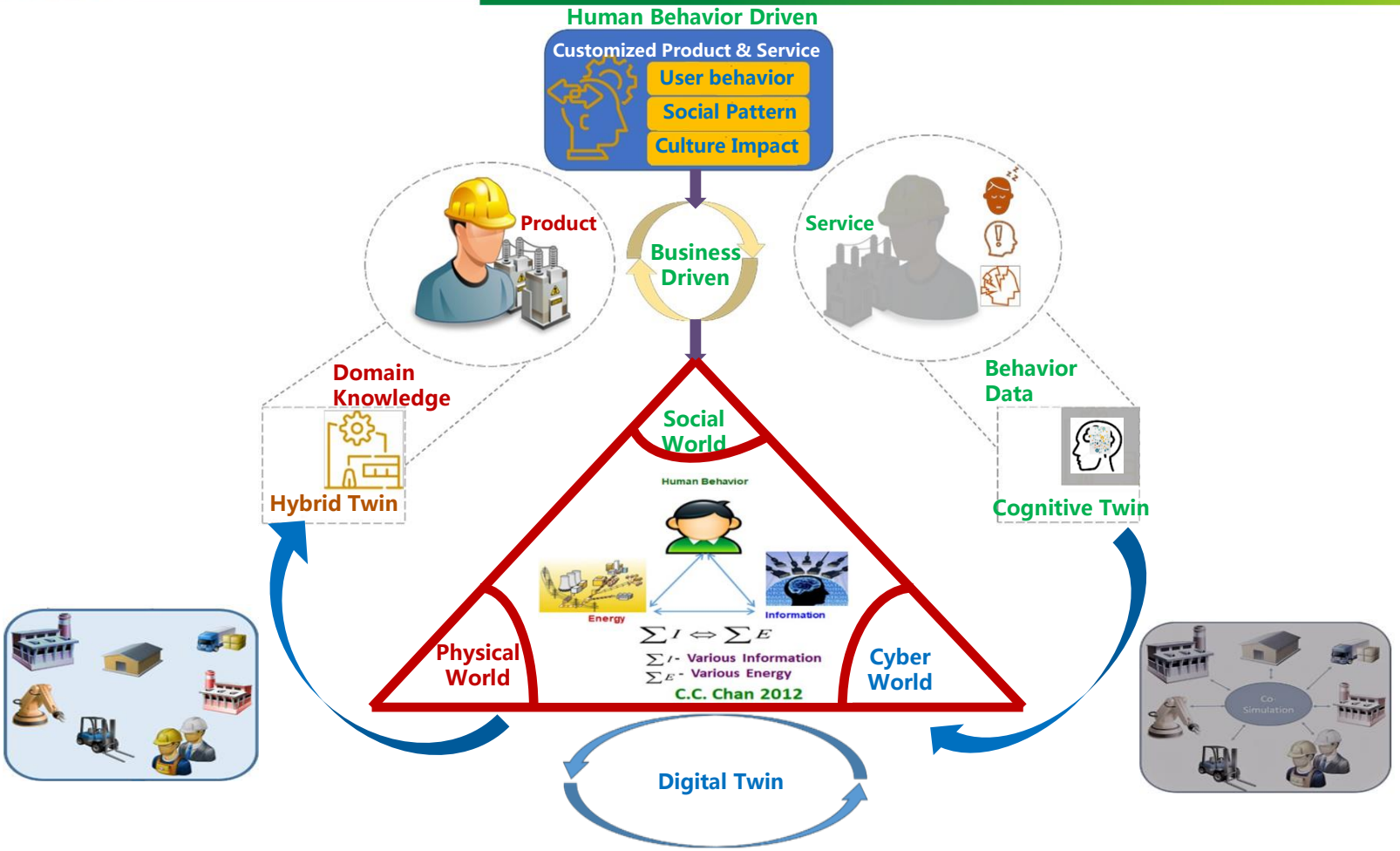


Four Flows



- Definition：Via merging into one, have more gain than adding (1+1>2)
- Mechanism：Via coupling and sharing, increase utilization of energy & assets
- Keys：Via Humanistic network, show dynamic causality and complex logic (disruptive)
- Benefits：Via Value flow, evolve technology, industry and eco-system (economic)

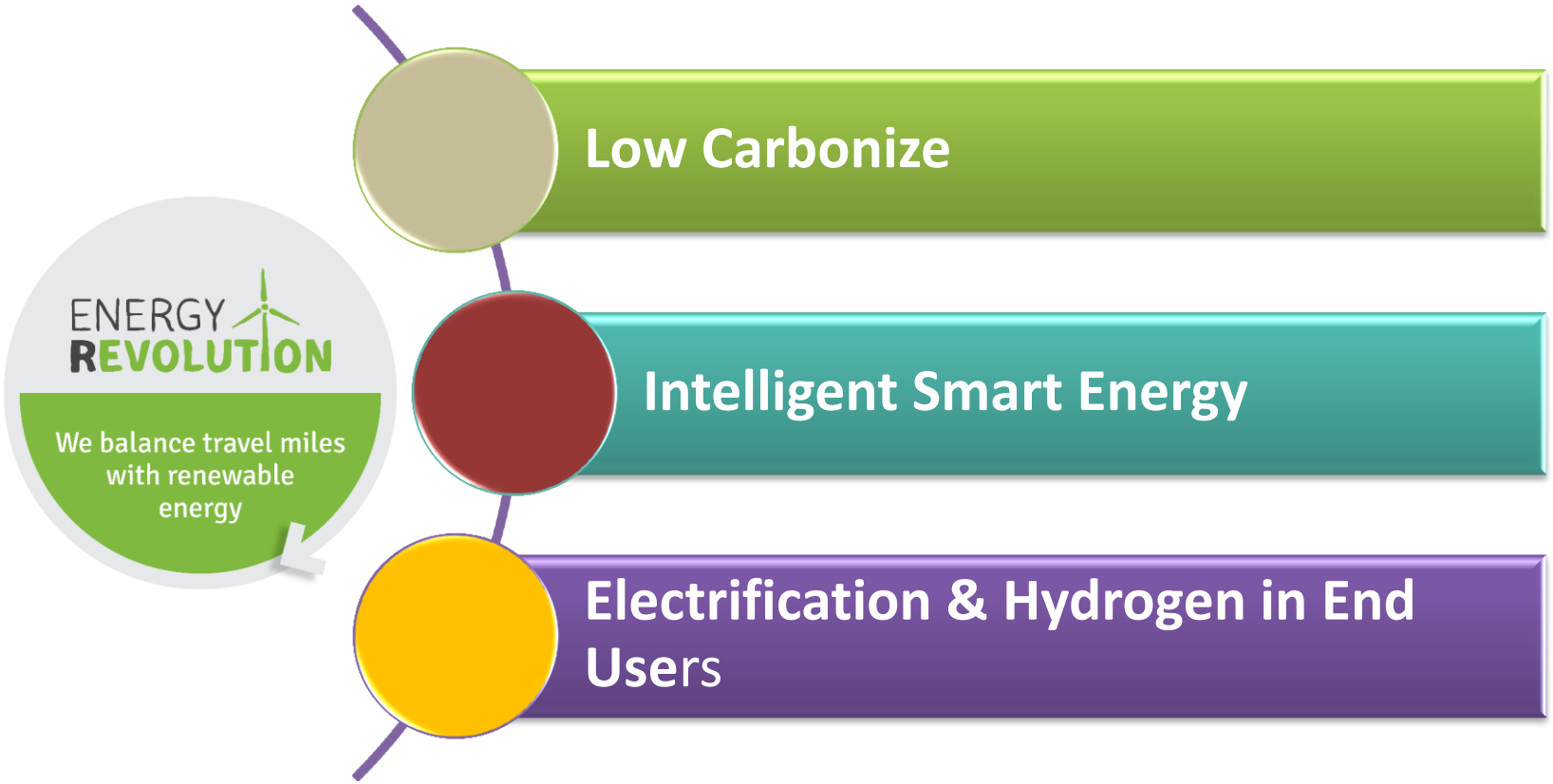
The Integration of 4 Nets 4 Flows - Driver of 4th Industrial Revolution



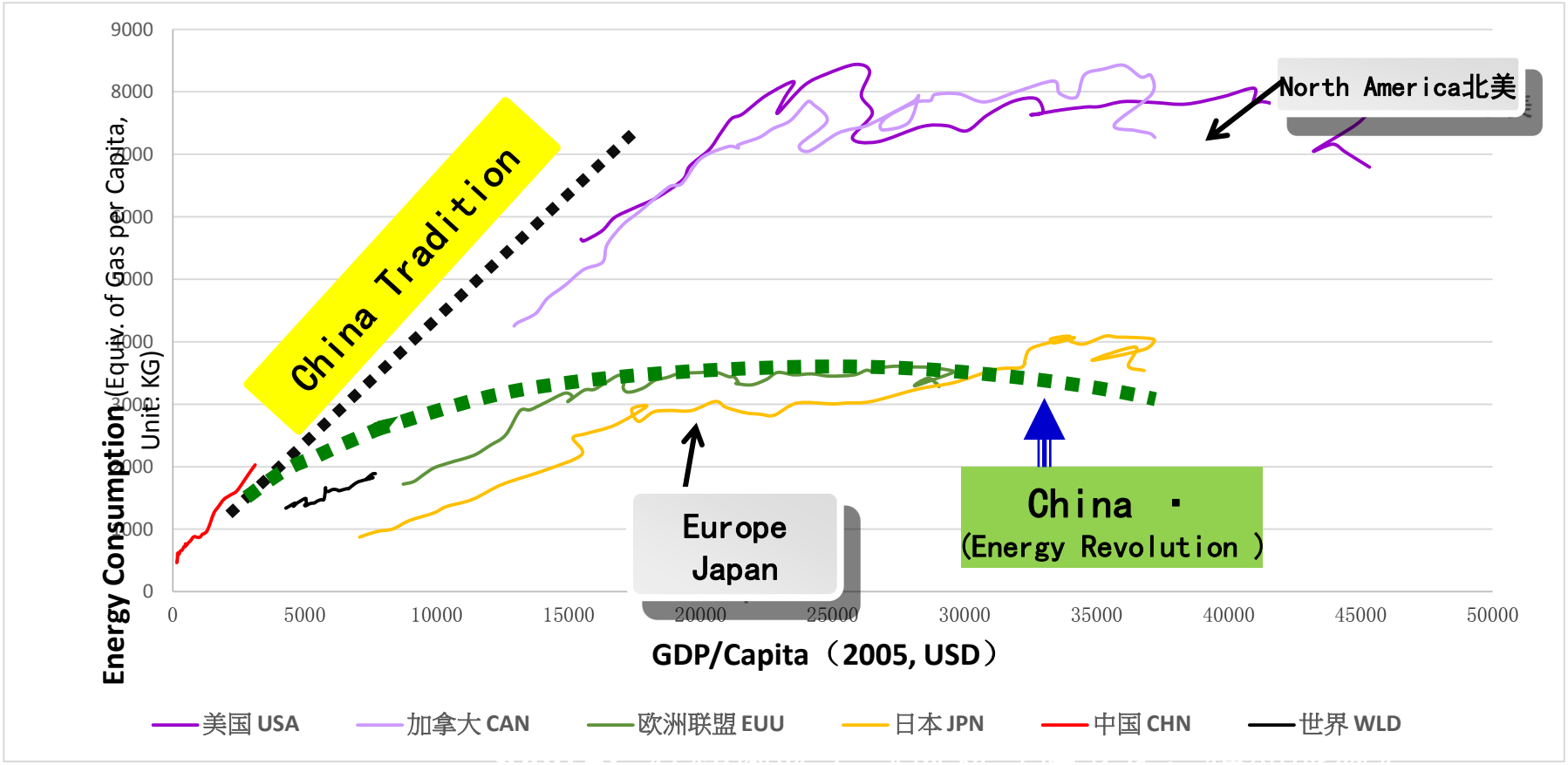
Hydrogen plays unique role in the integration of 4 Nets 4 Flows, since:

