

# Strategic Thinking on the Integrated Development of Hydro, Wind, and Solar Energy in the Yalong River Basin

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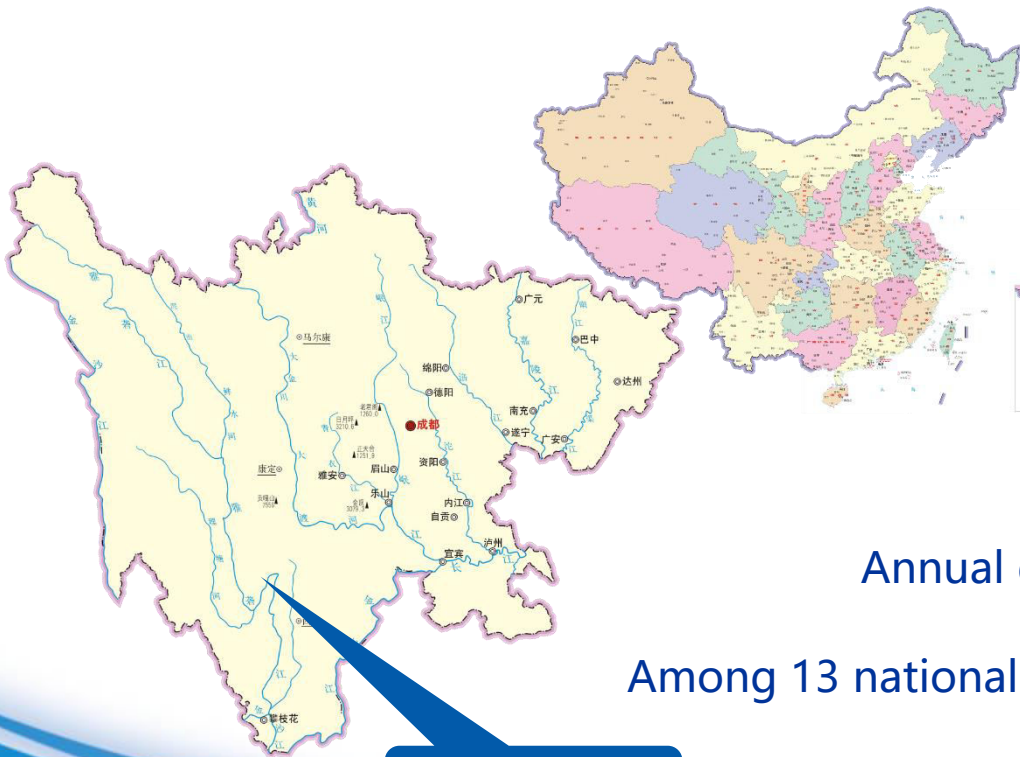


- 1 Development and Innovative Practices in Hydropower Resource Utilization**
- 2 Integrated Development Practices of Hydro, Wind, and Solar Energy**
- 3 Integrated Development Recommendations**
- 4 Conclusions**



- Yalong Hydro, formerly known as the Ertan Hydropower Development Company, was established in 1989 and was renamed to Yalong River Hydropower Development Company, Ltd., in November 2012
- Main business: **hydropower & new energy**
- Responsible for the development of hydropower resources in the Yalong River Basin and the construction and management of the cascade hydropower stations on the River

