Demand-Side Response of Residential Air Conditioning Load to Support Energy Saving and Carbon Reduction

Energy Foundation
China Cooling Efficiency Program

November 7, 2024
The 63rd APEC EGEEC Meeting, Tianjin, China

ENERGY FOUNDATION
能源基金会

China Cooling Efficiency Program

Energy Foundation China (EFC) is a professional grantmaking charity organization registered in California, U.S. It has been working in China since 1999 and is dedicated to China's sustainable energy development. Our vision is to achieve prosperity and a safe climate through sustainable energy. Our mission is to achieve greenhouse gas emissions neutrality, world-class air quality, energy access, and green growth through transforming energy and optimizing economic structure.

The mission of **EFC China Cooling Efficiency Program** is to assist China in maximizing greenhouse gas reduction through high-efficient and climate-friendly cooling.

Contents

Background:
Policy Progress & Climate Urgency

Background: Policy progress

Sep. 2020 - China announced Dual Carbon Goals at the 75th session of the UN General Assembly

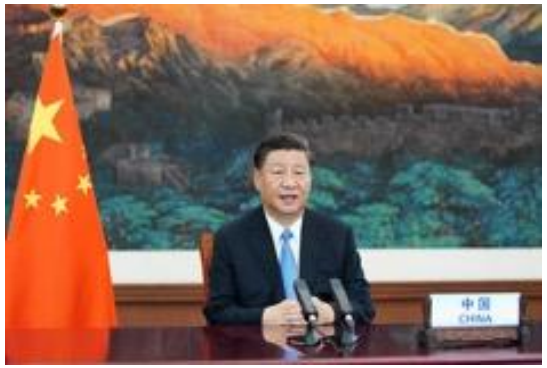
"China will strive to reach peak carbon emissions by 2030 and achieve carbon neutrality by 2060."

Sep. 2021 - The State Council: *Opinions on Fully, Accurately, and Comprehensively Implementing the New Development Concept to Achieve Carbon Peak and Carbon Neutrality*

Set principles and goals for the implementation of the *Dual Carbon* policies.

Oct. 2021 - The State Council: *Action Plan for Reaching Carbon Peak Before 2030*

Proposed the *Top Ten Actions for Carbon Peaking*



Background: Policy progress

Feb. 2021 - The National Development and Reform Commission (NDRC) and the National Energy Administration (NEA): *Guiding Opinions on Promoting the Integrated Development of Power Generation, Grid, Load, and Storage, and Multi-Energy Complementarity*

"Fully leverage the system's **flexibility** and regulation capabilities, as well as **demand-side resources**... and stimulate the **active participation** of **demand-side flexibility responses**."

Jan. 2022 - NDRC and NEA: *Guiding Opinions on Promoting the Integrated Development of Power Generation, Grid, Load, and Storage, and Multi-Energy Complementarity Opinions on Improving the System, Mechanism, and Policy Measures for the Green and Low-Carbon Transition of Energy*

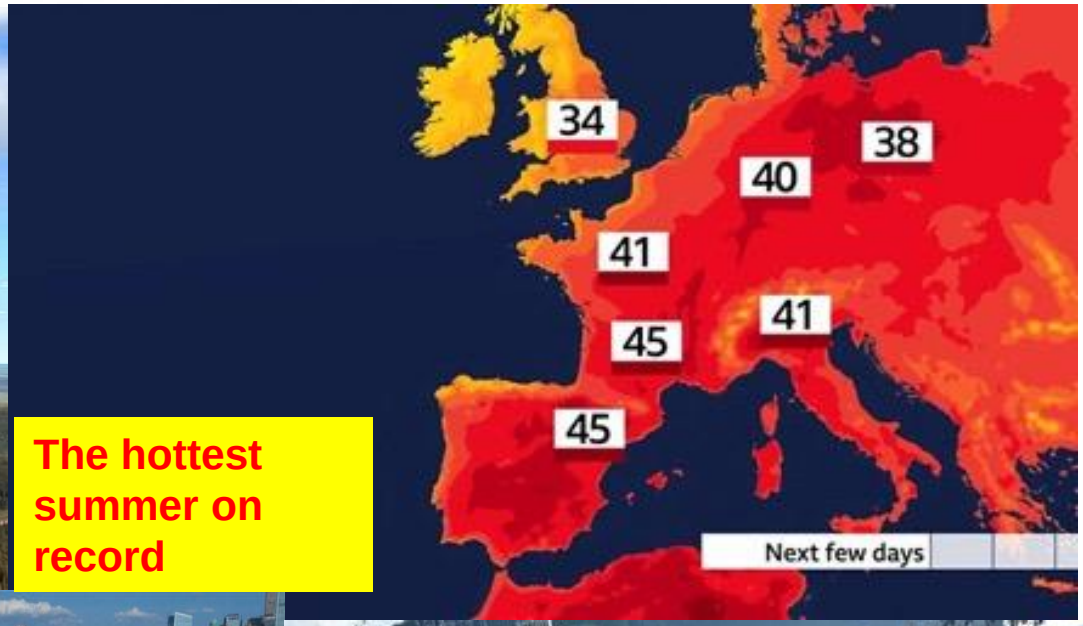
"Expand the scope of power **demand response** implementation, and explore various methods to tap into different types of **demand-side resources** and organize their **participation in demand response**…"

