APSEC Research Results sharing:

Research on Integrated Multi-energy System to Enhance Technological Progress of Renewable Energy Deployment in APEC Region

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APEC Sustainable Energy Center (APSEC)

APSEC'S Research Projects on New & Renewable Energy Technology in 2018

Asia-Pacific Economic Cooperation

APEC Sustainable Energy Center

- **APEC Fund Project (EWG 03 2016A) :** Study on the Cost-Effective Renewable Energy-Supply Solutions based on Innovative Solar Technologies to Promote Green Buildings in APEC Region 2016/07-2018/06

Nov. 3-5 2016, Workshop

Sep. 21-22 2017 , Workshop

Apr. 2018 (4 Report & 1 Website)

- **China NEA Funded Project:** Research and Experience Sharing on **Integrated Multi-energy System** for 'cleaner coal-fired power generation & renewable energy' in APEC Region) 2017/09-2018/12

Dec. 2018 (Research Report, in Chinese)

- **APEC Self-Funded Project (EWG 10 2018S):** Research on **Integrated Multi-energy System** to Improve Energy Efficiency and Enhance Technological Progress of Renewable Energy in APEC Region 2018/11-2019/06

This project aims to improve energy efficiency and enhance technological progress of renewable energy in APEC Region by carrying out research on integrated multi-energy system, which **can facilitate the goal of doubling the share of renewables in the APEC energy mix from 2010 by 2030.**

Integrated Multi-energy System Demand Potential in APEC Region

Asia-Pacific Economic Cooperation

APEC Sustainable Energy Center

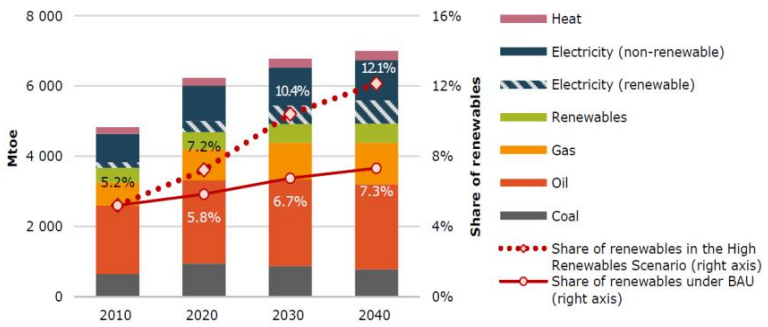
RE Power Target

No.	Economy	Share of Electricity Generation	
		Current Share (End-2016)	Target
1	Australia		23%（2020）
2	Brunei Darussalam		10%（2035）
3	Canada		No national target
4	Chile	16.0%	20%（2025）
5	China		27%（2020）
6	Indonesia		26%（2025）
7	Japan		27%（2030）
8	Korea		7%（2020），20%（2030）
9	Malaysia		9%（2020），11%（2030），15%（2050）
10	Mexico		35%（2024），37.7%（2030），50%（2050）
11	New Zealand		90%（2025）
12	Papua New Guinea		100%（2030）
13	Peru		60%（2025）
14	Philippines		40%（2020）
15	The Russian Federation		4.5%（2020）
16	Singapore		8% (no data)
17	Chinese Taipei	4.5%	9%（2020），20%（2025）
18	Thailand		20%（2036）
19	United States		No national target
20	Viet Nam		7%（2020），10%（2025）

Sourse: 《REN21 Renewables 2018 Global Status Report》

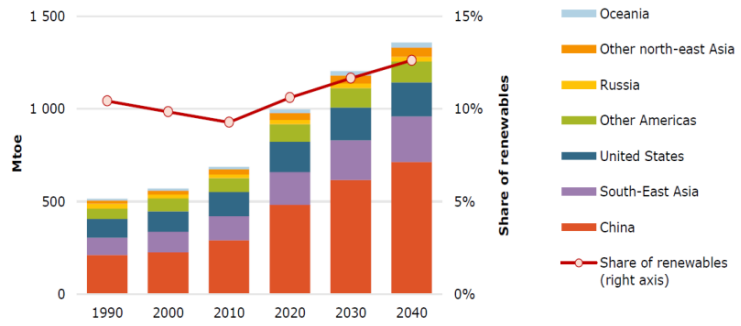
Developing trend

Figure 6.1 • Total final energy demand in the High Renewables Scenario, 2010-40



Sources: APERC analysis and IEA (2015a).