## (II) Overview of Hydropower Resources in the Yalong River Basin



Main Stream: 1571 Km

Annual Runoff: 60.9 B m<sup>3</sup>

Drop: 3830 m

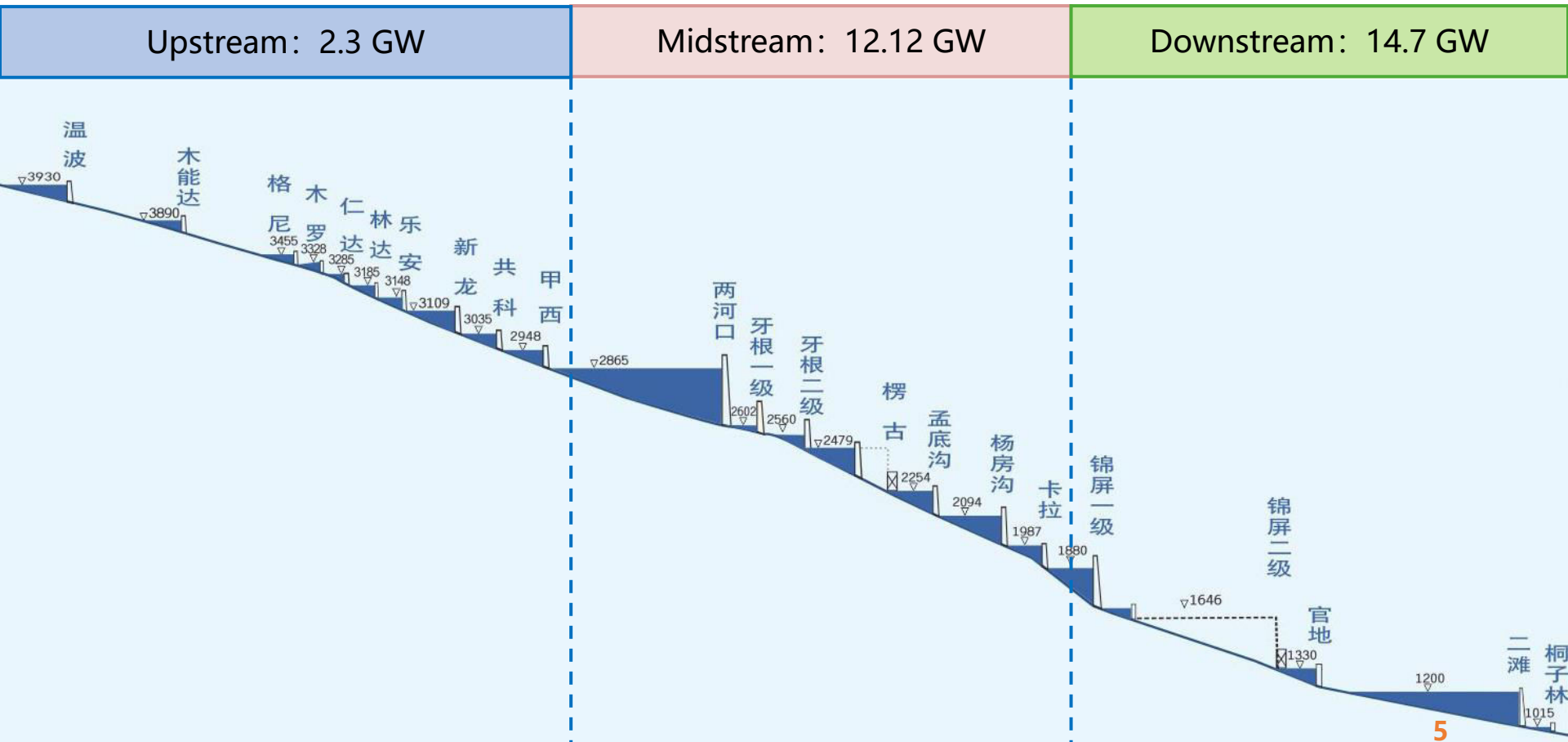
Total Capacity : **30 GW**

Annual generation capacity: **150 B kW·h**

Among 13 national hydropower bases: **Ranking No.3**

Yalong River

# (II) Overview of Hydropower Resources in the Yalong River Basin



## (II) Overview of Hydropower Resources in the Yalong River Basin

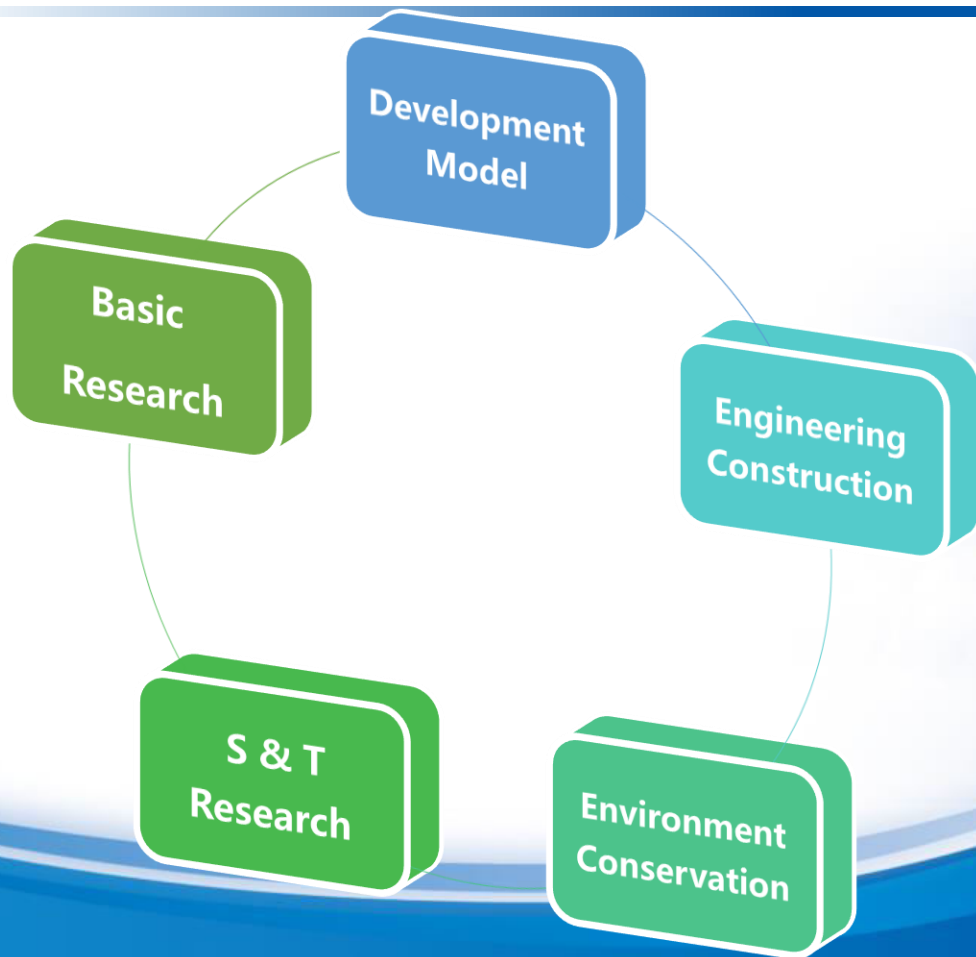
Lianghekou, Jinping I, and Ertan have been established with a total regulated storage capacity of 14.8 billion m<sup>3</sup>. Their coordinated operation enables Yalong River cascade hydropower stations to have multiple-year regulation capabilities, generating even more electricity during low-flow periods than high-flow periods, making it the top-performing large river.



- Downstream: ‘one reservoir and five stations’ with a total installed capacity of 14.7 GW, including Jinping I, Jinping II, Guandi, Ertan, and Tongzilin Hydropower Stations.
- Midstream: ‘one reservoir and seven stations’ with a total capacity of 12.12 GW. Yangfanggou and Lianghekou are completed (4.5 GW), Kela, Mengdigou, Yagen I are under construction (3.72 GW).
- Upstream: ‘one reservoir and ten stations’ with a total capacity of approximately 2.3 GW. There is potential for expansion to around 4 GW.

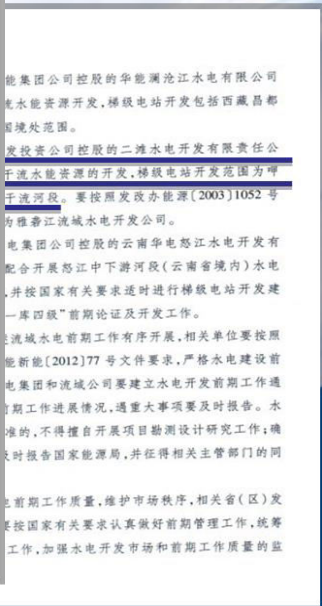
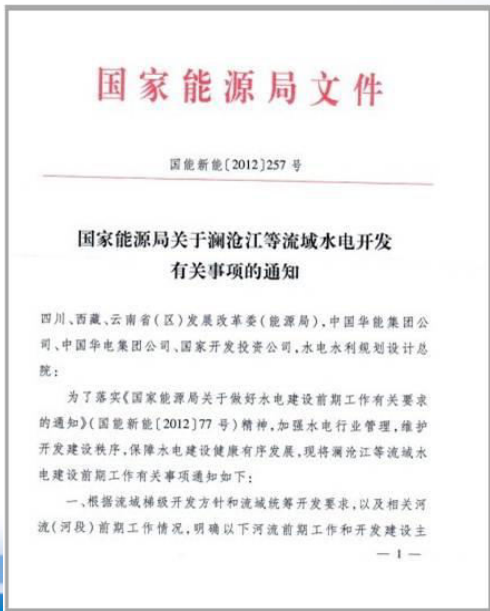