Sept. 2023 – NDRC and other five ministries revised the *Measures on Demand-side Management of Electricity (2023 edition)* . It added a specific chapter on demand response for the first time.

Promote **demand response** toward marketization, normalization, aggregation, and reliability. The **target demand response capacity** of each province will consist of **3% to 5% of the annual peak load by 2025**.

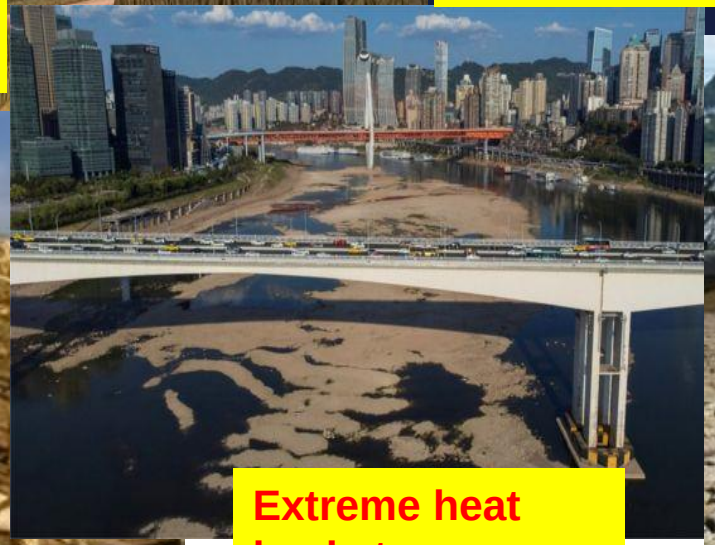
Background: Global "Boiling Era" has arrived!

Wildfires are raging in Canada



The hottest summer on record

欧洲迎来史上最热夏季



Extreme heat leads to severe drought

Background: High temperatures and electricity demand

High temperatures can lead to a **significant increase** in air conditioning **electricity demand**, putting considerable **pressure on the load** of power grid.

高温天气用电负荷激增 供电部门发安全提醒_腾讯视频

三亚近日用电负荷不断攀升 供电部门多举措保障夏季用电-新闻中心-南海网

四川2021年夏季用电负荷预计将破5250万千瓦|成都市|四川省_新浪新闻

"As **electricity load surges** due to **high temperatures**, power supply authorities have issued **safety warnings**."

*"Recently, **electricity load** in Sanya, Hainan has been **dramatically rising**. The power supply authorities have taken multiple measures to **ensure a stable power supply** during the summer."*

*"Sichuan's **electricity load in the summer** of 2021 is expected to **exceed 52.5 million kilowatts**."*

Background: High temperatures and electricity demand

High temperatures can lead to a **significant increase** in air conditioning **electricity demand**, putting considerable **pressure on the load** of power grid.