Figure 3.18 • Renewable energy production by regional grouping, 1990-2040



Sources: APERC analysis and IEA (2015).

Source: APEC ENERGY DEMAND AND SUPPLY OUTLOOK 6th Edition, APERC, http://aperc.ieej.or.jp/

Significance & Objectives of Developing Integrated Multi-energy System in APEC Region

2017 Leaders' Declaration
Da Nang, Viet Nam | 11 November 2017

9. We resolve to enhance energy security to sustain economic growth in the APEC region. We encourage the facilitation of energy-related trade and investment, enhancement of access to affordable and reliable energy, and promotion of sustainable, efficient, and clean energy sources, which, in particular, would contribute to reducing globa greenhouse gas emissions.

2014 Leaders' Declaration
Beijing, China | 11 November 2014

36. We welcome the Beijing Declaration ofthe 2014 APEC Energy Ministerial Meeting. We welcome the establishment of the APEC Sustainable Energy Center in China. We recognize the importance of promoting diversified energy supplies, and market-based competition and pricing mechanisms that reflect demand and supply fundamentals as appropriate to each economy. We encourage member economies to take actions to eliminate trade protection and restrictive measures that may impede progress in renewable energy technologies and development of this sector, and we endorse the Energy Ministers' aspirational goal to double the share of renewables including in power generation by 2030 in APEC' s energy mix. We affirm our commitment to rationalize and phase out inefficient fossil fuel subsidies that encourage wasteful consumption while still providing essential energy services. We

- **Explore the opportunities and challenges** for promoting the application of integrated multi-energy system in APEC region.
- **Increase members' general knowledge and support sustainable energy policy-making processes** in integrated multi-energy system by publishing project report online.
- **Promote technological progress** of renewable energy and energy policy making in APEC region.

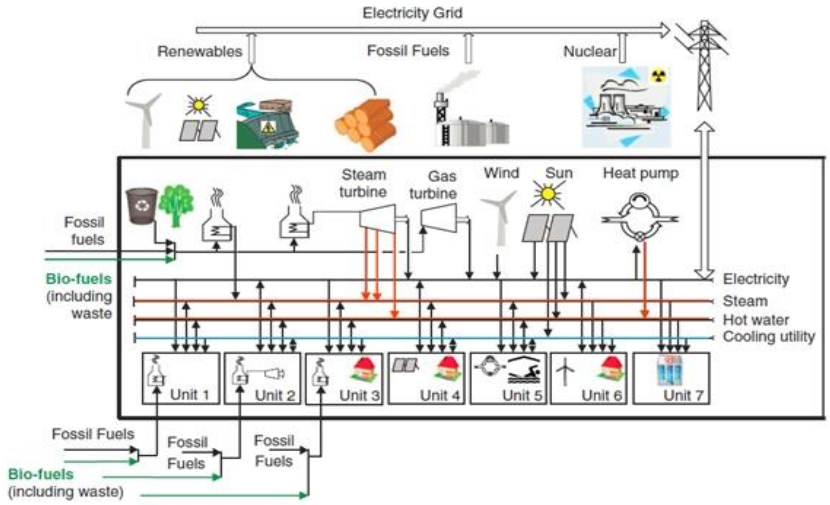
Overview of Integrated Multi-energy System

Integrated Multi-energy System in a broad sense

- **Integrated Multi-energy System refers to an energy use mode**, in which multiple energies are complemented with each other and effectively utilized in consideration of their unique characteristics and diverse energy consumers, so as to ease the contradictory between energy supply and demand, protect and make use of natural resources rationally, and achieve environmental benefits.
- Energy systems have always been "Integrated Multi-energy System". In the past in China, it primarily includes coal, hydro, and nuclear. Now, more RE and gas and DG have been included.

Benefit

- **Promoting** the development of clean energy.
- **Improving** local energy supply system and **promoting** integrated, intelligent and efficient application of energy.
- **Enhancing** energy accessibility, to provide electricity for areas without access to electricity.
- **Improving** energy infrastructure to boost local economy.