## (IV) Innovative Practices in Hydropower Development

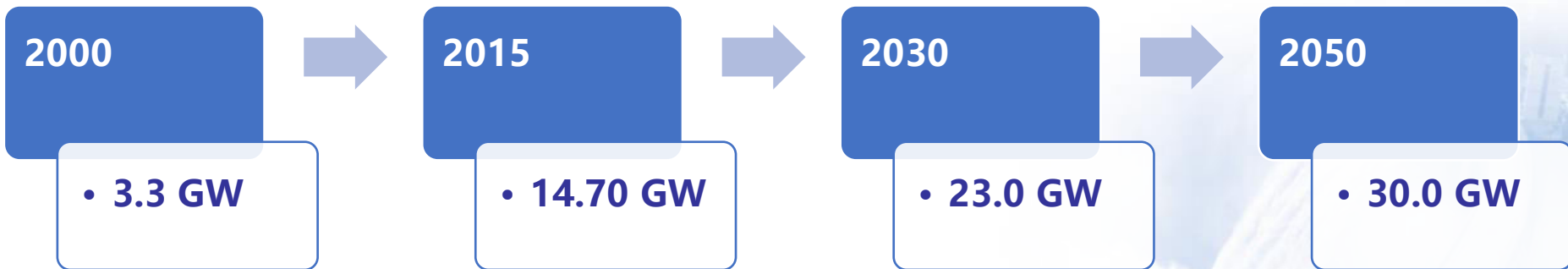




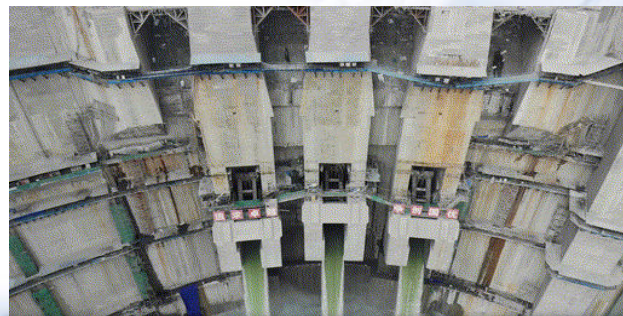
In 2003 and 2012, the NDRC and NEA assigned the responsibility to the Yalong River Company for the development of water resources in the Yalong River Basin, marking the beginning of the "One Entity, One River" development model.



## ➤ The "Four-Stage" Strategic Development of Hydropower Resources



Lianghekou Hydropower Station



Yangfanggou Hydropower Station

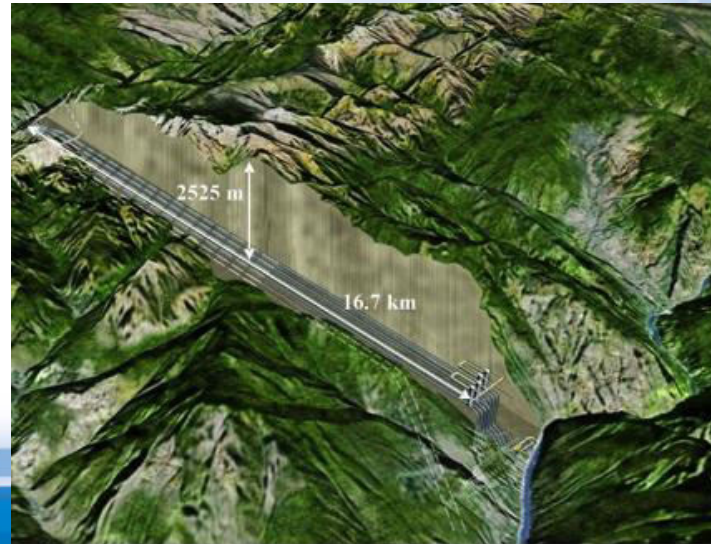
### The Tallest Dam - Jinping I Arch Dam (305 m)

- Tackled the challenges of constructing the tallest arch dam with safety and efficiency
- Addressed complex geological conditions in the dam foundation
- Significantly advanced the technological progress in extra-high arch dams worldwide



### The Largest and Deepest Hydraulic Tunnels - Jinping II (4.8 GW)

- Preventing rock bursts with extreme pressure of 100 MPa in the super-long headrace tunnel with the world's deepest overburden (2500 m)
- Handling high-pressure and high-flow water surges
- Significantly advanced the technology for deep underground engineering worldwide



### The 3<sup>rd</sup>-highest Embankment dams- Lianghekou (295 m)

- Advancing Embankment dam construction technology to the 300 m level in China
- Promoting the design, construction, and management of high-altitude 300 m Embankment dams in Tibetan regions.

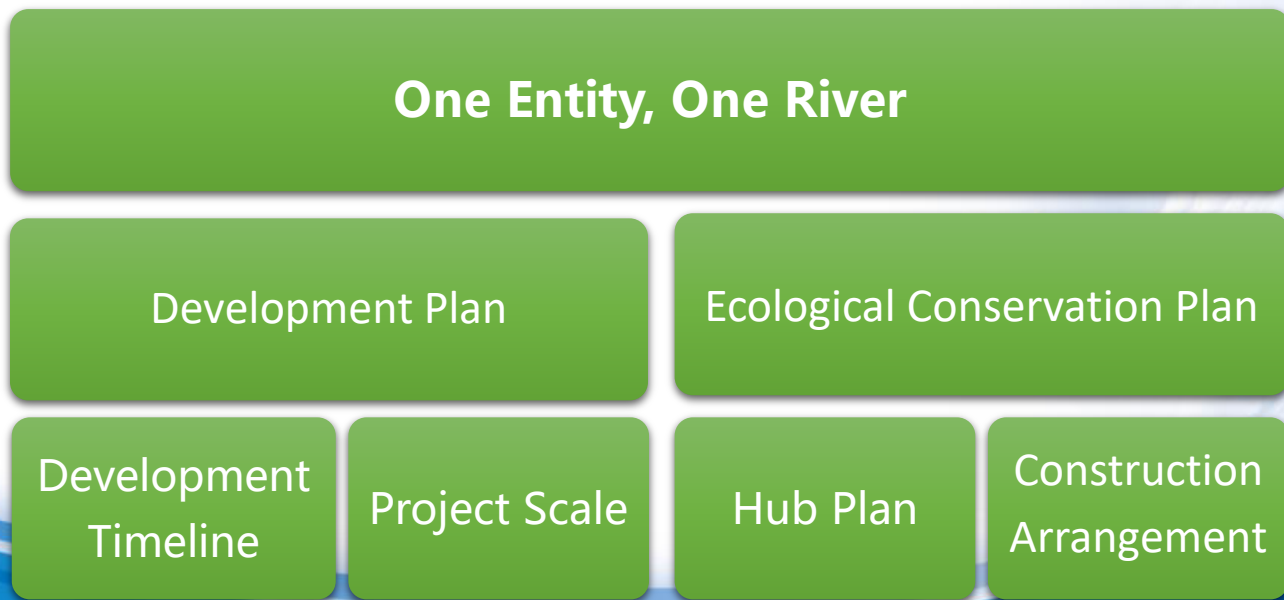


### The 1<sup>st</sup> Domestic EPC Hydropower Project over 1 GW – Yangfanggou (1.5 GW)



- Pioneered the EPC mode for the design and construction of large hydropower stations in China

- Concept of "watershed coordination and harmonious development"
- Explore a watershed development model that promotes harmonious coexistence between humans and nature



## Establishing Joint Fish Hatcheries

— a multi-station collaborative approach, investing over ¥500 M to construct four fish hatcheries, covering the entire basin