1. **Hydrogen is able to couple electric energy & chemical energy**
2. **Hydrogen possess both property of energy & substance, as well as fuel & material**

Energy Revolution



Energy Consumption per Capita by Countries



Intelligent Energy System: Convert Waste Energy into Useful Energy

Approach: Coordinating Energy Flow, Information Flow, Material Flow, Value Flow

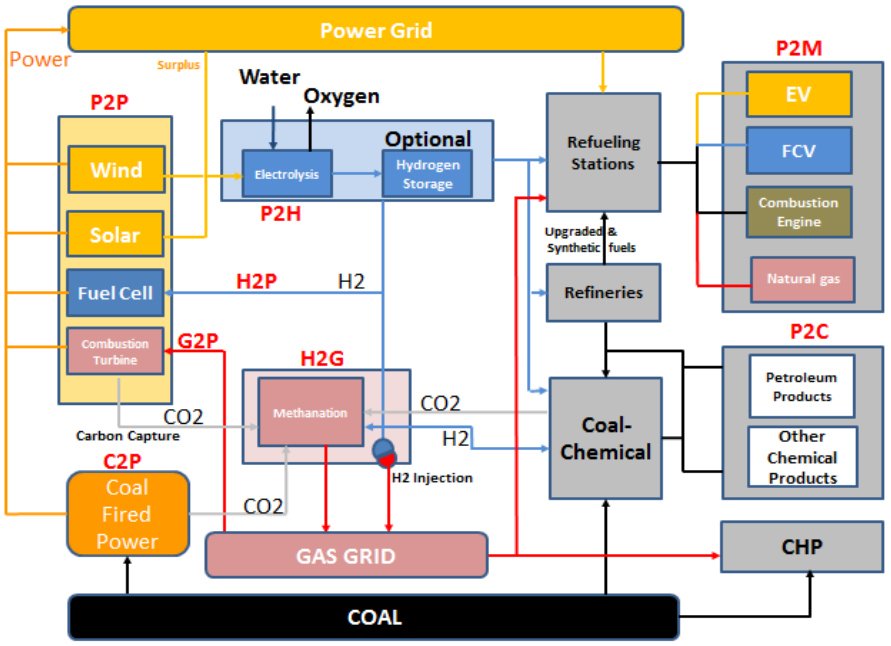
4F Principle:
Energy Flow
Information Flow
Material Flow
Value Flow

- Use 4-Flows integration principle
- Overcome 4 key conflicts

Fossil /Renewable
Centralized /Distributed
Primary / Second
Power / Chemical

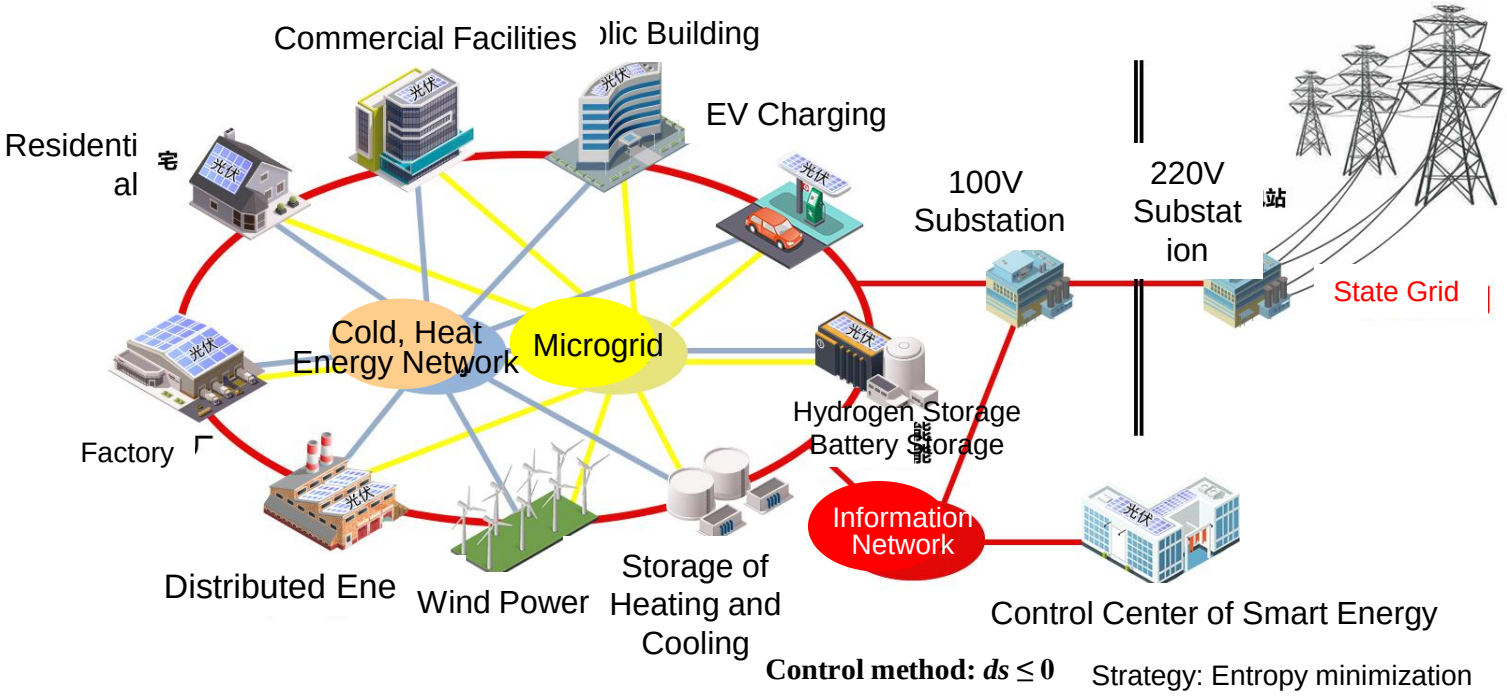
Carbon Neutral

Eco-system



Energy Internet → **Coupling of E-flow & M-flow** → **Carbon Neutral Smart Energy Eco-system**

Carrier and Network of 4N4F



Control method: $ds \leq 0$ Strategy: Entropy minimization

Entropy Reduction → Orderly → Self-organizing → Intelligent System

The Information Revolution

- The information revolution has entered a new era of artificial intelligence, which is a disruptive technology.

- The revival of artificial intelligence marks a new stage. The information evolution will go through several stages such as digitalization, networking, and intelligence.

AUTOMOBILE REVOLUTION

- Electrification
- Intelligent
- Connected and Sharing

Mobility is Freedom.

Mobility is the most apt expression for our quest for happiness.

Historical Document Signed at EVS.9

Committing Support to Formation of World Electric Vehicle Association

16th November 1988

Memorandum of Understanding

1 The undersigned, representing throughout the world a large majority of the organizations and people who, in their respective countries, undertake the development of electric road vehicles or, more generally, electric propulsion, indicate by this memorandum their desire to join forces and share their experiences.
Therefore they resolve to convene within the framework of a worldwide organization, the aims and structure of which are described hereunder.

2 The aims of the worldwide organization are:
- to facilitate the exchange of information which encourages the development of electric vehicles;
- to coordinate the schedule of "EVS" symposia to be held once every two years and, by rotation, in the three geographical zones: American continent, Asia and Pacific, Europe and Africa.
Using this principle, EVS 10 will be held in the Asia-Pacific zone and EVS 11 in the Europe-Africa zone, following EVS 9 in Canada.
The world organization has strictly no authority over national or regional meetings but specifically reserves all rights for future "EVS" worldwide symposia, insofar as appropriate concern, duplication and fruitless competition.

3 To establish this world organization and activate the above aims, pending early administration, Canada has been asked to help for an initial period and has graciously agreed to provide a centralized Secretariat, under the direction of a Steering Committee comprising of a limited number of representatives of the three geographical zones nominated by the organizations active in electric vehicle development within these zones.

This Steering Committee is instructed to propose as soon as possible general working rules for the world organization, to the success of which the undersigned are committed and for which they pledge to devote themselves their utmost efforts.

Toronto, Canada
November 15, 1988.

16 novembre 1988

DÉCLARATION

1 *Les personnalités soussignées, représentant sur le plan mondial une large majorité des organismes et personnes participant dans leur pays respectif au zone d'influence au développement de véhicule électrique routier ou de façon plus générale des engins de propulsion électrique, marquent par le présent mémorandum leur volonté de joindre leurs efforts et de partager leur expériences..*

C'est pourquoi ils conviennent de se rencontrer au sein d'un organisme à l'échelle mondiale dont les buts et la structure sont définis ci-après.

2 *Les buts de cet organisme sont :*

- de faciliter l'échange de toutes informations susceptibles de favoriser le développement du véhicule électrique;

- de coordonner l'organisation des symposium "E.V.S." au rythme d'un tous les deux ans, par rotation entre les trois zones géographiques : continent américain, Asie-Pacifique, Europe-Afrique. Ce principe de rotation entraînera l'organisation d'E.V.S. 10 dans la zone Asie-Pacifique et d'E.V.S. 11 dans la zone Europe-Afrique, après EVS 9 tenu au Canada.