*“The Guilin Power Supply Bureau has taken multiple measures to cope with the **summer electricity peak**.”*

*“Power **supply cutoffs** and **electricity usage restrictions** have been implemented in many regions across the country. Is this energy-saving control measure **advisable**?”*

Background: High temperatures and electricity demand

Electricity load surge

- **This Year** – “On July 24, 2024, the **national maximum electricity load reached 1.451 billion kilowatts**, setting a new **historical record**, **exceeding** the maximum load of last year **by over 100 million kilowatts**. Currently, 17 provincial-level power grids have set new historical highs for their load.” (Jul 2024, NEA)

- **Last Year** – “Under normal weather conditions, the national **maximum electricity load in the summer of 2023** will be approximately **1.37 billion kilowatts**, an **increase of 80 million kilowatts compared to 2022**. If extended periods of extreme high-temperature weather occur, the national maximum electricity load this summer could rise by nearly 100 million kilowatts compared to 2022.” (Apr 2023, China Electricity Council)

Background: High temperatures and electricity demand

The proportion of air conditioner load

- By the end of 2020, the **proportion of room air conditioners load** during the summer peak period in the **peak load** had reached **30-40%** nationwide, and this figure continues to rise.
- Currently, in many provinces, the share of room air conditioners cooling load in the total electricity load during the summer peak period exceeds 40%. In provinces like **Zhejiang, Hubei, and Sichuan**, this proportion has reached **40-50%**.
- In some major cities, this **proportion exceeds 50%.**

Background: High temperatures and electricity demand

Additional economic and environmental costs!

Coal-fired power generation for Ensuring power supply?

Power supply cutoffs and electricity usage restrictions?

Background: Can the demand side make a difference?

Demand-side response refers to the practice where, during periods of tight (or surplus) electricity supply, or when there is a temporary shortage (or abundance) of electricity, grid companies invite users with load adjustment capabilities to actively reduce (or increase) their electricity load during agreed-upon time periods. This is done based on the supply-demand situation, with users receiving compensation (or subsidies) for their active participation in adjusting their electricity consumption as agreed with the grid.




Background: Can the demand side make a difference?

- **Common participants:** Industries, commercial buildings, office buildings, mobile communication base stations, data centers, electric vehicle charging and swapping stations, cold storage facilities, and others.

- **A new possibility:** **Can residential electricity usage also make a difference?** — As the share of room air conditioner load continues to rise in the summer, the participation of **residential air conditioning load in the grid's demand-side response** becomes increasingly important and urgent.

- **Challenges and obstacles:** Lack of awareness and willingness to participate; installation of related hardware and software requires certain technical barriers and investment; insufficient economic incentives; individual loads are dispersed and difficult to aggregate, etc.




Introduction to the Huzhou DR Project

Huzhou Residential Air Conditioning Load Demand-Side Response

Zhejiang Province Air Conditioning Load

Cooling load in summer

- Total air conditioning load: About 33-39 Million kW
- Industry: About 5.4-8.5 Million kW
- Commercial & Non-industry: About 8.4-13.6 Million kW
- Residential AC: About 13-19 Million kW

Heating load in winter

- Total air conditioning load: About 20 Million kW
- Industry: About 2.8-7.2 Million kW
- Commercial & Non-industry: About 3.6-7 Million kW
- Residential AC: About 60-13.4 Million kW

Huzhou City's air conditioning load

Cooling load in summer	Heating load in winter
Industry：1.11 Million kW	Industry：1.41 Million kW
Commercial：0.74 Million kW	Commercial：0.36 Million kW
Residential：2.97 Million kW	Residential：1.44 Million kW

Huzhou Residential Air Conditioning Load Demand-Side Response

A comprehensive implementation plan for residential air conditioners to participate in demand-side response under the carbon-inclusive mechanism has been established and put into practice.