锦屏  
官地  
鱼类  
增殖  
站



雅砻  
江中  
游鱼  
类增  
殖站



两河  
口牙  
根鱼  
类增  
殖站



二滩  
桐子  
林鱼  
类增  
殖站





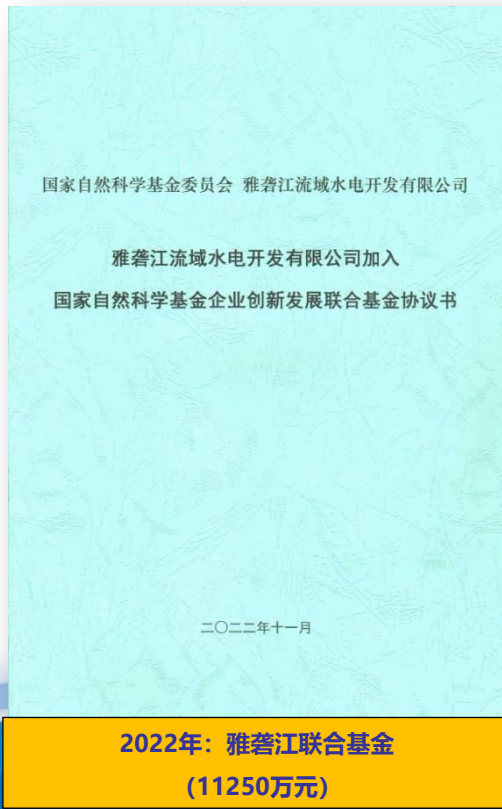
All cascade hydropower stations in the downstream of the Yalong River have received **national-level awards for ecological civilization.**



Ertan - Environmental Friendly Project Award

Jinping I & II, Guandi, Tongzilin - National Soil and Water Conservation Ecological Civilization Project Award

### Collaboration with the NNSFC to establish the **Yalong River Joint Fund**



### Postdoctoral Workstation & Engineering Special Advisory Team



博士后工作站挂牌

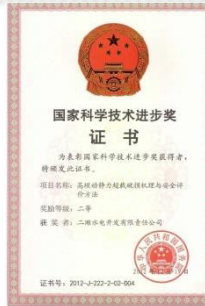


两河口工程特咨团

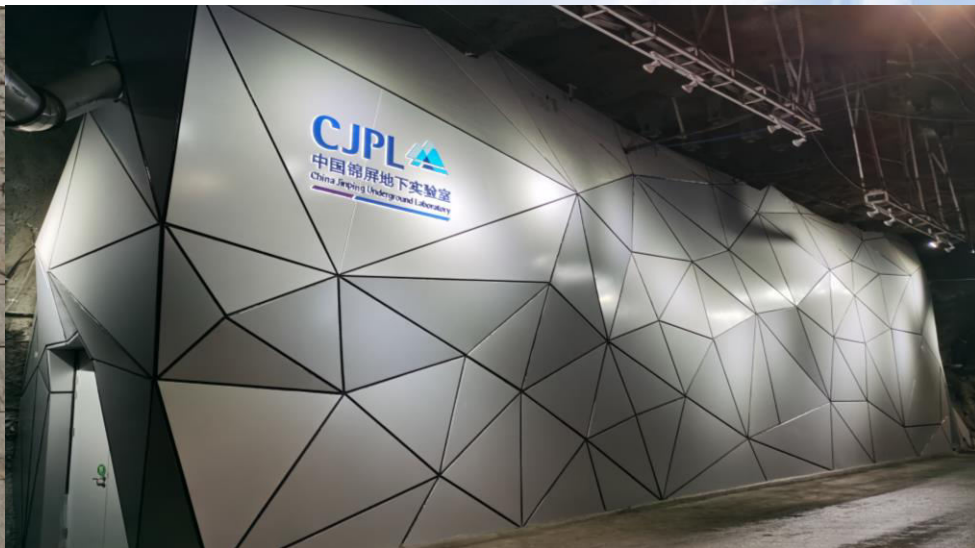


锦屏工程特咨团

# 4. Scientific and Technological Research Innovation



- 2010: jointly established the **China Jinping Underground Laboratory** with Tsinghua University.
- 2017: jointly established "Ultra-Deep Underground Ultra-Low Radiation Background Frontiers in Physics Experimental Facility, " which is the largest underground laboratory worldwide.



➤ More than 10 research teams have successively joined to conduct scientific research. This has contributed to China's dark matter and nuclear astrophysics research, enabling it to transition from following and keeping pace to leading in the field.

### 清华大学CDEX实验团队

2013年发表了我国首个暗物质直接探测实验结果。2016年发表了世界最灵敏轴子暗物质实验结果。2021年发表暗物质轻质量区域世界最灵敏限制。2022年发表了国际上使用锗探测器的暗物质直接探测实验的最好结果。未来将计划开展吨级高纯锗暗物质探测器的研究。



### 清华大学中微子实验团队

将探寻太阳和地球“最核心处”的物质组分,研究太阳、地球核心的原初形态及从一团星际尘埃聚合成恒星和行星的物理规律,寻找无中微子双β衰变信号。



### 清华大学低本底实验团队

设有极低本底测量与分析中心,面向前沿物理实验、环境辐射监测、地球科学等研究领域开展极低本底测量技术研究和样品检测服务。



### 四川大学华西医院深地医学实验团队

利用深地低辐射本底环境,对比开展不同深度地下环境与正常地面环境下细胞分裂、生殖发育、生物进化、肿瘤免疫学等相关研究,并探索深地环境下治疗癌症、延缓衰老的可能。



### 四川大学GeoDEX实验团队

依托CJPL优势观测条件,建设世界最深处地质深地原位探测站,有望证明“地质时变”驱动本源、时空演变过程及对人类的影响,检验地球科学基本假设及理论模型,获取地质时变产生过程中的原创性、突破性、颠覆性发现,揭示深地科学本质规律。



### 中国原子能院JUNA实验团队

2022年10月26日团队最新科研进展在国际顶级学术期刊《Nature》发表,成果将关键核天体反应 $^{19}\text{F}(p, \gamma)^{20}\text{Ne}$ 的测量范围推进到世界最低能区,国际首次揭示了宇宙最古老恒星中的钙丰度之谜,进一步揭示了古老恒星的演化命运。该文章也是《自然》杂志发表的第一篇我国核物理装置实验成果文章。



### 上海交通大学PandaX实验团队

成果曾入选2016年《科技导报》十大科学进展和2017年美国物理学会亮点。2022年发表了国际上由暗物质直接探测实验组采用宇宙线加速暗物质手段给出的最强限制。未来计划开展30吨级液氙暗物质研究,并启动百吨级实验大科学培育计划。