Principle of Local Integrated Multi-Energy System

(http://wiki.zero-emissions.at/index.php?title=Information_about_heat_integration)

Overview of Integrated Multi-energy System

Grid side

- Capitalize on the advantages of large-size comprehensive energy base in wind, solar, water, coal and natural gas resources to promote the construction and operations of a complementing system that covers wind, solar, water, coal and natural gas resources . It can effectively improve the utilization efficiency of RE, promote the absorption of RE and increase the utilization efficiency.
- **Main application modes**

1) Thermal power + RE (Wind, Solar……)

2) Pure RE

Wind + Solar + Energy Storage
Solar + Hydro power
Wind + Hydro power
……

User side

- Develop a system that allows the complementation of conventional energies, to satisfy the electricity, heat, cold and natural gas demands of end users, realize the collaborative supply and stepped utilization of energies through natural gas fire CCHP, renewable energy network and smart energy micro-network.
- **Main application modes**

1) Smart Microgrid

2) Combined cooling, heating and power by natural gas(CCHP)

3) Distributed Energy

Overview of Integrated Multi-energy System

Key technologies

• Renewable Energy Technology

Solar (PV, CSP…)

Wind Power

Hydro Power

Biomass (Methane gas, Power Generation…)

• Energy Storage

Storage Battery

Pumped Storage

Ice Storage

Heat Storage

Overview of Integrated Multi-energy System

Key technologies

- **Integration Technologies**

1. Generation expansion planning of Integrated multi-energy system
2. System Optimal Control Technology
3. Virtual Power Plant Technology
4. Energy Storage Technology for Suppressing Power Fluctuation of Renewable Energy
5. Virtual Synchronous Generator Technology
6. Multi-energy flow energy management technology

Virtual Synchronous Generator

Overview of Integrated Multi-energy System

Key technologies

- **Advanced Transmission, Information and Telecommunications Technologies**

1. **UHV Transmission Technology (including UHV DC & UHV AC)**
2. **Information and Communication Technology (including Remote communication & Local communication)**
3. **Energy big data technology**

Changji-Guquan ±1100 kV UHV DC in China

Douli-Jinmen 1000 kV UHV AC in China

China's Experiences in Developing Integrated Multi-energy System

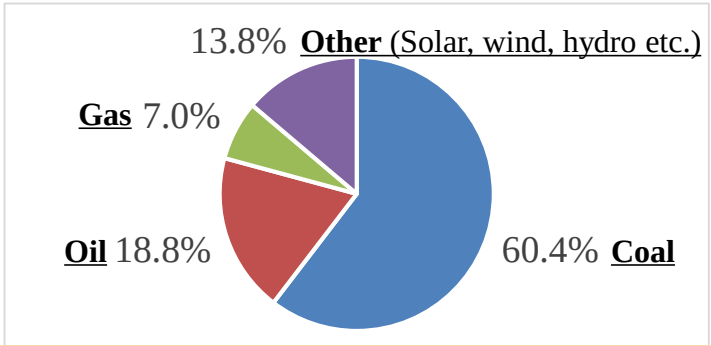
Development background

- **The RE consumption becomes an issue.**

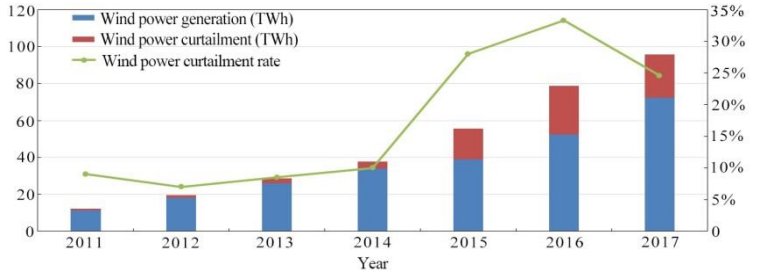
Hydro power, wind power and solar power curtailment in Western China has become a new challenge since 2011