MEMORANDUM SIGNED FOR WORLD ELECTRIC VEHICLE ASSOCIATION



Participants from Top left: B. Fijalkowski (Poland), R. Atanassov (Bulgaria), H. Payot (France), C. Hayden (U.S.), Z. Feng (China), W.A. Adams (Canada), Bottom left: M. Chiogioji (US), R. Leembruggen (Australia), J. Lea (Korea), L. Secord (Canada), C.C. Chan (Hong Kong), F. Dierkens (A.V.E.R.E.), A. Ananthakrishna (India), T. Matsuo (Japan). The above gentlemen signed the memorandum of agreement for the formation of a World Electric Vehicle Association during EVS.9 last November. Cliff Hayden (US), Ferdinand Dierkens (Europe) and Dr. C. Chan (Asia) have been appointed a steering committee.

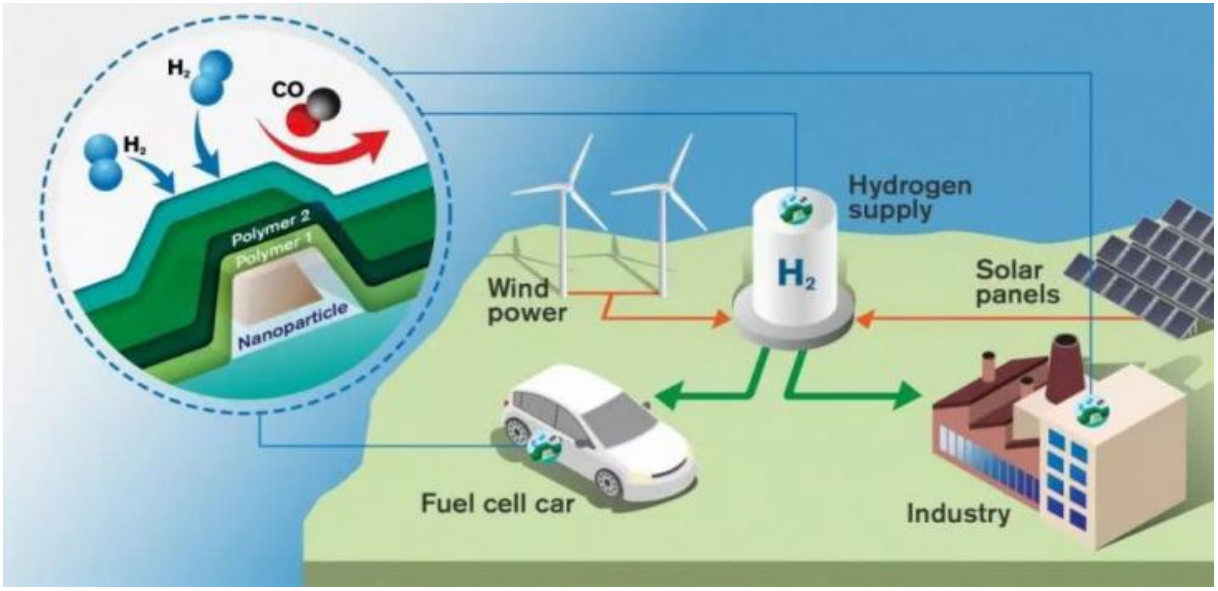
Automobile Revolution

- Video Clip on Automobile Revolution



Development of Hydrogen Technology

Different Types of Hydrogen 不同种类的氢气



- 灰色 – 从化石燃料制造
- 粉红色 – 从核能或生物能制造
- 蓝色 – 从化石燃料加上碳捕捉制造
- 绿色 – 从可再生能源制造

- **Gray – made with fossil fuels**
- **Pink – from nuclear energy and biomass**
- **Blue – made with fossil fuels with CCS**
- **Green – made with renewables**

Five Uses of Hydrogen 氢气的五大用途

- **1. Power Generation and Grid Balancing. Centralized and Distributed Power Grid.**
- **2. Transportation Fuel. Heavy & Light Duty Vehicles, Fleets, Rails, Ships, Airplanes.**
- **3. Fuel for Residential and Commercial Buildings.**
- **4. Feedstock for Industry (Ammonia, Methanol, Refineries, Steel) and Aviation, Marine.**
- **5. Fuel for Industry。**

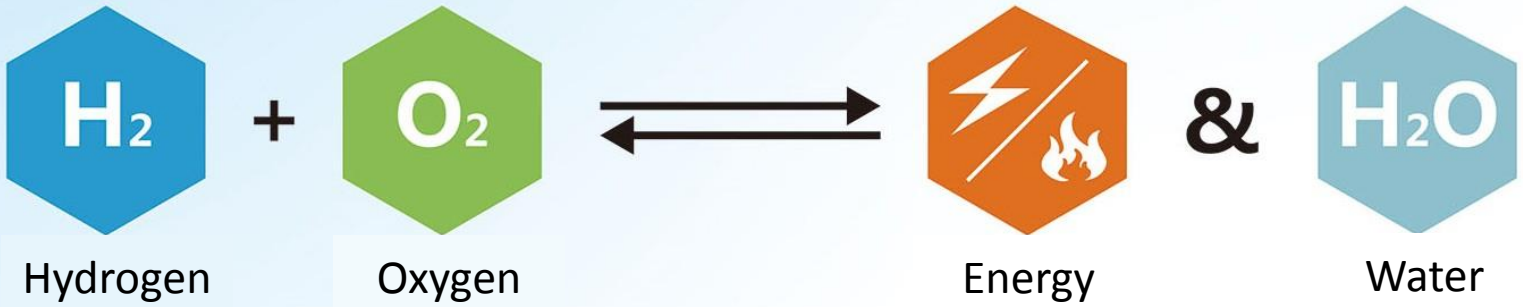
- 1. 发电和电网平衡，集中或分布式电网。氢作为能量载体和存储介质。
- 2. 交通燃料：重型和轻型车辆，车队，高铁，轮船，飞机。
- 3. 住宅和商业建筑燃料。
- 4. 工业园来（氨，甲醇，炼油厂，钢铁）和航空，航海。
- 5. 工业燃料。



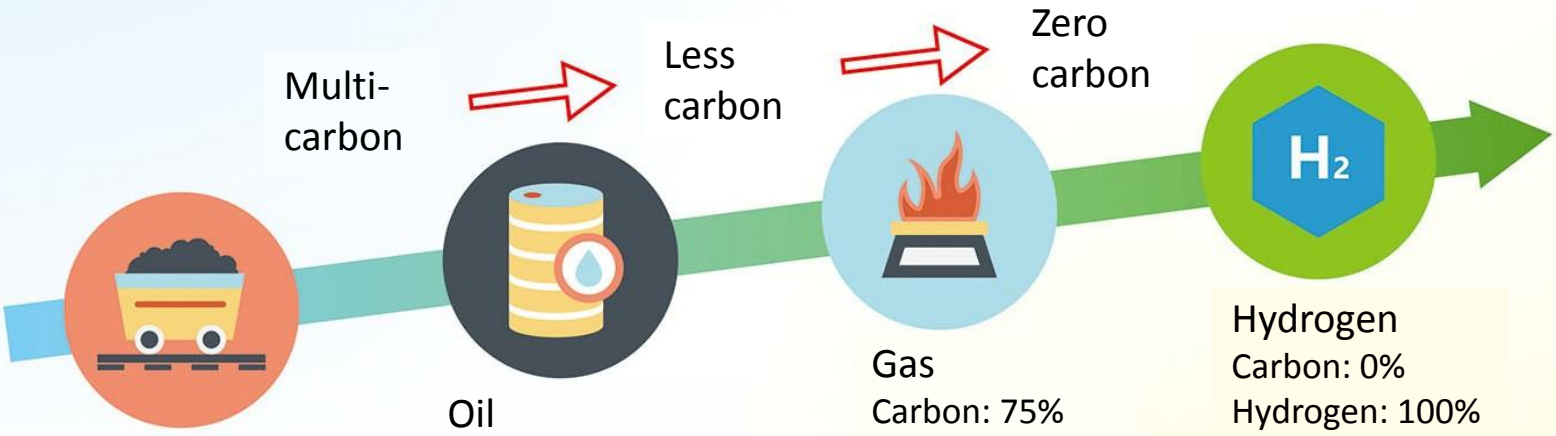
Characteristics of Hydrogen Energy

Clean

Hydrologic cycle: Provide or consume energy, but without any pollutions



Low Carbon

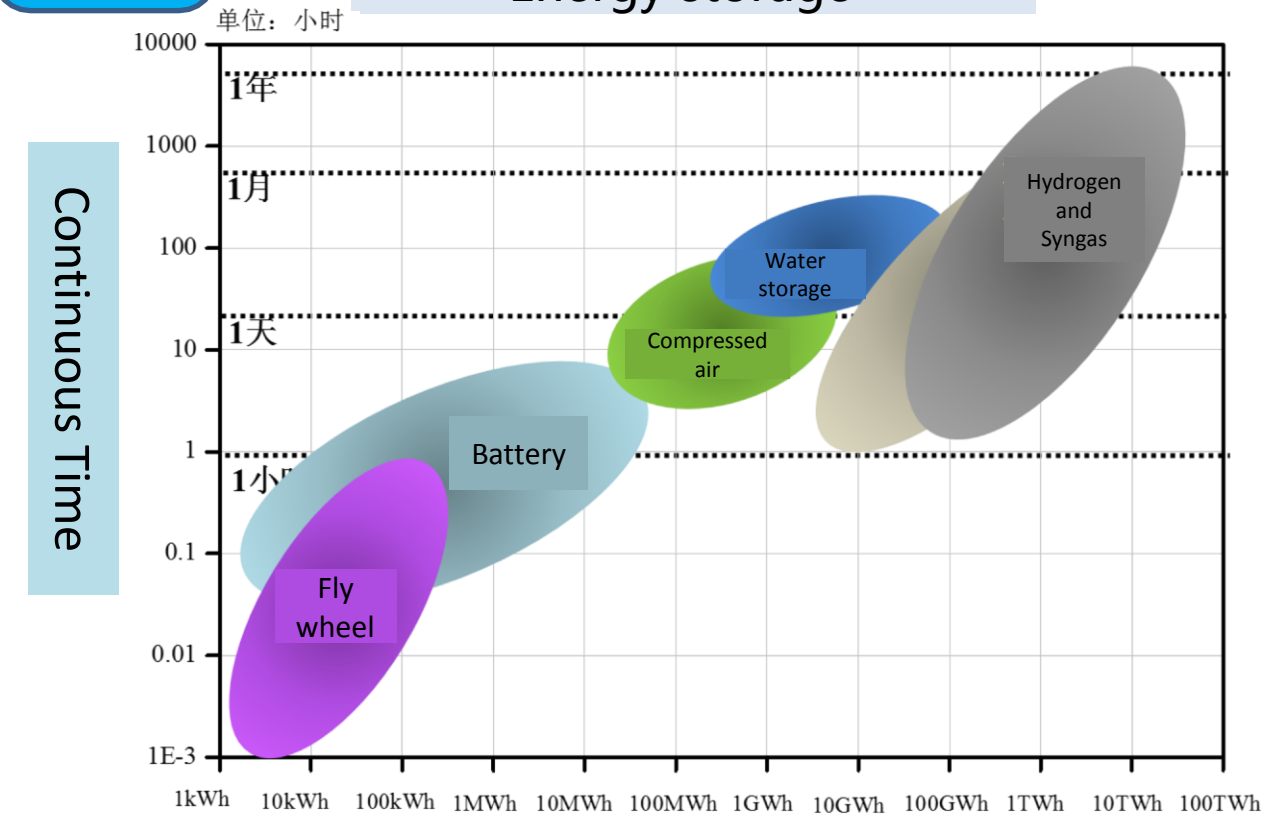


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Characteristics of Hydrogen Energy