### 工业和信息化部电子第五研究所

主要开展深地环境下集成电路软错误试验,基于CJPL极低宇宙射线本底的条件,通过长期监测IC阵列在深地环境下的存储内容变化情况,获得IC由封装材料剂量放射性同位素产生的 $\alpha$ 粒子导致的软错误特性,为IC可靠性研究提供关键数据。



### 生态环境部北京师范大学 锦屏极低辐射本底测量联合实验室

将搭建3套极低本底环境样品放射性核素测量平台,1套极低本底人体剂量放射性核素测量平台,开展相关极低本底测量前沿科学研究。



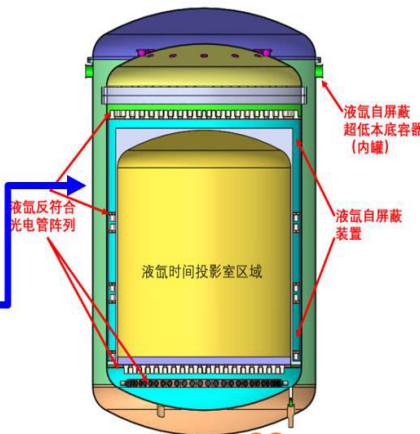
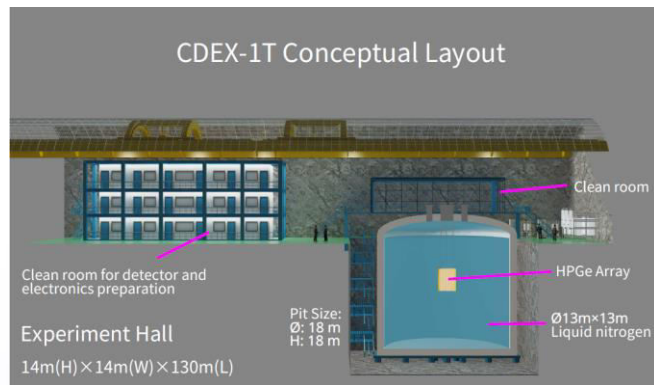
### 中科院武汉岩土所 深地岩石力学实验团队

研发了相邻同向短周期固定式和单侧向扩孔移动式传感的岩体监测方法,动态准确预警了锦屏大设施施工标开挖过程中的岩爆风险。基于监测信息即时准确评估了“9.5”泸定地震对锦屏大设施施工稳定影响。



## The experimental projects conducted at the Jinping Underground Laboratory:

- CDEX (High-Purity Germanium + 0vbb Experiment)
- PandaX (Liquid Xenon Dark Matter + High-Pressure Gaseous Xenon 0vbb Experiment)
- Liquid Argon Dark Matter Experiment
- JUNA (Jinping Underground Nuclear Astrophysics Experiment)
- Neutrino Experiment
- Geomechanics Experiment
- Underground Biology Experiment
- Deep Medicine Research Experiment
- .....

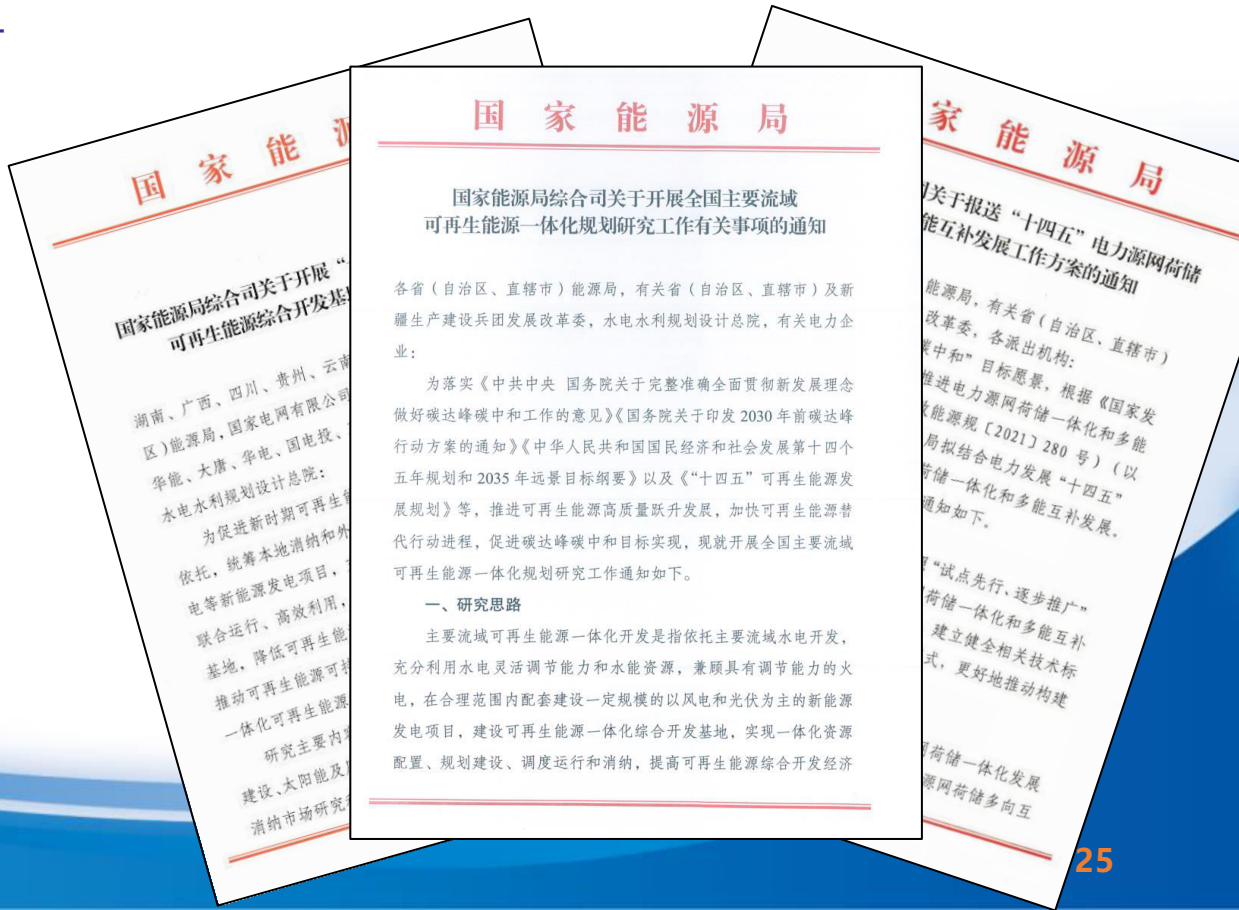


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Since the start of the 14<sup>th</sup> Five-Year Plan period, the NEA has raised requirements such as "integrated renewable energy", and allocated resources to conduct integrated renewable energy planning and studies in key river basins.