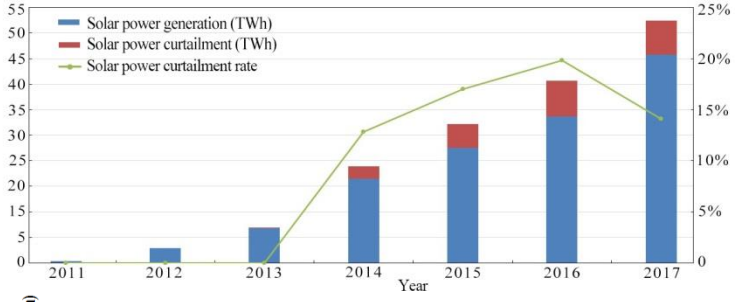
- **The overall efficiency of the energy system is relatively low.**

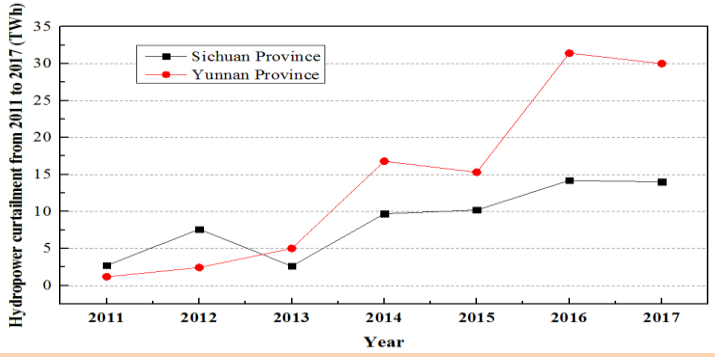
The demand-side response mechanism has not been fully established. The complementary and gradient utilization of different supplying system are insufficient; The remote areas such as some islands and high altitude Tibetan region, it's urgent to solve the power supply problem.



Energy Consumption Structure of China in 2017 (NEA)







Situation of Wind, Solar and Hydro power curtailment of China from 2011 to 2017 (NEA)

China's Experiences in Developing Integrated Multi-energy System

China's policy support

China's on-grid Tariffs Policies of RE (2018)

	可再生能源发电种类	标杆上网电价（元/千瓦时，含税）	实施时间	政策
Solar	光伏电站和"全额上网"模式的分布式光伏发电项目	0.50（一类资源区） 0.60（二类资源区） 0.70（三类资源区）	2018 年 5 月 31 日	《国家发展改革委 财政部 国家能源局关于 2018 年光伏发电有关事项的通知》（发改能源〔2018〕823 号）
	"自发自用、余电上网"模式的分布式光伏发电项目	全电量度电补贴：0.32		
	村级光伏扶贫电站（0.5 兆瓦及以下）	0.65（一类资源区） 0.75（二类资源区） 0.85（三类资源区）	2018 年 1 月 1 日	《国家发展改革委关于 2018 年光伏发电项目价格政策的通知》（发改价格规〔2017〕2196 号）
	分布式光伏扶贫项目	全电量度电补贴：0.42		
	太阳能热发电	1.15（仅适用于 2020 年 12 月 31 日前全部建成投产的首批示范项目）	2016 年 8 月 29 日	《国家发展改革委关于太阳能热发电标杆上网电价政策的通知》（发改价格〔2016〕1881 号）； 《国家能源局关于推进太阳能热发电示范项目建设有关事项的通知》（国能发新能〔2018〕46 号）
Wind	陆上风电	0.40（一类资源区）； 0.45（二类资源区） 0.49（三类资源区） 0.57（四类资源区）	2017 年 1 月 1 日	《国家发展改革委关于调整光伏发电陆上风电标杆上网电价的通知》（发改价格〔2016〕2729 号）
	非招标的海上风电	0.85（近海风电） 0.75（潮间带风电）		
Biomass	农林生物质发电	0.75	2010 年 7 月 1 日	《国家发展改革委关于完善农林生物质发电价格政策的通知》（发改价格〔2010〕1579 号）
Garbage	垃圾焚烧发电	0.65	2012 年 4 月 1 日	《国家发展改革委关于完善垃圾焚烧发电价格政策的通知》（发改价格〔2012〕801 号）