High energy density

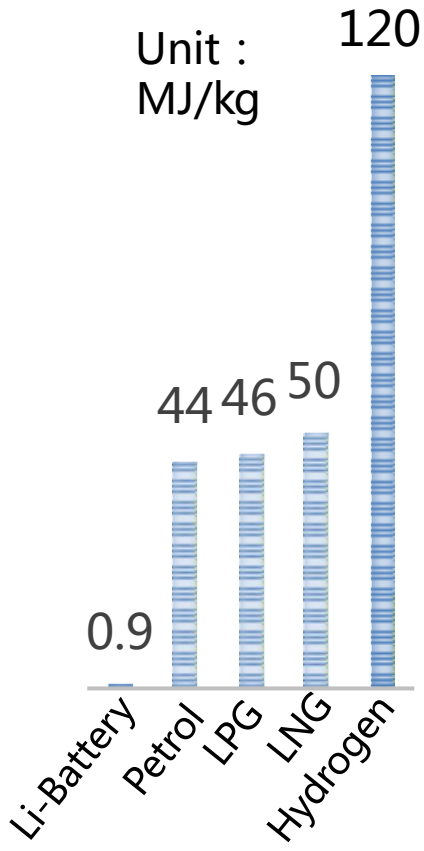
Multi energy carrier
Energy storage



Continuous Time

Energy Storage

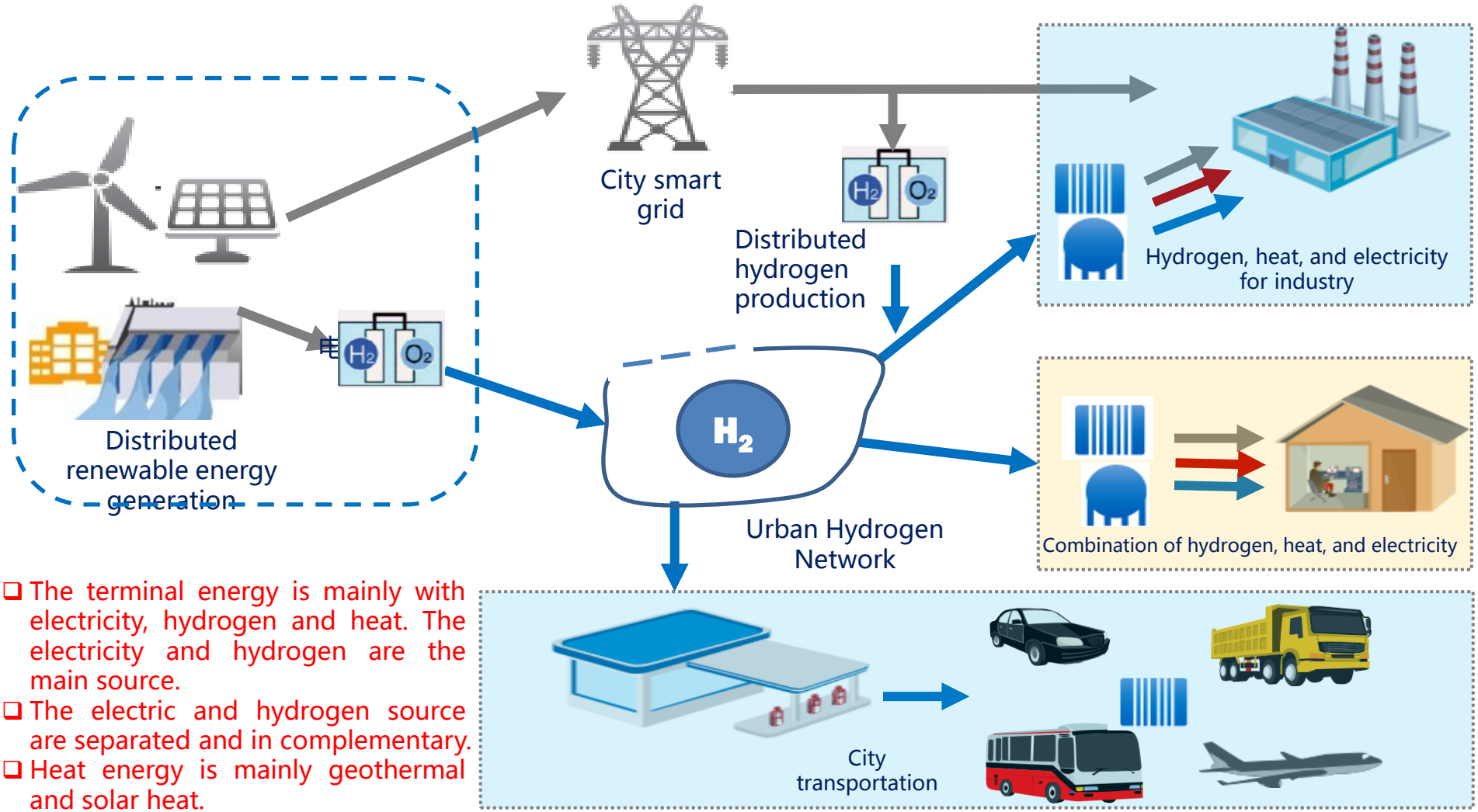
Multi energy carrier
Energy density



70MPa Hydrogen with high pressure storage, energy density higher than Li-Battery

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Electric Hydrogen System for Future Energy

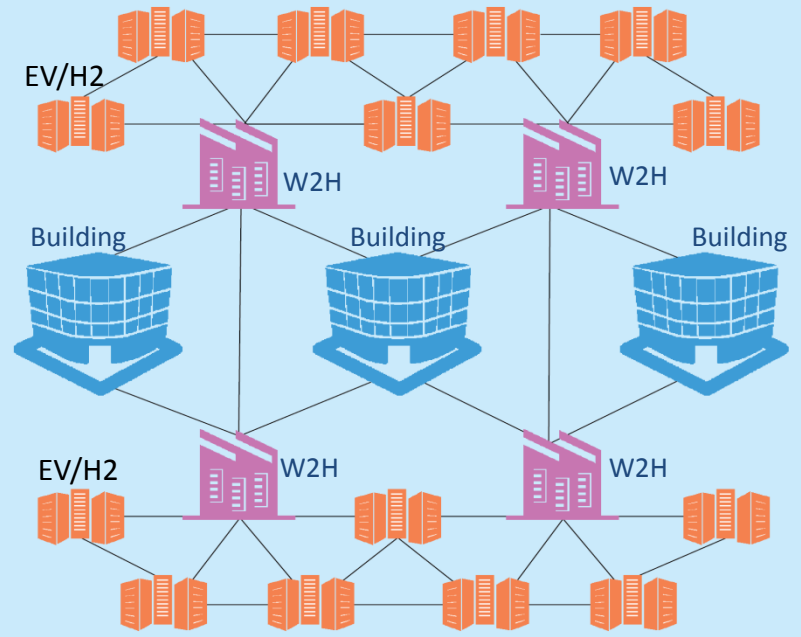


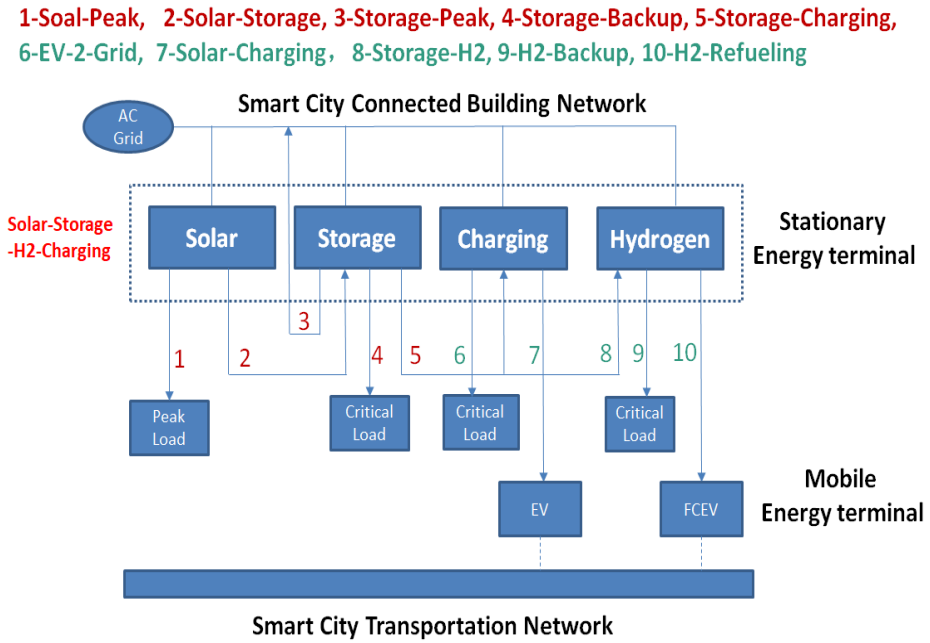
- The terminal energy is mainly with electricity, hydrogen and heat. The electricity and hydrogen are the main source.
- The electric and hydrogen source are separated and in complementary.
- Heat energy is mainly geothermal and solar heat.