## 国家能源局

### 国家能源局综合司关于开展全国主要流域 可再生能源一体化规划研究工作有关事项的通知

各省（自治区、直辖市）能源局，有关省（自治区、直辖市）及新疆生产建设兵团发展改革委，水电水利规划设计总院，有关电力企业：

为落实《中共中央 国务院关于完整准确全面贯彻新发展理念做好碳达峰碳中和工作的意见》《国务院关于印发 2030 年前碳达峰行动方案的通知》《中华人民共和国国民经济和社会发展第十四个五年规划和 2035 年远景目标纲要》以及《“十四五”可再生能源发展规划》等，推进可再生能源高质量跃升发展，加快可再生能源替代行动进程，促进碳达峰碳中和目标实现，现就开展全国主要流域可再生能源一体化规划研究工作通知如下。

#### 一、研究思路

主要流域可再生能源一体化开发是指依托主要流域水电开发，充分利用水电灵活调节能力和水能资源，兼顾具有调节能力的火电，在合理范围内配套建设一定规模的以风电和光伏为主的新能源发电项目，建设可再生能源一体化综合开发基地，实现一体化资源配置、规划建设、调度运行和消纳，提高可再生能源综合开发经济

## 国家能源局

### 关于报送“十四五”电力源网荷储 互补发展工作方案的通知

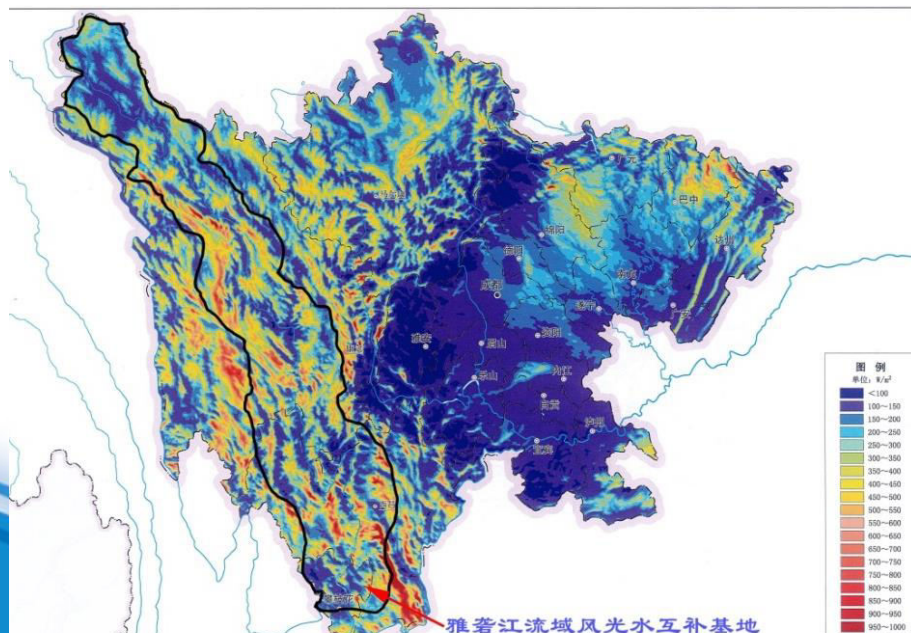
能源局，有关省（自治区、直辖市）发展改革委，各派出机构：  
“碳达峰”目标愿景，根据《国家发展和改革委员会  
推进电力源网荷储一体化和多能  
互补发展规划〔2021〕280号》（以  
后简称《通知》），结合电力发展“十四五”  
源网荷储一体化和多能互补发展。  
通知如下。

“试点先行、逐步推广”  
源网荷储一体化和多能互补  
建立健全相关技术标准  
式，更好地推动构建

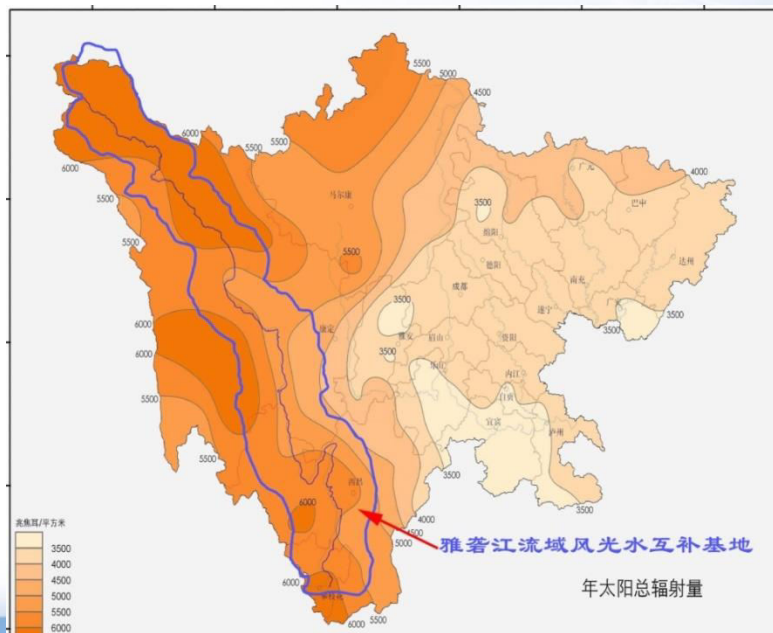
源网荷储一体化发展  
源网荷储多向互



- The Yalong River Basin has abundant hydropower, wind power, and solar resources, with a total capacity exceeding 80 GW. The potential wind and solar resources total over 40 GW, and the pumped storage capacity exceeds 10 GW.



四川省70米高度年平均风功率密度分布图  
区域风能资源等级多为2级



四川省年太阳总辐射量分布图  
西部大部分属太阳能资源二类和三类地区

## 1. Pursue the carbon peaking and neutrality goals and build a new power system

The 3 major control reservoirs in the Yalong River Basin have a total storage capacity of 24.3 B m<sup>3</sup>, and there is tremendous potential for the development of hydro, wind, and solar energy in a complementary manner. The base has been included in the national "14<sup>th</sup> Five-Year Plan", for building a new type of power system primarily based on new energy.

专栏6 现代能源体系建设工程	
01	<p><b>大型清洁能源基地</b></p> <p>建设雅鲁藏布江下游水电基地。建设金沙江上下游、<u>雅砻江流域</u>、黄河上游和几字湾、河西走廊、新疆、冀北、松辽等清洁能源基地，建设广东、福建、浙江、江苏、山东等海上风电基地。</p>
02	<p><b>沿海核电</b></p> <p>建成华龙一号、国和一号、高温气冷堆示范工程，积极有序推进沿海三代核电建设。推动模块化小型堆、60万千瓦级商用高温气冷堆、海上浮动式核动力平台等先进堆型示范。建设核电站中低放废物处置场，建设乏燃料后处理厂。开展山东海阳等核能综合利用示范。核电运行装机容量达到7000万千瓦。</p>
03	<p><b>电力外送通道</b></p> <p>建设白鹤滩至华东、金沙江上游外送等特高压输电通道，实施闽粤联网、川渝特高压交流工程。研究论证陇东至山东、哈密至重庆等特高压输电通道。</p>
04	<p><b>电力系统调节</b></p> <p>建设桐城、磐安、泰安二期、浑源、庄河、安化、贵阳、南宁等抽水蓄能电站，实施电化学、压缩空气、飞轮等储能示范项目。开展黄河梯级电站大型储能项目研究。</p>
05	<p><b>油气储运能力</b></p> <p>新建中俄东线境内段、川气东送二线等油气管道。建设石油储备重大工程。加快中原文23、辽河储气库群等地下储气库建设。</p>

### 2. A major initiative to ensure national energy security

After the completion of the entire base, it will generate approximately 200 B kW·h of electricity annually, providing a huge quantity of high-quality and stable clean renewable energy for East China, Central China, and the Sichuan-Chongqing region.