China's Experiences in Developing Integrated Multi-energy System

China's policy support

- **CCHP:**

《Guidance on the Development of Natural Gas Distributed Energy》(F.G.N.Y.〔2011〕2196)
《Implementation Rules for Natural Gas Distributed Energy Demonstration Project》(F.G.N.Y.〔2014〕2382)
《Interim Measures for Distributed Generation Management》(F.G.N.Y.〔2013〕1381)

- **Smart Grid:**

《Guidance on Promoting Smart Grid Development》(F.G.Y.X.〔2015〕1518)

- **New Energy Microgrid**

《Guidance on Promoting the Construction of New Energy Microgrid Demonstration Project》 (G.N.X.N.〔2015〕265)

- **"Internet +" smart energy**

《Guidance on promoting "Internet +" smart energy development》(F.G.N.Y.〔2016〕392)

- **Integrated Multi-energy**

《Opinions on Promoting the Construction of Integrated Multi-energy Demonstration Project》(F.G.N.Y. 〔2016〕1430)

- **Energy Storage**

《Guidance on Promoting Energy Storage Technology and Industry Development》(F.G.N.Y. 〔2017〕1701)

China's Experiences in Developing Integrated Multi-energy System

First batch of demonstration projects

- In July 2016, NEA issued a notice to collect demonstration projects of Integrated Multi-energy System, and a total of 261 projects were summited.

- In January 2017, NEA announced the first batch of 23 Integrated Multi-energy System demonstration projects

Pattern I: User Side	
NO.	Project Location
1	Beijing Lize Financial Business District, Beijing
2	Guyuan County, Zhangjiakou, Hebei Province
3	Langfang Economic Development Zone, Langfang, Hebei Province
4	Xianghe County, Langfang, Hebei Province
5	Datong Economic & Technical Development Zone, Datong, Hebei Province
6	Zhalute Zhahazhuoer Industrial Park, Tongliao, The Inner Mongolia Autonomous Region
7	Suzhou Industrial Park, Suzhou, Jiangsu Province
8	Chengnan Economic New Zone, Gaoyou, Jiangsu Province
9	Hefei Airport Economic Demonstration Area, Hefei, Anhui Province
10	Qingdao Economic Development Zone, Qingdao, Shandong Province
11	Future Science and Technology City, Wuhan East Lake High-tech Development Zone, Wuhan, Hubei Province
12	Shenzhen International Low Carbon City, Shenzhen, Guangdong Province
13	Jingbian Industrial Park for Comprehensive Utilization of Energy and Chemical Industry, Yulin, Shanxi Province
14	Yanan New town, Yanan, Shanxi Province
15	Ansai District, Yanan, Shanxi Province
16	Fuping County, Weinan, Shanxi Province
17	The Xinjiang Production and Construction Corps Twelfth Division, Xinjiang Province

Pattern II: Grid Side	
NO.	Project Location
1	Zhangbei County, Zhangjiakou, Hebei Province
2	Tumoteyouqi, Baotou, The Inner Mongolia Autonomous Region
3	Kala Town, Muli County, Liangshan, Sichuan Province
4	Longmen Economic & Technical Development Zone, Hanchen, Shanxi Province
5	Geermu county, Haixizhou, Qinghai Province
6	Hainanzhou, Qinghai Province

China's Experiences in Developing Integrated Multi-energy System

Selected Reference Projects in China

- **National Demonstration Project of "Wind-PV-Energy Storage-Transmission" in Zhangjiakou, Hebei Province**

At present, **this is the world's largest project of "four in one"**: 500 MW Wind power, 100 MW PV power generation, 110 MW energy storage system, and intelligent transmission.

- **"Hydropower-PV" Integrated Multi-energy Project in Longyangxia, Qinghai Province**

At present, **this is the world's largest "Hydropower-PV" Integrated Multi-energy Project:** 850 MW PV power generation and 1280 MW Hydropower; The concept of "Virtual Hydropower" is put forward.

China's Experiences in Developing Integrated Multi-energy System

Selected Reference Projects in China

- **"Six in one" Multi-distributed Renewable Energy Hybrid Project of GCL Energy Center in Suzhou, Jiangsu Province**

At present, this is the Largest Micro Energy Utilization Project in China: Phase 1 and phase 2 power generation could provide 808 kW electrical energy and CCHP system could provide 400 kW electric or 400 kW heat/cold energy.