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Hydrogen Application in Smart City

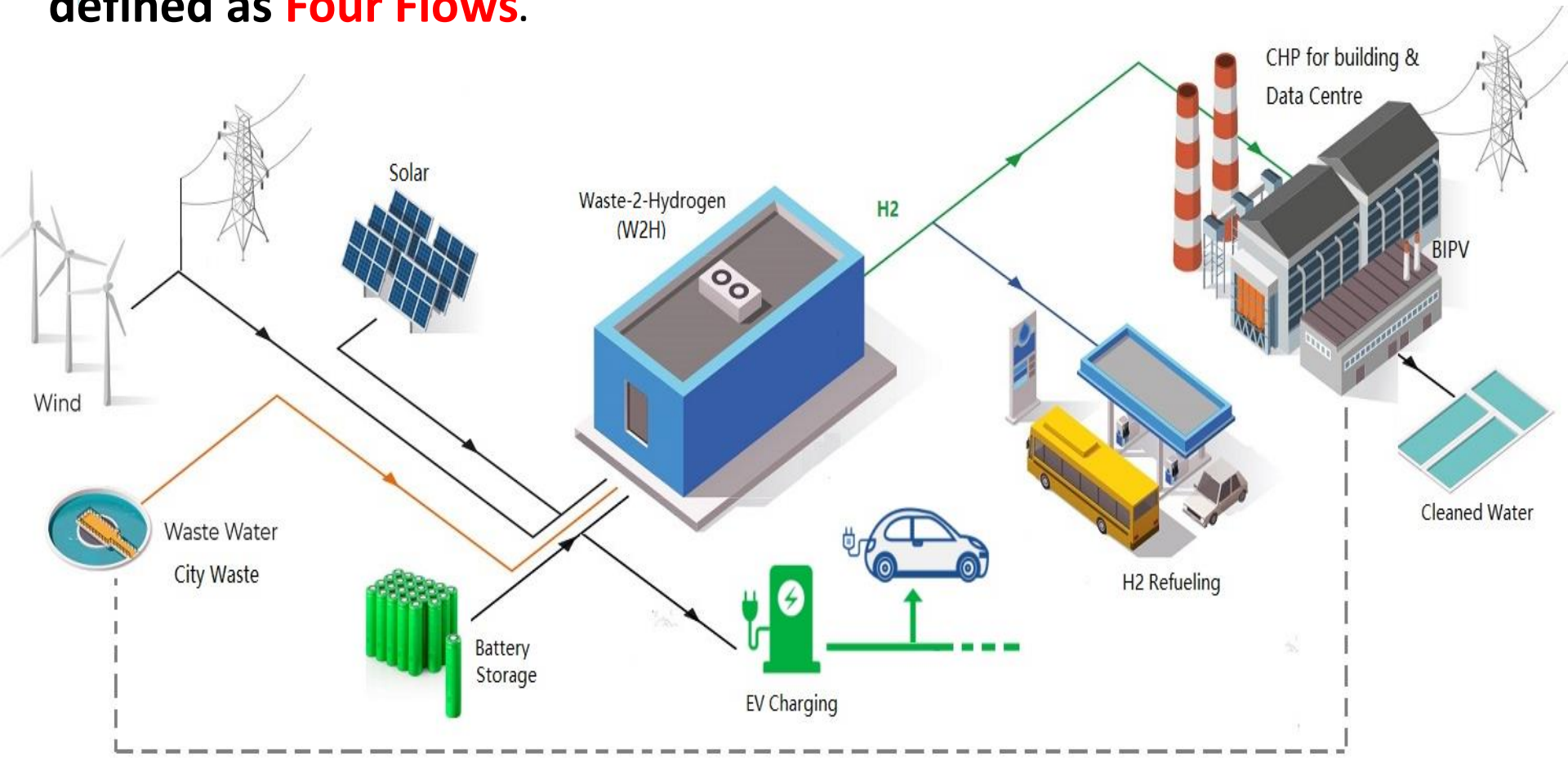
Using H2/Electricity to couple City Building Network (Energy/Information/Humanity) and City Transportation (mobility) network, is defined as integration of Four Networks.





Hydrogen Application in Waste Water Management

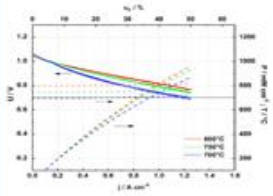
By changing waste water / city waste into useful resources via H2, Energy management (information flow) will create added values (value flow) via coupling of energy flow and material flow, as defined as Four Flows.



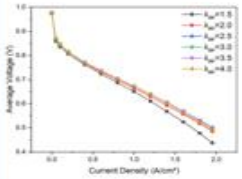
SOFC Features 固态氧化物燃料电池特点

Suitable For Power Generation & Grid Balancing

1 高电流密度及功率密度



SOFC stack:
~1 W/cm²
@ 0.7V
(kW_e class)



PEMFC stack:
~0.5 W/cm²
@ 0.7V
(kW_e class)

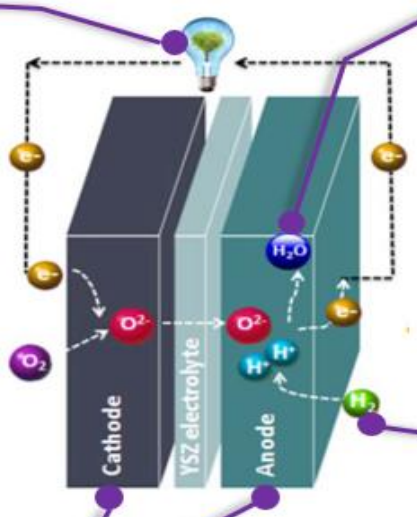
2 无需贵金属作为催化剂

	PEMFC	SOFC
运行温度 /°C	~80	600~900
催化剂	Pt贵金属	廉价金属陶瓷、钙钛矿材料
系统结构	固态+液态	全固态


阳极：镍金属陶瓷


电解质：氧化物陶瓷


阴极：铁基钙钛矿材料



固体氧化物燃料电池

(Solid Oxide Fuel Cell)

主要应用场景：分布式发电、热电联供、动力电源等

3 高品质余热实现热电联产

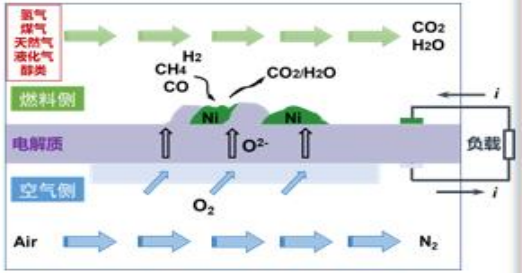
ENE·FARM type S



日本住宅用SOFC热电联供项目
Ene Farm type S
电效率：55%
热效率：32%
燃料：天然气
额定功率：700W
同时提供电力及70°C热水，综合能效可达87%(LHV)

ENE FARM 累计13万台 突破
※東京ガスグループがエネファームを販売した累計台数（2020年3月時点）

4 能直接使用多种碳氢燃料



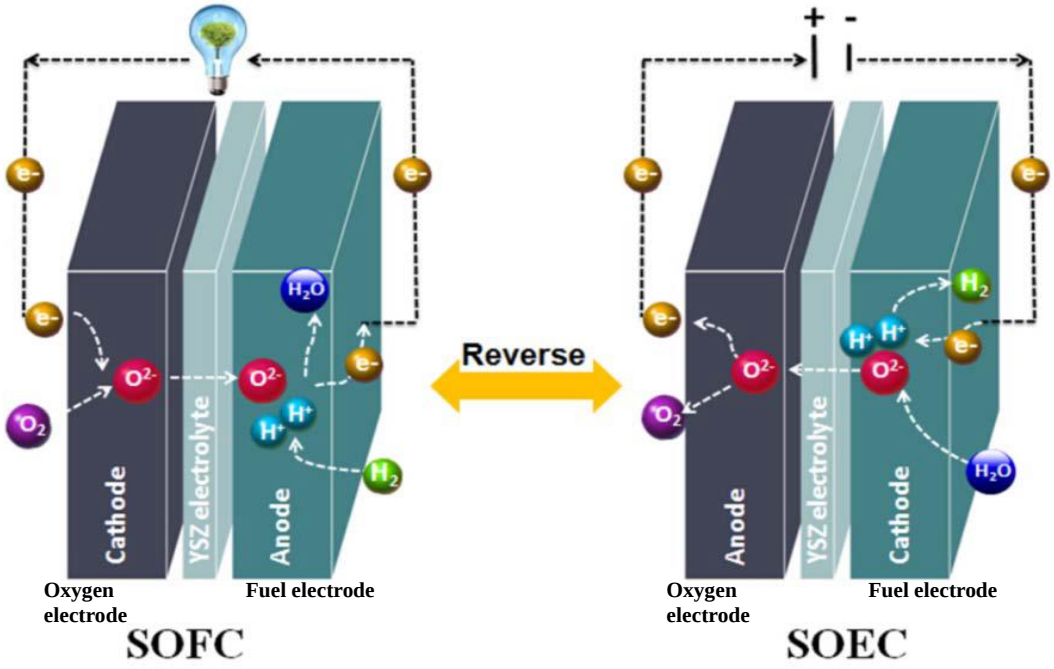
SOFC能够直接使用氢气、煤气、天然气、液化气、醇类等燃料发电



SOFC Principles 固态氧化物燃料电池原理

SOFC: Solid Oxide Fuel Cell——发电

SOEC：Solid Oxide Electrolysis Cell——电解



电极反应：

燃料极（Fuel electrode）

$$H_2O(l,g)+2e^- \underset{SOFC}{\overset{SOEC}{\rightleftharpoons}} H_2(g)+O^{2-}$$

$$CO_2(g)+2e^- \underset{SOFC}{\overset{SOEC}{\rightleftharpoons}} CO(g)+O^{2-}$$

氧气极（Oxygen electrode）

$$O^{2-} \underset{SOFC}{\overset{SOEC}{\rightleftharpoons}} O_2(g)+2e^-$$

总反应方程：

$$H_2O(l,g) \underset{SOFC}{\overset{SOEC}{\rightleftharpoons}} H_2(g)+\frac{1}{2}O_2$$

$$CO_2(g) \underset{SOFC}{\overset{SOEC}{\rightleftharpoons}} CO(g)+\frac{1}{2}O_2(g)$$