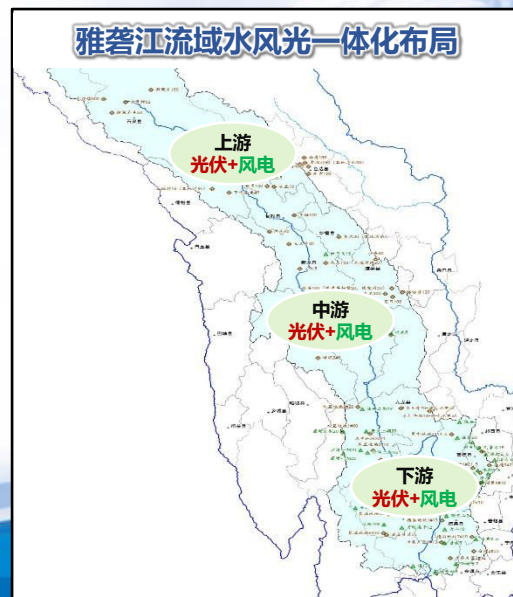
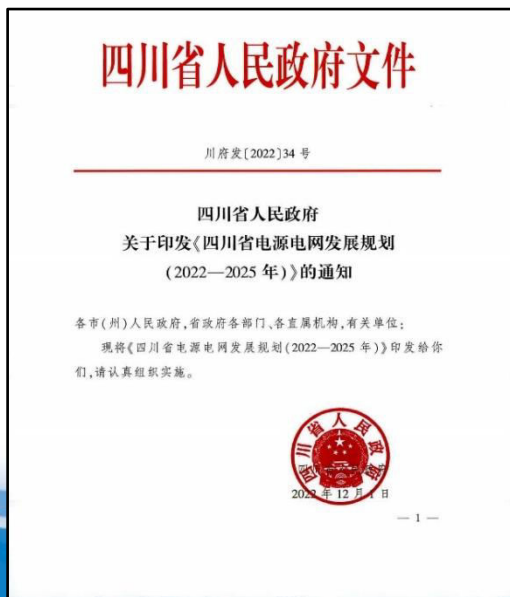
### 3. A major initiative for “Lucid waters and lush mountains are invaluable assets”

The Integrated Demonstration Base will produce 100% clean and renewable energy. When the base is fully completed, it will generate over 200 B kW·h green electricity annually, which is equivalent to reducing CO<sub>2</sub> emissions by approximately 150 M tons per year.



## 4. A major initiative for the national and Sichuan Province's "14<sup>th</sup> Five-Year Plan"

- One of the nine major clean energy bases designated by the nation
- One of the bases with integrated water, wind, and solar energy identified for accelerated building in Sichuan Province

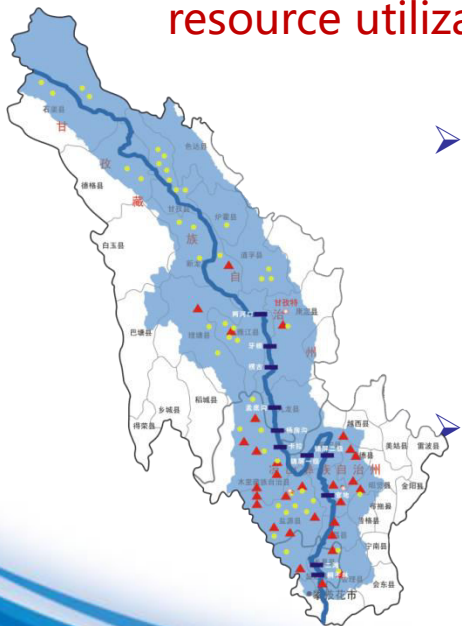


### 5. Driving regional economic and social development & helping ethnic areas achieve revitalization



The development and construction of the Yalong River Basin, which flows through the Tibetan region of the western Sichuan Plateau and the Yi Autonomous Prefecture of Liangshan, is a key battleground for China's poverty alleviation efforts. The development of the base will bring significant direct investment, effectively driving regional economic and social development, and will contribute to promoting rural revitalization in ethnic areas.

1. "One entity, one river" approach can effectively coordinate and optimize resource utilization, enhancing the economic viability of new energy projects.



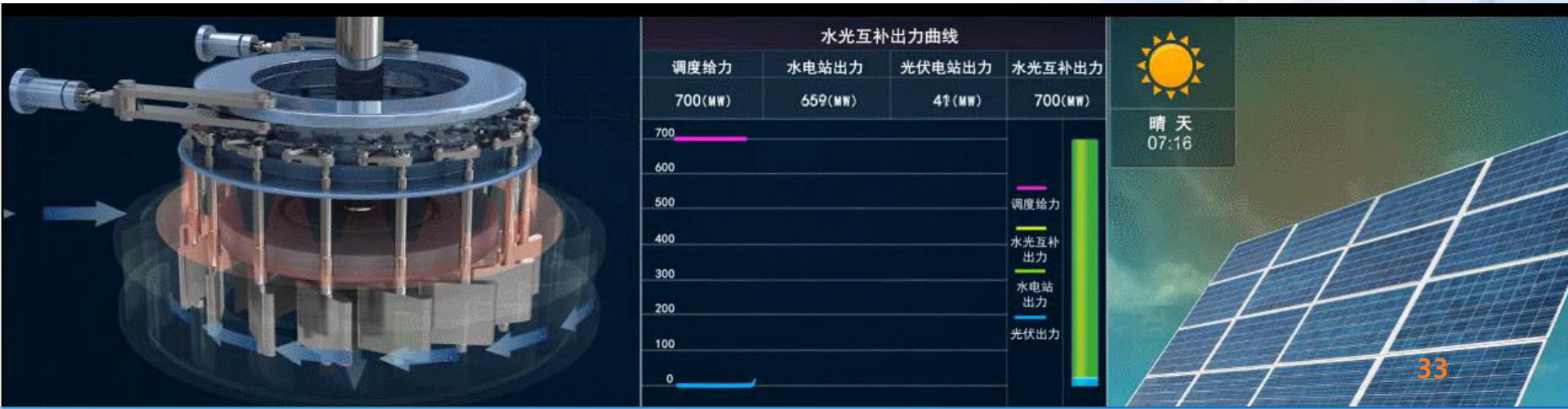
- Improving resource utilization efficiency, accelerating construction and saving on investments
- Unified management to improve efficiency





2. Hydropower stations have excellent regulation performance, which enhances the stability of new energy output.

The three major control reservoirs have a total regulation capacity of 14.8 B m<sup>3</sup> and the installed capacity has reached 19.2 GW, providing significant regulation capacity for the development of wind and solar energy and enhances the grid's capacity to integrate wind and solar power.