- **Smart Microgrid System of North Customer Service Center of State Grid Corporation in Tianjin**

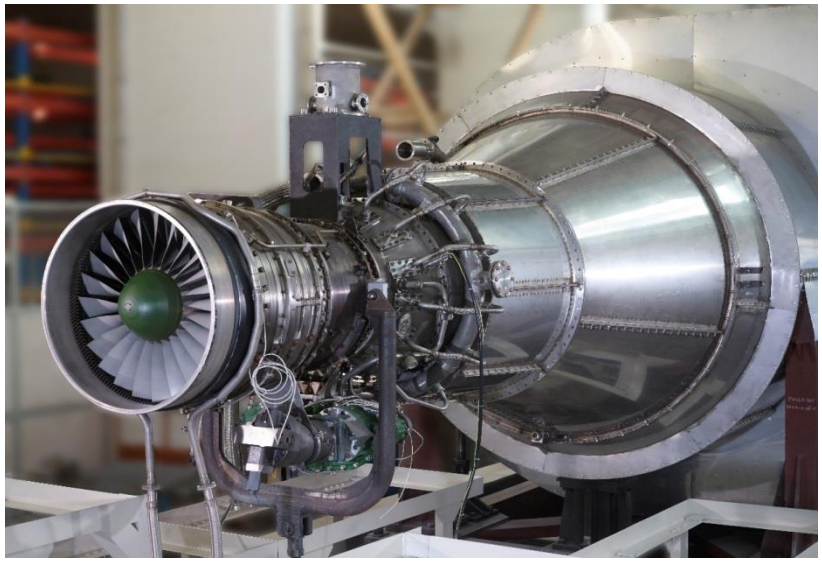
Power-centered, centralized and distributed supply, covering the integrated and coordinated supply of electricity, cold, heat and hot water. RE provides 90% refrigeration and 93.2% heat capacity.

China's Experiences in Developing Integrated Multi-energy System

Selected Reference Projects in China

- **Dongfushan Island Microgrid Project in Zhejiang Province**

Largest off-grid Wind-Solar-Diesel Integrated Multi-energy and seawater desalination: with a grosss installed capacity of 510 kW ,the project covers seven 300 kW wind power units, 100 PV, 2000AH batteries, 200 kw diesel generator and one set of seawater desalination system (50 tons/day).



- **Natural gas distributed CCHP Project in Tianjin**

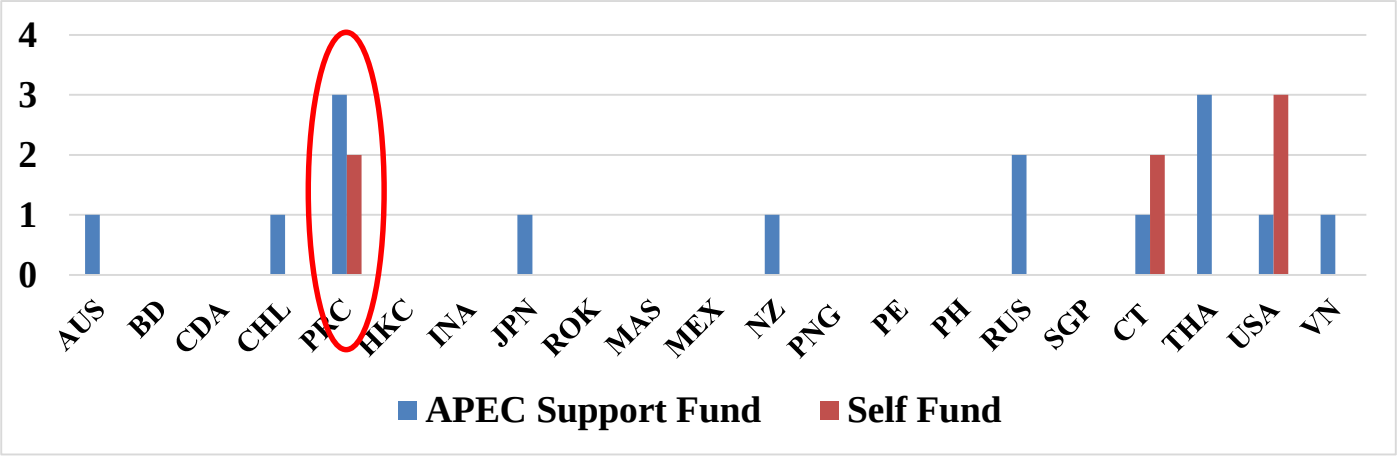
Core Equipment Gas Turbine Generator is independent R&D and produced by affiliated entity of China Aeroengine Group, , with independent intellectual property rights. It is first commercial application in domestic energy engineering field