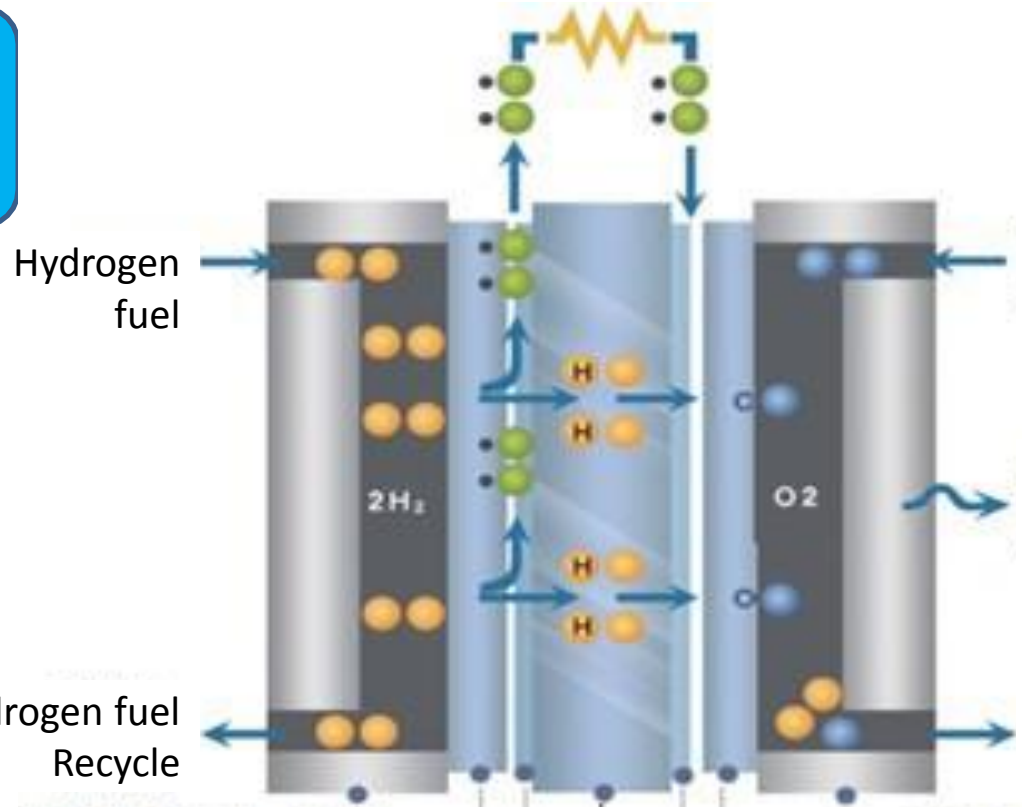
- **High efficiency;**
- **H_2 production;**
- **CO_2 conversion.**

共电解H_2O和CO_2技术——实现电能的有效储存和C减排

PEM Fuel Cell Principles 質子交換膜燃料电池原理

Suitable For Transportation: Vehicles, Trains, Ships, Airplanes

High efficiency
No pollution



The efficiency of hydrogen fuel cells can reach 50-80%, which is much higher than that of internal combustion engines.

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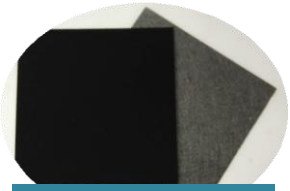
PEM Fuel Cell Progress

1 Hydrogen fuel cell: Independent R&D

Complete

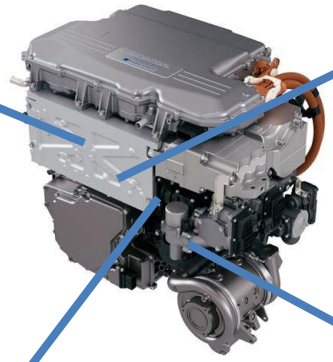
In plan

- Catalyst
- Proton-
- Exchange membrane
- Gas diffusion
- Electrode



Membrane electrode

Fuel cell





Stack assembly

- Stack design
- Assembly process
- Sealing
- Quick activation

- Flow path
- Material
- Forming
- Anti-corrosion coating



Titanium bipolar plate



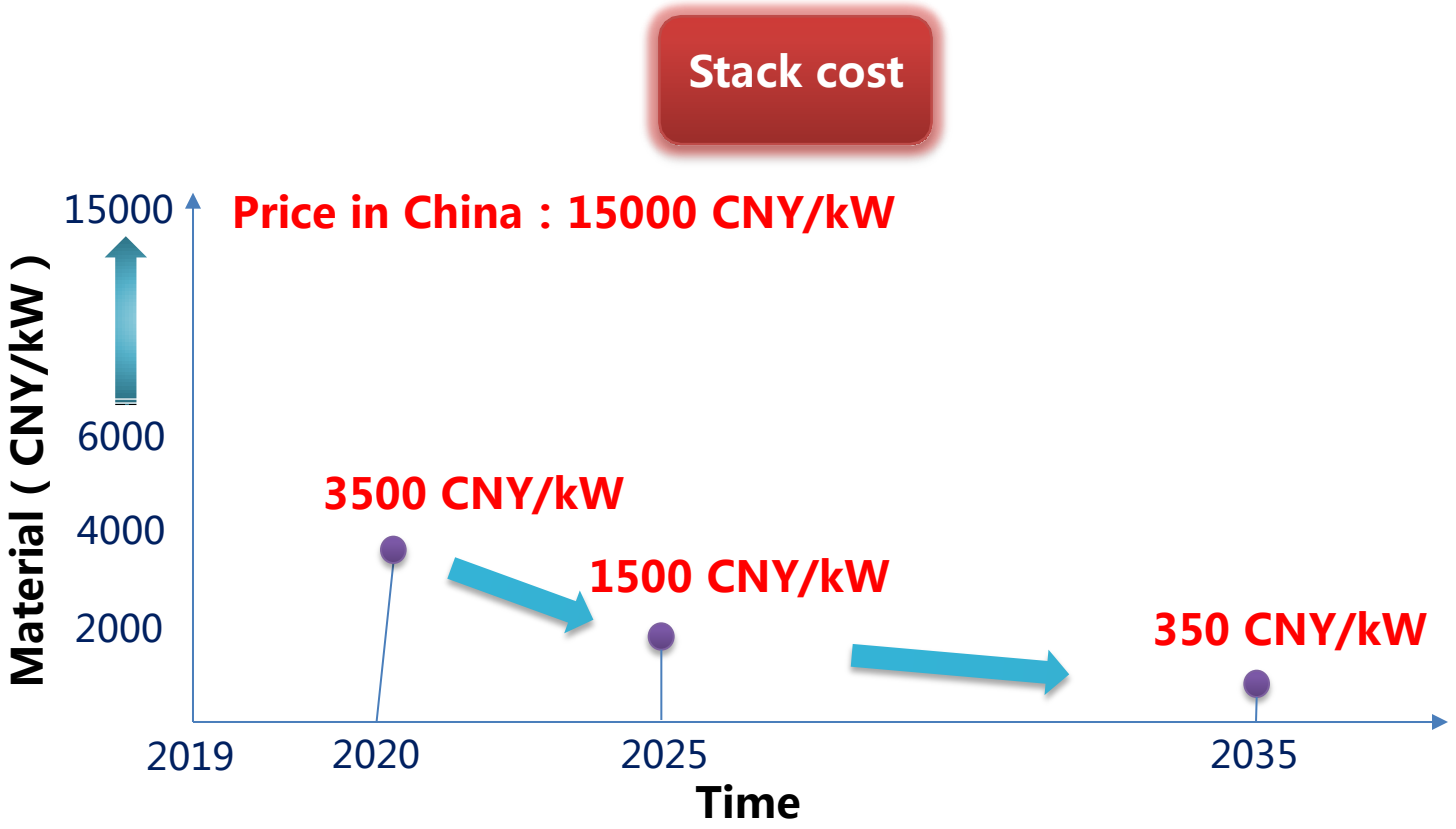
Auxiliary

- System control
- Bump of hydrogen
- Air compressor
- System packaging

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PEM Fuel Cell Progress

Hydrogen fuel cell R&D: Low cost



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PEM Fuel Cell Progress

Parameters

	2020 China	Japan MIRAI	Objective
Power density (kW/L)	3.0	3.1	**3.0**
Platinum (g/kW)	0.25	0.3	**0.3**
Power level (kW)	50-100	114	**60 , 90 , 120**
Start temperature (℃)	-30	-30	**-30**
Lifetime	5000-10000	>5000	**10000**

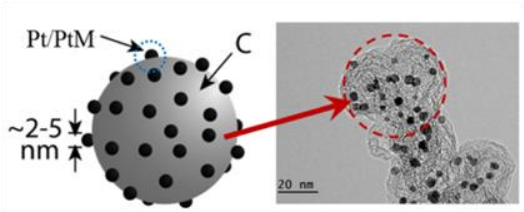
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PEM Fuel Cell Progress- Key Materials and Components

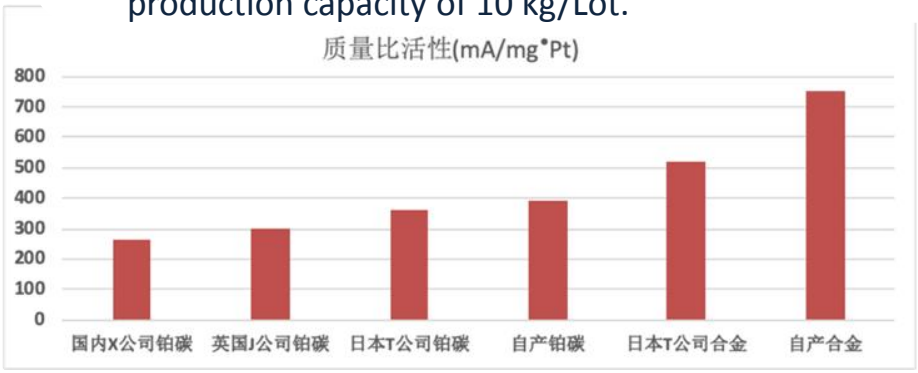
Catalyst

Main items:

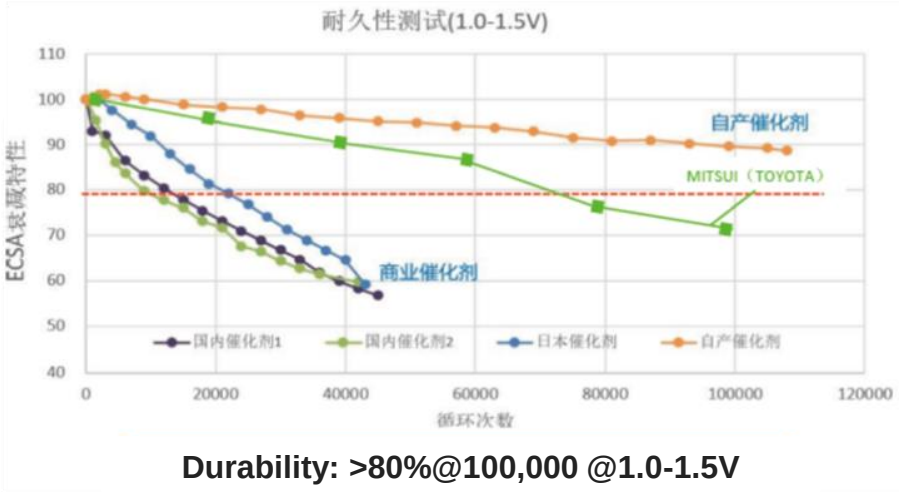
1. Corrosion-resistant, easy-to-load carbon-based carrier.
2. Multi-element alloy catalyst with high quality activity and low Pt loading.
3. Mass production process, equipment and production line R&D.