AC

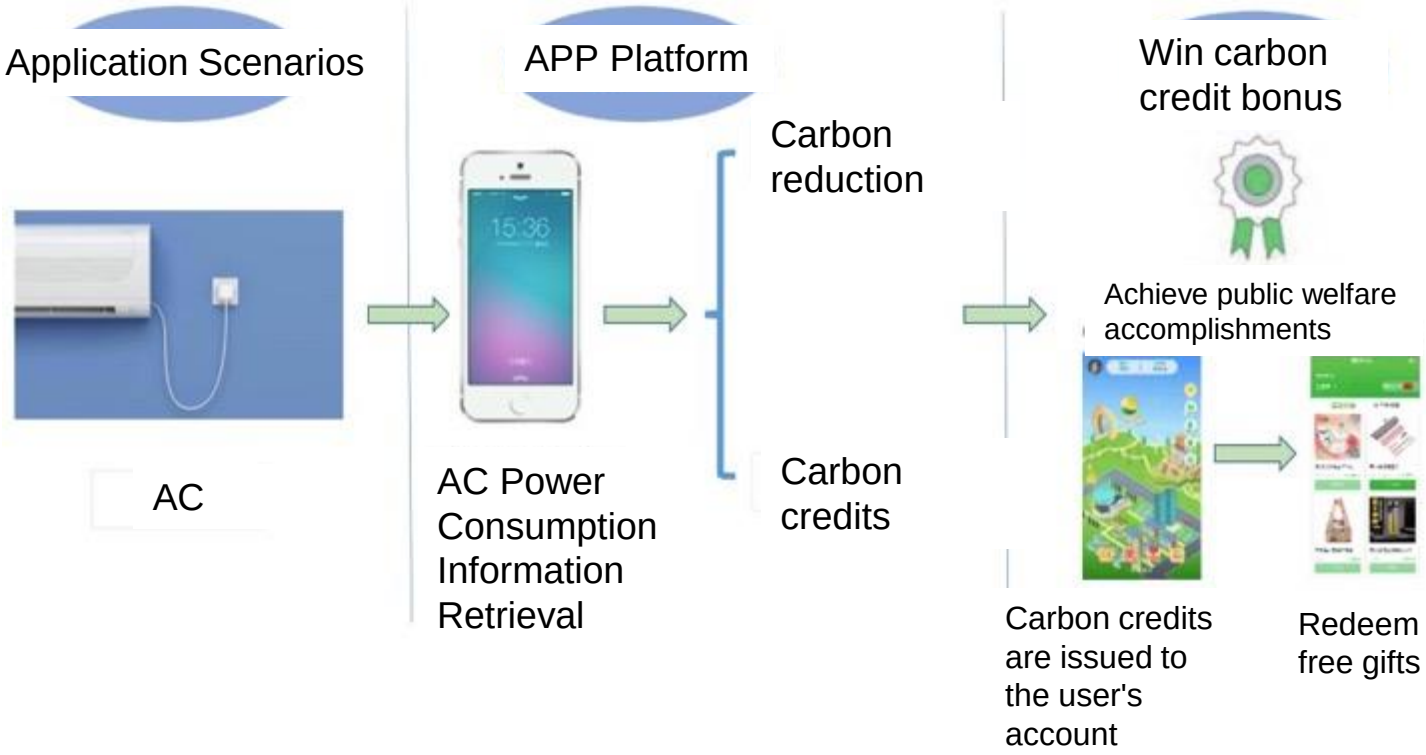
Air conditioning data collection is completed through a user interaction app (required hardware: AC compan ion).

APP for AC user interaction

- Grid → AC: The AC user interaction A PP enables air AC users to conduct d emand-side response actions based on factors such as electricity grid pric es and grid dispatch requirements.
- AC → Carbon Talent Platform: Energ y-saving and carbon reduction benefit s are converted into carbon credits.

Carbon Talent Platform

The platform enables top-level functions such as calculating the carbon effects of AC demand-side response actions, managing carbon accounts, and facilitating carbon credit trading and redemption.



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AC companion

The principle of the Air Conditioner Companion:
The Wi-Fi module of the AC Companion connects to the home router and receives commands from a mobile device. The infrared function is the core of the AC Companion. It contains infrared codes for hundreds of air conditioner brands and can control the air conditioner's power, temperature settings, mode settings, and other functions via infrared.