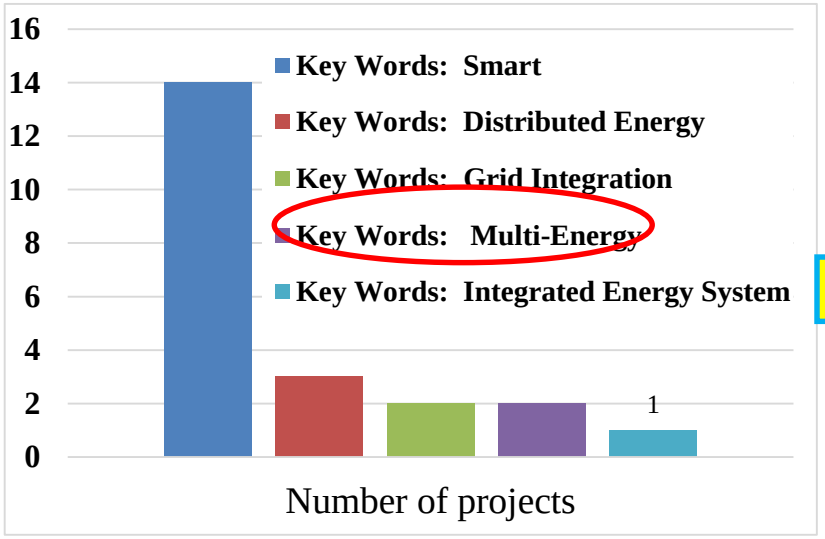
APEC Projects in the field of Integrated Multi-energy System (2006-2018)

Summary of APEC Projects in the field of Integrated Multi-energy System (2006-2018)