- The quality and activity of the catalyst are better than the commercial catalysts, and the durability performance is better.
- The pilot production line has been completed and has production capacity of 10 kg/Lot.



Mass Activity



Durability: >80%@100,000 @1.0-1.5V

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PEM Fuel Cell Progress- Key Materials and Components

Proton exchange membrane

Main items:

1. Resin dispersion and infiltration technologies.
2. High conductivity, high durability, low swelling.
3. Mass production process, equipment and production line R&D.



- Complete the exploration of the staged laboratory classification process conditions.
- Completed the preliminary verification of 20-50 m2 pilot test process.
- Completed the pilot-level verification product performance evaluation. No humidification performance index exceeds similar products of international companies.
- The construction of the pilot production line is in progress.



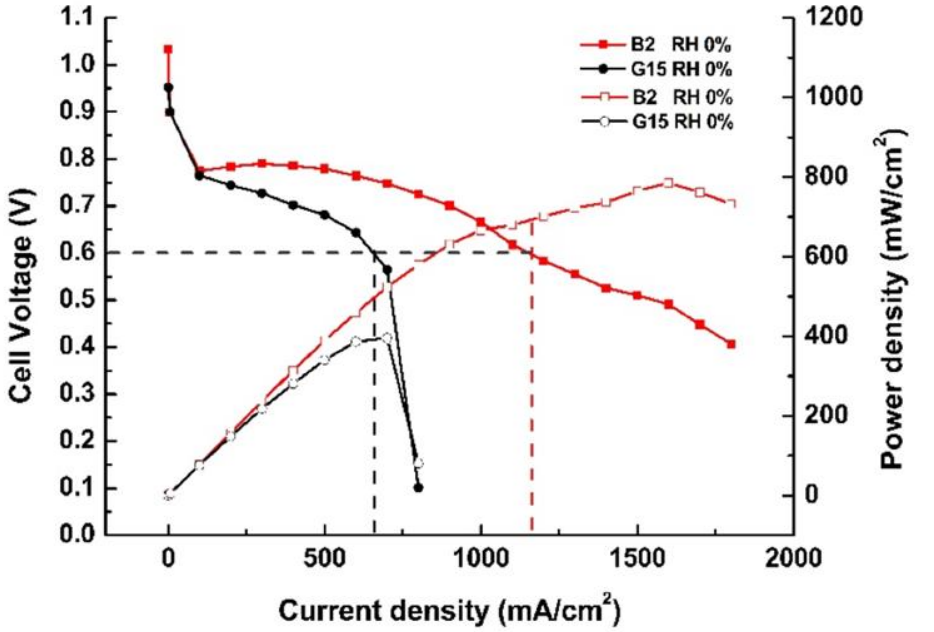
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PEM Fuel Cell Progress- Key Materials and Components

Proton exchange membrane

Test performances

Item	In China	Other Countries
Thickness	(8-12) ±1μm	15±1μm
Resistance	1.4-1.8mΩ	1.7mΩ
Hydrogen permeation	2-4mA/cm^2	2-4mA/cm^2
Swelling	MD < 2%, TD < 5%	MD < 1%, TD < 7%
Mechanical strength	> 60Mpa	约40Mpa



- Performance parameters are basically consistent with other products.
- Membrane electrode performance is better than other products under low humidity.

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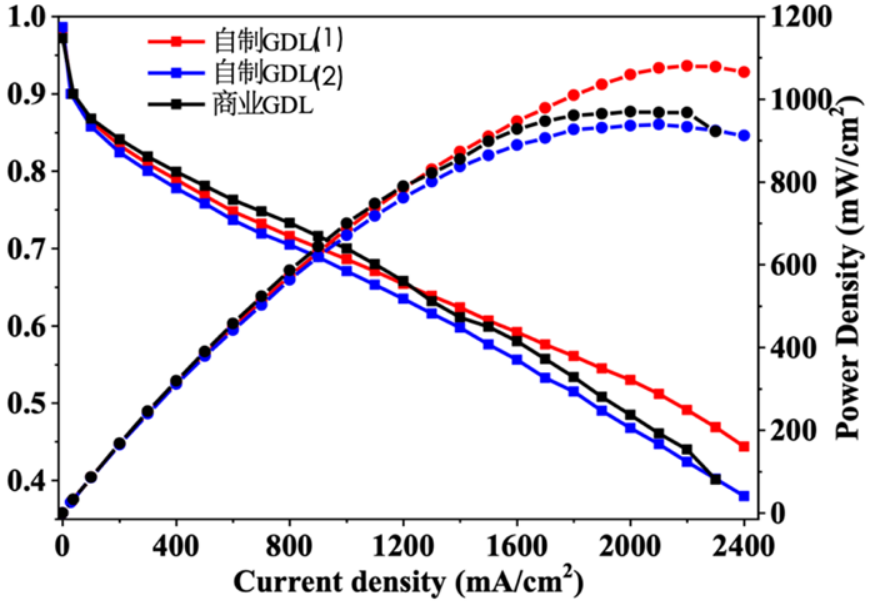
PEM Fuel Cell Progress - Key Materials and Components

Diffusion layer

Main items:

1. Focus on composition and structure design of the gas diffusion layer, microporous layer composition, and realize high temperature operation and current density.
2. Influence analysis of the process parameters such as the formation of the gas diffusion layer, and the design of the mechanized production line.

- Mass transfer performance at high current density exceeds commercial products.
- 50x50cm size gas diffusion layer (production 1000 piece/day).



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PEM Fuel Cell Progress- Key Materials and Components

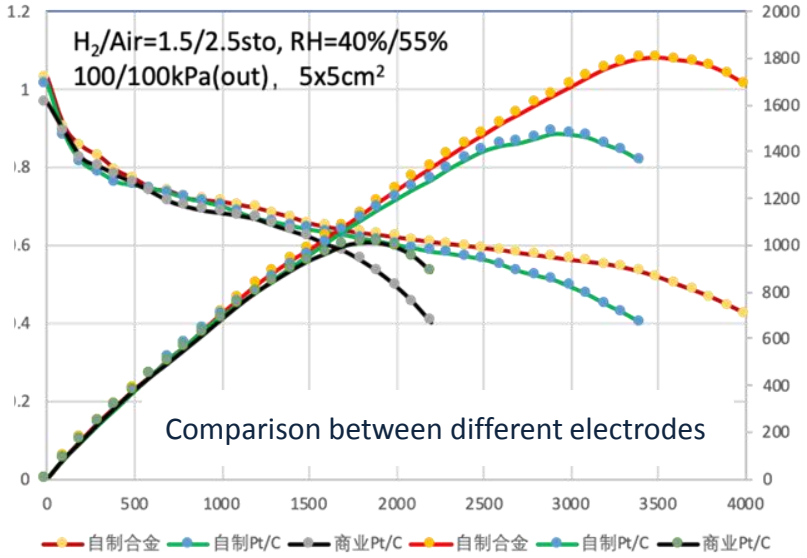
Membrane electrode

Main items:

1. Using independent-developed catalyst and gas diffusion layer, focus on slurry composition and structure, and coating process to realize low Pt loading, high performance and long-life membrane electrode.
2. Automated process development and production line.

In progress

- Complete 1.2W/cm2 for 300cm2.
- Automated process development and production line (2000piece/day max).
- Developing alloy catalyst high performance membrane electrode 1800mW/cm2.





Production workshop

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PEM Fuel Cell Progress- Key Materials and Components

Metal bipolar plate

Main items:

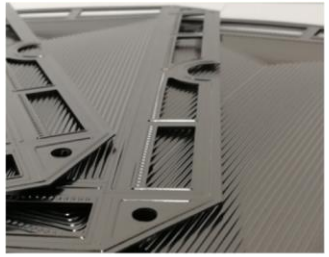
1. Fuel cell bipolar plate design.
2. Dense feature and sealing welding process of titanium bipolar plate.
3. Plate surface treatment.
4. Pilot production line design and implementation

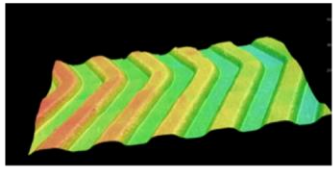
In progress

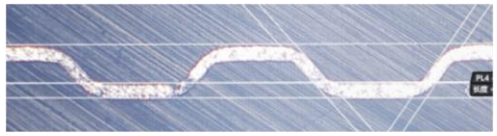
- Complete 20 patents on simulation, forming, welding, etc.
- Complete mass production (30000 piece/mon).
- Pilot production of coating
- Automated welding production line

Surface treatment process comparison

Material	Source	Substrate Dissolution (ppm)	Contact resistance (mΩ•cm²)
316L不锈钢	裸板	18.35	35.70
316L/DLC涂层	瑞典	9.66	19.20
316L/碳基涂层	德国	16.78	2.50
钛板	裸板	0.67	4.30
Ti/DLC	日本	0.50	5.00
Ti/碳基涂层	德国	0.60	3.40
Ti/自研工艺	**自研**	**0.30**	**3.70**







Cut surface analysis

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PEM Fuel Cell Progress- Key Materials and Components

Metal bipolar plate

Completed all equipment installation, single debugging, joint debugging, and achieved 2000 sets of components offline



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PEM Fuel Cell Progress- Pilot Line

Stack design and assembly

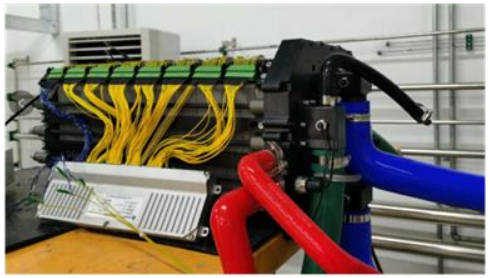
Main items:

1. High performance, electrochemistry-flow Field, structure.
2. Simulation analysis of full cell stack.
3. High accuracy packaging and sealing.
4. High power full cell assembly.