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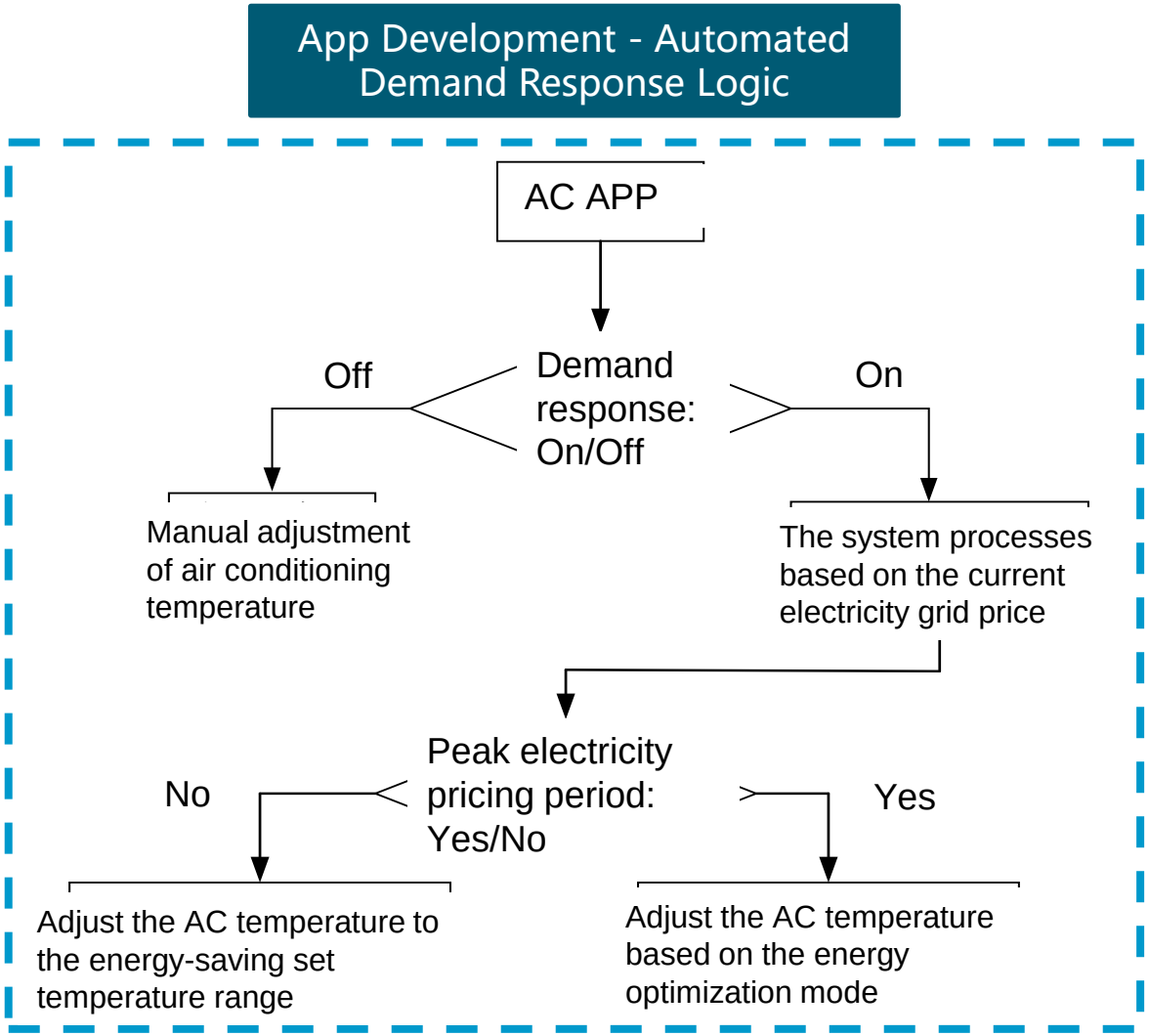

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App Development - Interface

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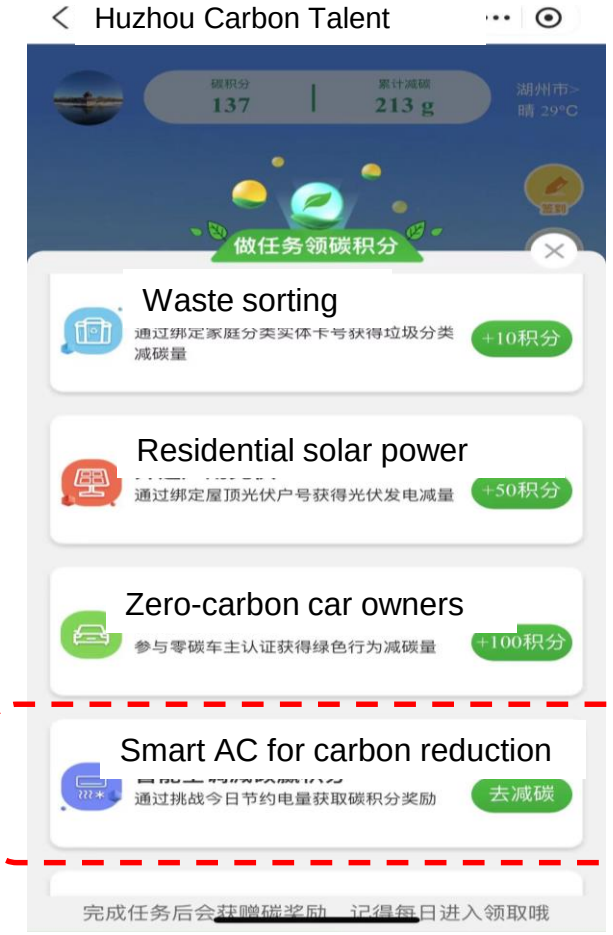