No.	Project No.	Proposing Economy	Co-Sponsoring Economies	Project Title	Key Words
1	EWG 01 2009S	United States	Australia; Indonesia; Japan; Singapore; Chinese Taipei; Thailand; Viet Nam	Using Smart Grids to Enhance Use of Energy Efficiency and Renewable Energy Technologies	Smart (14)
2	EWG 15 2011A	Russia	Canada; Japan; Korea; Singapore; Chinese Taipei; Thailand; United States	Piloting Smart-Microgrid Projects for Insular and Remote Localities in APEC Economies	
3	IST 01 2011A	China	Japan; Korea; Russia; Chinese Taipei; Thailand	Cooperative Study on Efficient Renewable Resources Integration and Distribution Technologies for Smart Grid Construction	
4	CTI 30 2011T	United States	China; Japan; Korea; Chinese Taipei	Workshop on Regulatory Approaches to Smart Grid Investment and Deployment	
5	EWG 04 2012A	China	Australia; Chile; Hong Kong, China; Indonesia; Korea; Chinese Taipei; Thailand; United States	Study of Demand Response's Effect in Accommodating Renewable Energy Penetration in the Smart Grid	
6	EWG 08 2012	New Zealand	Chinese Taipei; Thailand; United States	Urban Development Smart Grid Roadmap - Christchurch Recovery Project	
7	EWG 03 2013A	China	Canada; Hong Kong, China; Singapore; Thailand; Japan; New Zealand; United States	Building Code Harmonization in Energy Smart Community	
8	EWG 06 2013A	Thailand	Chinese Taipei; United States; China; Hong Kong, China; Malaysia; Indonesia; Viet Nam	APEC Smart DC Community Power Opportunity Assessment	
9	EWG 07 2014A	Thailand	China; United States	Realization of APEC Low Carbon Model Town through Smart Grid Development (LCMT-SGD)	
10	EWG 23 2015A	Chinese Taipei	China; Korea; Thailand; United States	Best Practices for Developing the Green Energy Smart Farm in the APEC Region	
11	EWG 03 2015S	Chinese Taipei; United States		2015 Energy Smart Community Initiative (ESCI) Best Practices Awards Program	
12	EWG 04 2016S	Chinese Taipei; United States		2017 Energy Smart Communities Initiative (ESCI) Best Practices Awards Program	
13	EWG 09 2018S	United States		APEC Energy Resilience Smart Grid Workshop	
14	EWG 02 2014S	United States	Canada; Singapore	Cyber-Energy Nexus Study - Opportunities, Challenges and Best Practices for **Smart Energy** Technology	
15	EWG 09 2012	Russia	China; Indonesia; Japan; United States	Combined Heat and Power (CHP) Technologies for Distributed Energy Systems	Distributed Energy (3)
16	EWG 11 2017A	Thailand	Chinese Taipei; United States of America; Japan; Philippines	Empowering a Distributed Energy Resource Future through Regulatory and Market Reforms	
17	EWG 16 2018A	Chile	Japan; Mexico; Singapore; Chinese Taipei; United States	Distributed Energy Resources Regulation and Rate Design	
18	EWG 02 2009	Japan	New Zealand; United States	Addressing Grid-Interconnection Issues in Order to Maximize the Utilization of New and Renewable Energy Sources	Grid Integration (2)
19	EWG 05 2012A	Viet Nam	New Zealand; Chinese Taipei; United States	Small Hydro and Renewable Grid Integration Workshop	
20	**EWG 03 2018S**	**China**		Establishment of a Cloud-based Sharing Platform of Multi-Energy Microgrids for APEC Economies	Multi-Energy (2)
21	**EWG 10 2018S**	**China**		Research on Integrated Multi-Energy System to Improve Energy Efficiency and Enhance Technological Progress of Renewable Energy in APEC Region	
22	EWG 13 2017A	Australia	Philippines; New Zealand; Indonesia; Japan	Integrated Energy System Planning for Equitable Access to Sustainable Energy for Remote Communities in the APEC Regions using North Sulawesi as a Pilot Project/Test Bed	Integrated Energy System

APEC Projects in the field of Integrated Multi-energy System (2006-2018)





EWG 03 2018S	China	Establishment of a Cloud-based Sharing Platform of **Multi-Energy** Microgrids for APEC Economies
EWG 10 2018S	China	Research on **Integrated Multi-Energy** System to Improve Energy Efficiency and Enhance Technological Progress of Renewable Energy in APEC Region

Integrated Multi-energy System Demand Potential in APEC Region

- **Recommendations on Promoting Integrated Multi-energy System in APEC Region**

  - **Reaching consensus on the definition of Integrated Multi-energy in APEC region**
  - **Capacity Building Activities Based on Achievements and Experiences of Member Economies including China**
  - **Making Roadmap for Promoting Integrated Multi-energy System in APEC region**
  - **Exploring the Business Model of Integrated Multi-energy Projects under Green Financing Initiative**
  - **Evaluate Potential Risks and Study Feasible Mitigation Mechanism in the Promoting Process of Integrated Multi-energy Projects**

Work Plan in Year 2019 and Proposed Joint Efforts with EGNRET

Tasks Ahead

- APEC Publication based on the completion report of the project, for better knowledge sharing and definition understanding
- To publish a Book with the title of "Technology Choices and Policy Supports for Energy Transition: China's Experience of Cleaner Energy Supply"
- Prepare new project proposals on the topic of "Integral Smart Energy Planning and Practice for Cities' Sustainable Development in APEC Region ", both in China and within APEC

Proposed Collaboration

- Welcome experts or delegates from member economies from/through both EGNRET and EGEE&C to join our research team
- Thanks for recommending/sharing best Cases or Practice to be collected into our research reports
- APSEC will ensure periodical progress reports and results sharing in EG's/APSEC's activities

THANKS!

"Joining Hands Toward Sustainable Energy Development in the Asia-Pacific Region."