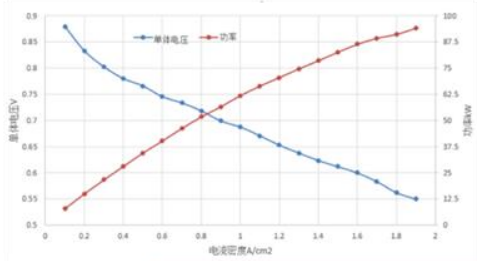
SPIC-80kW stack R&D

2020.01	2020.03	2020.05	2020.06	2020.10
Material for single stack	Structure for single stack	Stack assembly	Test and integration	Engine inspection

Key progress



80 kW stack prototype



C147-C300
Cph-7 polarization curve

C147-C300
Measured performance

Rated power
85.8KW@0.6V/cell
Peak power
95kW@0.55V/cell
(3.0kw/L)



Ningbo Automatic assembly line (300 set/mon)

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PEM Fuel Cell Progress- Pilot Line

Testing & Activation

Main items:

1. Build a test platform for fuel cell and stack.
2. Comprehensive test methods for fuel cell and stack.
3. Research on the activation method for high power fuel cell.
4. Comprehensive performance test and evaluation: polarization, electrochemistry, impedance, sealing, insulation, flow and resistance, low temperature storage.

In progress

- Complete the test platform for 100W, 500W, 1kW, 2kW, 6kW, 60kW, 120kW, 150kW, next, activation and polarization performance test for membrane electrode and stack.
- Have the ability to evaluate membrane electrode and stack standards.



Activation test platform

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PEM Fuel Cell Progress- Auxiliary System

Auxiliary system

R&D

Integration, control and testing

Integration & Control:
Verify key components;
Compact system;
Control and simulation

System performance:
Cold and hot start test;
Stable and dynamic test;
Safety monitoring and identification;

Key devices and system

Core device R&D, Inspection:
Air compressor;
Hydrogen cycling;
Core controller and actuator;

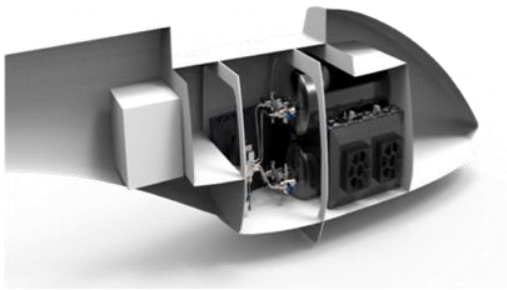
Progress



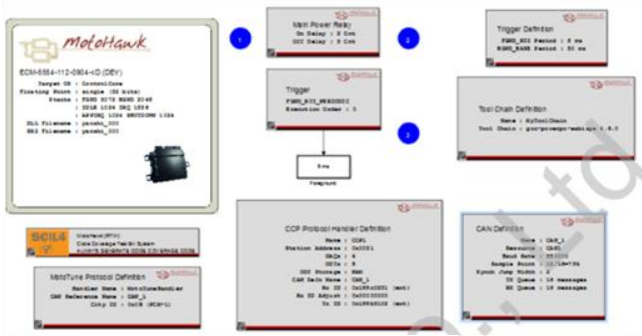
100kW system integration and test



DCDC, compressor



10kW fuel cell for UAV

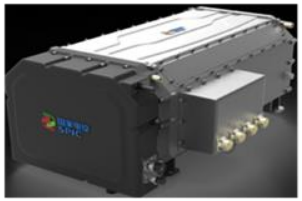
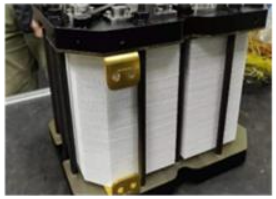


Verification of control and simulation

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PEM Fuel Cell Progress- Application

Products in different applications

	Car	Aerospace	Train	Distributed power
Power	60/120kW	2kW-120kW	Min. 350kW	Min. 30kW
Cooling	Water	Air	Water	Water
Area	300cm²	65cm²	≥300cm²	300cm²
Power density	>1000mW/cm²	>500mW/cm²	>800mW/cm²	>800mW/cm²
Bipolar plate	Titanium	Titanium	Titanium/graphite	Titanium/graphite
Current Progress				
Schedule	December, complete inspection, ready for sale	October, complete sample for fixed and spiral wings	June 2021, complete integration of high power stack	Parameter customization

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Exciting Innovation from HK Innovative Company

Metamorphosis of The Hydrogen Economy

	Hydrogen Economy 1.0 ~2010	Hydrogen Economy 1.1 < 2020	Hydrogen Economy 2.0 2021 -2025	Deep Green Hydrogen Economy 2.0 2025 - 2030
H_2 Supply	SMR or Nuclear	H_2 Economy 1.0 +Biomass	H_2 Economy 1.1 + Electrolyzer + EAT Si	H_2 Economy 2.0
Accessibility	<50 H_2 stations globally	<600 stations worldwide	Pilot Modularized H_2 stations	Full coverage of Modularized H_2 stations
Market Coverage	~Zero Usage	Establishment of Dominant Market Players	Collaboration and Consolidation	Complete Transformation

Red = Problematic Blue = work in progress Light green = initial success Deep Green = Success

Silicon Energy Revolution – by Epro Advance Technology ® (EAT)

- EAT is a company with HQ in Hong Kong Yuen Long Industrial Estate
- EAT Si – the key to Hydrogen Economy
- Science:

$$EAT\ Si + 2H_2O \rightarrow SiO_2 + 2H_2 \quad (1)$$

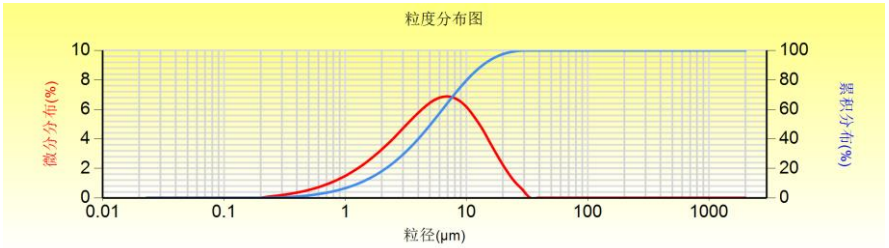
$$EAT\ SiO_2 + 2NaOH + H_2O \rightarrow Na_2SiO_3 + 2H_2 \quad (2)$$

Just add water!



Particulars of EAT Si

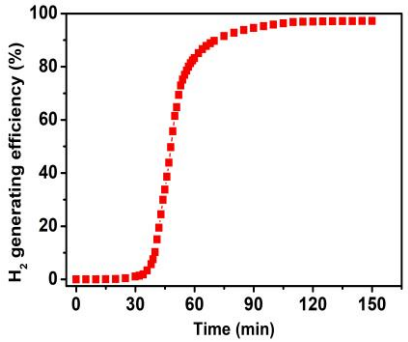
- D_{100}@~30 μm vs nano Si
- 14 weight % H_2 capacity
- Scalable production process
- Simple and controllable release mechanisms
- Safe, transportable on-demand H_2 generation



μ







The beauty and secret is combining chemical reaction, metallurgy, physics and mechanical process. To achieve mm/μm scale of silicon, but behaves as nm of silicon!

Engineering and Innovation Potentials

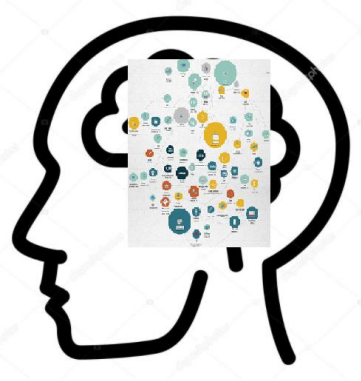
- **Creating the perfect solution for grid storage**
- **Creation of H_2 reactor modules that serves as on-board H_2 generators for transportation vehicles, micro grids, H_2 Gas Stations**
- **Optimization and adoption of these breakthrough technologies to promote Carbon Neutrality**

Way Forward

If we want to make hydrogen happen, for example, it is not going to be by just building the infrastructure and seeing what happens next. It is going to be by working with decision makers and policy makers so we can find ways forward: what legislation and standards need to be put in place, what bottlenecks need to be cleared. We cannot just be quiet. If we stay quiet we risk ending up saying: "Well, I am sorry, it didn't happen because we failed to speak up." We have to be proactive and help things happen.

— Ben Van Baurden, CEO Royal Dutch Shell

Concluding remarks



Features of Hydrogen Energy :

- Clean
- Low Carbon
- Coupling Electric Energy and Chemical Energy
- Contribution to Energy Revolution, Mobility Revolution and Smart City
- Contribution to Fourth Industrial Revolution

Human---Machine---Environment Three in One

Eco-innovation is the key for smart energy

陈清泉院士科创中心
C.C.Chan Academician Science
& Technology Innovation Center

Inspiration

Imagination

Innovation

Integration

Implementation

Investment


Creating enriched and comfortable car utilization experiences for customers by providing a range of services that address various driving situations
Optimizing energy use for the entire society and realizing stress-free and environmentally considerate living with a high quality of life
Toyota Friends
Charge my Prius, please.
Guidance based on driving history and understanding of driver intention
OK!
Tailored ads
Traffic congestion forecast, probe-based traffic information
ITS spot
Attention! Curve ahead!
Next-generation HELPNET
Automatic notification based on accident status
Road-vehicle communication system
Pedestrian to vehicle communication system
Vehicle-to-vehicle communication system
DSSS
Red light ahead
Advanced driving support systems
FEMS
FEMS
F-Grid CEMS
High-efficiency power generation system
Plant factory
HEMS
BEMS
Enriching Lives of Communities
Energy man...
Rebuilt or reused batteries
G-Station
Charging station
Contact-less charging
BEMS
H2Veneli
Support of energy-efficient lifestyle
Thank you!
Intelligent parking
Automatic parking
Smart mobility park
Ha:mo NAVI
Multi-modal route guidance
Ha:mo RIDE
Car sharing system using ultra compact electric vehicles
OK!
SAFETY
Toward the realization of Toyota's ultimate goal: zero casualties from traffic accidents
CONVENIENCE
Building a stress-free traffic environment where everyone can move around smoothly, exactly as they wish