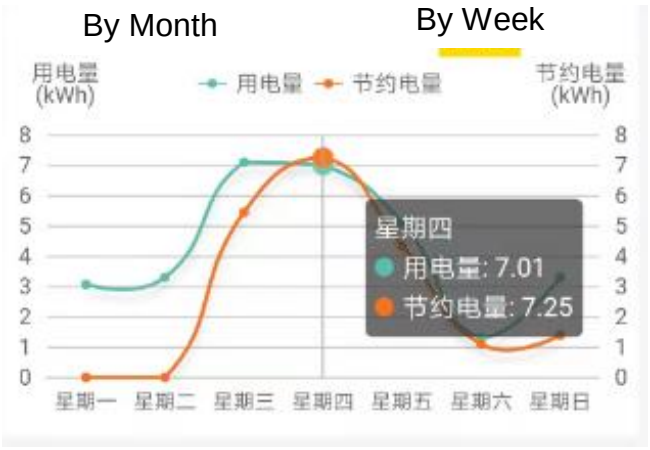

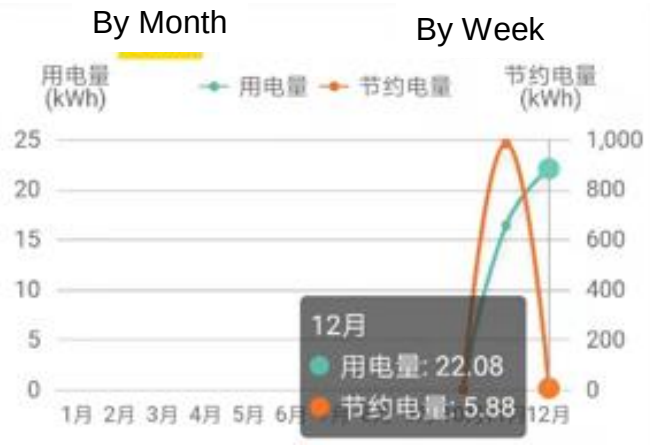

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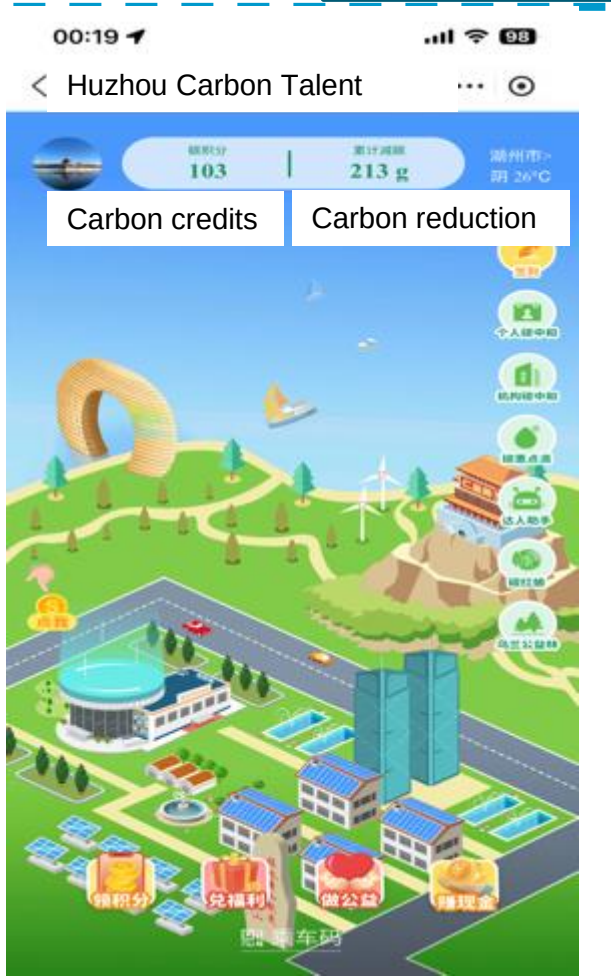

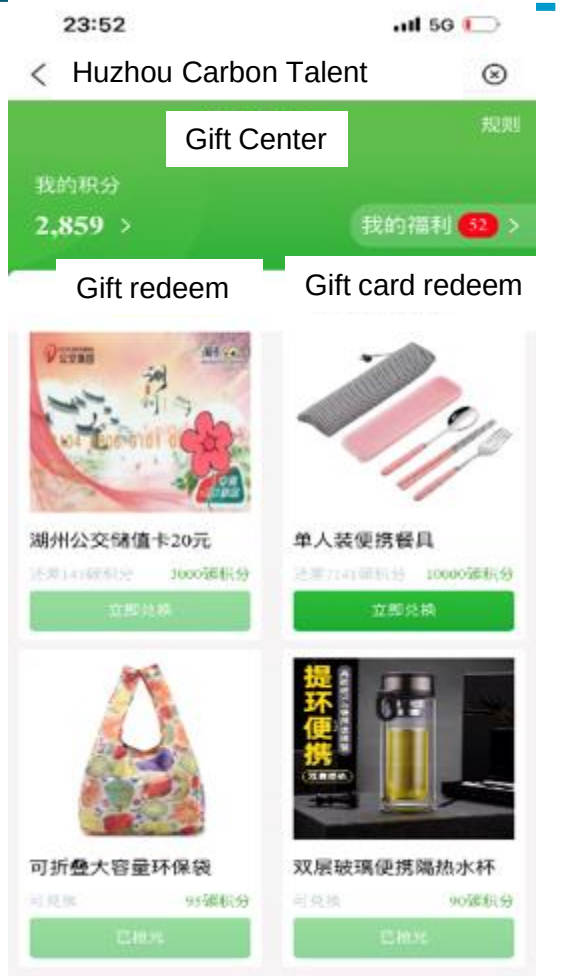

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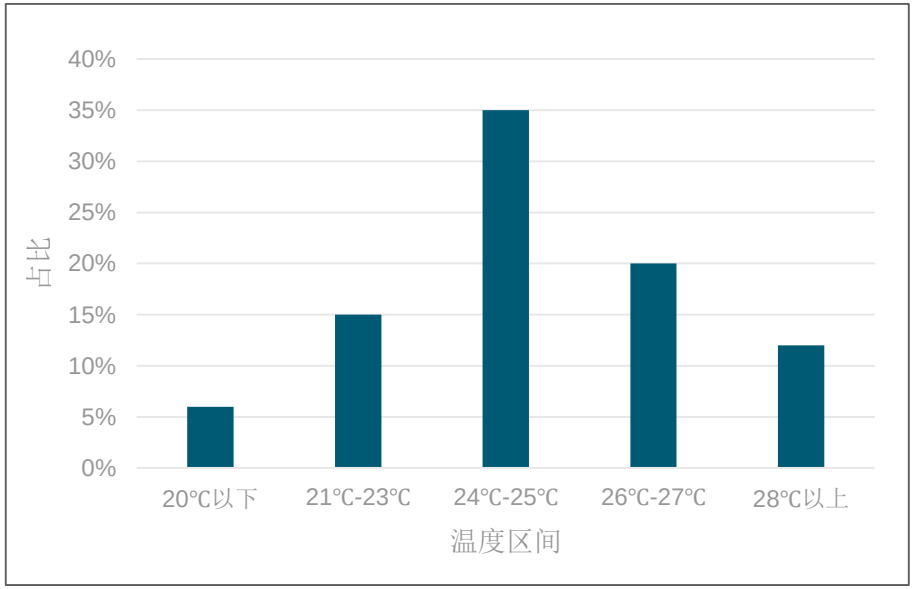
#	Area	AC model	Brand
User 01	Huzhou	Wall-mounted	Midea
User 02	Huzhou	Wall-mounted	Midea
User 03	Huzhou	Wall-mounted	Aux
User 04	Huzhou	Wall-mounted	Midea
User 05	Huzhou	Wall-mounted	Gree
User 06	Huzhou	Wall-mounted	Gree
User 07	Huzhou	Wall-mounted	Aux
User 08	Huzhou	Wall-mounted	Gree

AC models of some pilot users

Installation of AC companion



Distribution of residential AC temperature settings

RAC DSR Potential: "According to the State Grid Zhejiang Electric Power Company, the whole Zhejiang province can reduce its AC load by up to 7.3 million kW and 2.9 million kW, respectively, if AC temperatures are set at regulated temperatures of 26° C [78.8° F] in summer and 20° C [68° F] in winter."

Zhejiang Province in 2023: 1.52 million KW participated in RAC DSR; accounting for only 20% of the full potential.

Huzhou Residential Air Conditioning Load Demand-Side Response

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Energy Efficiency 2023

How does the hottest year on record drive urgency for efficiency measures?

Demand response programmes offer new ways to reduce the burden on power grids

To relieve pressure on power grids during hot periods, operators are embracing new strategies. This includes enabling appliances and cooling devices to be flexible and adapt energy usage according to real-time electricity demand, thus aiding grid balance during peak periods and offering consumers cost savings. This "demand response" can involve voluntary electricity use reduction during emergencies or financial incentives for consumers who reduce consumption.

For example, in Texas, when electricity demand hit an all-time high this summer, the grid operator increasingly used its demand response and energy flexibility programmes. These programmes reward large energy consumers for reducing demand during grid stress or shifting consumption to off-peak hours. In 2023, demand response payments are 20 times higher, benefiting programme participants.

In China, the Huzhou air conditioner demand-side management pilot was the first of its kind aimed at the residential sector. Wi-Fi connected air conditioners were enabled allowing users to adjust their settings via a smartphone app. The Chinese government has developed demand-side management plans to cover at least 5% of the country's electricity consumption by 2025, mostly from industry and cooling in public sector buildings.

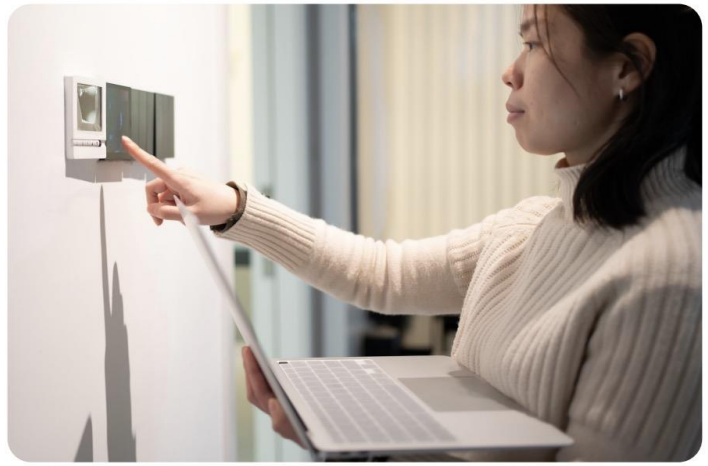
DEMAND FLEXIBILITY: ENHANCING GRID-FRIENDLY COOLING

PROJECT PERIOD: 2022–2024
COUNTRIES: China
PARTNERS: Energy Foundation China (EF China)

China, with the world's largest installed power generation capacity, still faces significant challenges in managing its energy demand, especially during extreme weather events. The 2022 heatwave exposed vulnerabilities in the country's electrical grid. A spike in cooling demand caused widespread power outages, highlighting the need for innovative solutions to stabilize the energy supply and minimize the need for fossil fuel-based peaker power plants — high-emitting power plants used in times of high demand.

MANAGING PEAK COOLING DEMAND

To demonstrate the potential impact of smart appliances and controls that enable users or utilities to better manage electricity use in response to overall demand on the power grid — i.e., demand response — CCC partnered with EF China for a pilot project in Huzhou. This



Smart home control switch in China (Credit: Wengen Ling)

https://www.cleancoolingcollaborative.org/blog/smart-cooling-solutions-exploring-the-role-of-demand-side-management-in-china/

Reflections on Future Work

Reflections on Future Work

- Scale-up and demonstration of Huzhou pilot; Scaling –> More significant energy savings and carbon reduction effects
- How can Carbon Inclusive truly be ”inclusive"? How can the incentive mechanism be more effective?
- How can smart home AC contribute to AC load’s participation in demand-side response?
- New focus areas for demand-side response? (Traditional high-energy-use sectors PLUS Residential AC load aggregation)

THANK YOU