3. Hydropower has abundant transmission lines, improving the reliability of accommodating new energy sources.

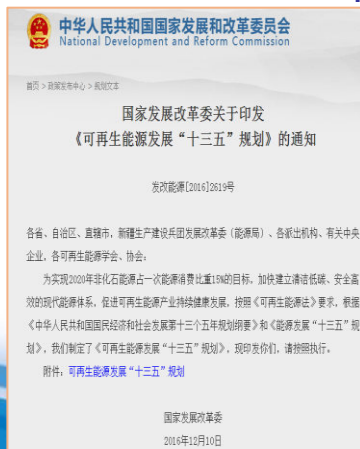
➤ Yalong River basin have already established the Jinshu DC and Yazhong DC transmission projects, with the capacity to transmit 15 GW of hydropower and renewable energy electricity from the middle and lower reaches of the Yalong River.

➤ Sichuan-Chongqing Ultra-High Voltage AC project will primarily collect clean energy from the upper and middle reaches of the Yalong River.

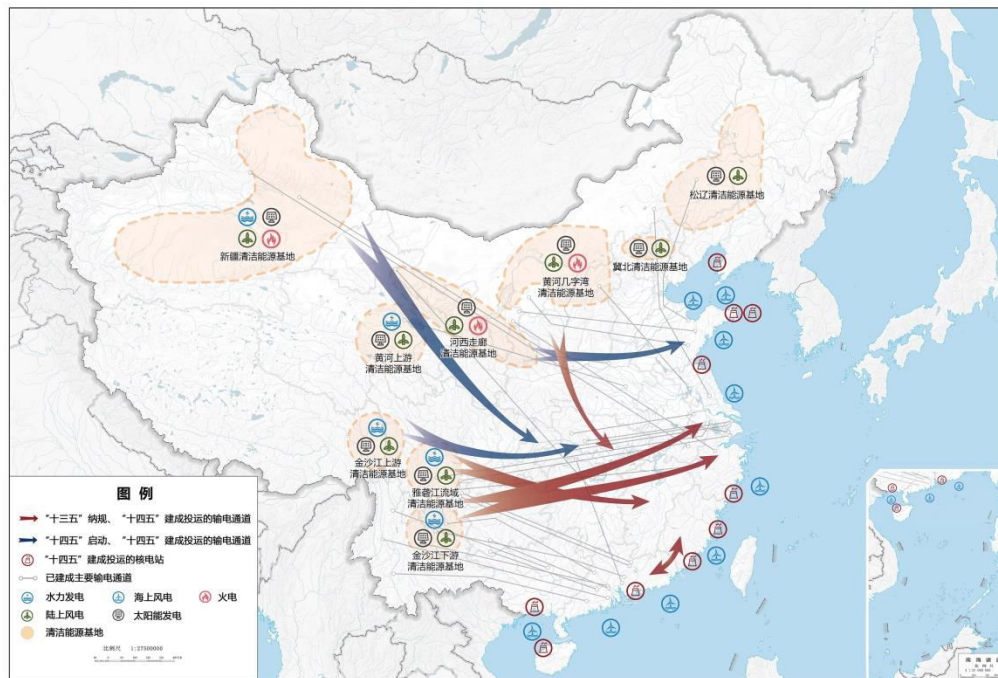


## 1. Enhancing top-level design and continuously updating the plans to advance the clean energy demonstration base in the basin.

In 2015, Yalong Hydro conducted resource surveys and preliminary planning for the base while actively coordinating with relevant authorities at the national and Sichuan province levels to reach consensus and promote the inclusion of the demonstration base planning in the "13<sup>th</sup> Five-Year Plan" for both national and provincial development.



At the beginning of the 14<sup>th</sup> Five-Year Plan, efforts continued to promote the inclusion of the demonstration base planning in the national "14<sup>th</sup> Five-Year Plan" and the "2035 Vision Outline". The concept and technical approach of integrated water, wind, and solar energy development gradually evolved into a national strategy and industry requirement, gaining widespread recognition and becoming one of the primary approaches.



- The National Energy Administration has mandated the research on integrated planning for renewable energy in major river basins nationwide.
- At present, the planning of the integrated demonstration base for hydro, wind and solar energy in the Yalong River basin has been completed.

### 国家能源局

#### 国家能源局综合司关于开展全国主要流域 可再生能源一体化规划研究工作有关事项的通知

各省（自治区、直辖市）能源局，有关省（自治区、直辖市）及新疆生产建设兵团发展改革委，水电水利规划设计总院，有关电力企业：

为落实《中共中央 国务院关于完整准确全面贯彻新发展理念做好碳达峰碳中和工作的意见》《国务院关于印发 2030 年前碳达峰行动方案的通知》《中华人民共和国国民经济和社会发展第十四个五年规划和 2035 年远景目标纲要》以及《“十四五”可再生能源发展规划》等，推进可再生能源高质量跃升发展，加快可再生能源替代行动进程，促进碳达峰碳中和目标实现，现就开展全国主要流域可再生能源一体化规划研究工作通知如下。

#### 一、研究思路

主要流域可再生能源一体化开发是指依托主要流域水电开发，充分利用水电灵活调节能力和水能资源，兼顾具有调节能力的火电，在合理范围内配套建设一定规模的以风电和光伏为主的新能源发电项目，建设可再生能源一体化综合开发基地，实现一体化资源配置、规划建设、调度运行和消纳，提高可再生能源综合开发经济

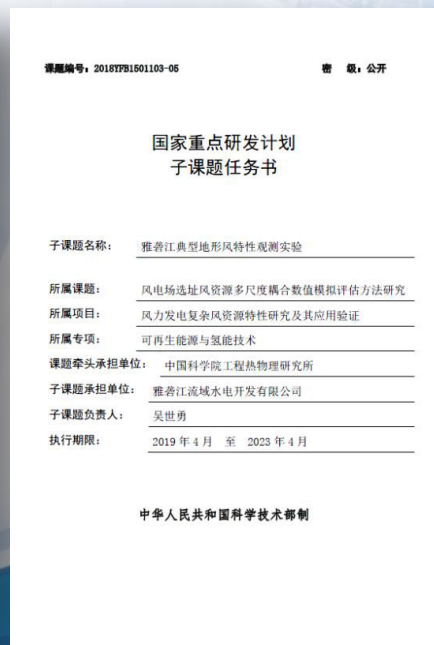
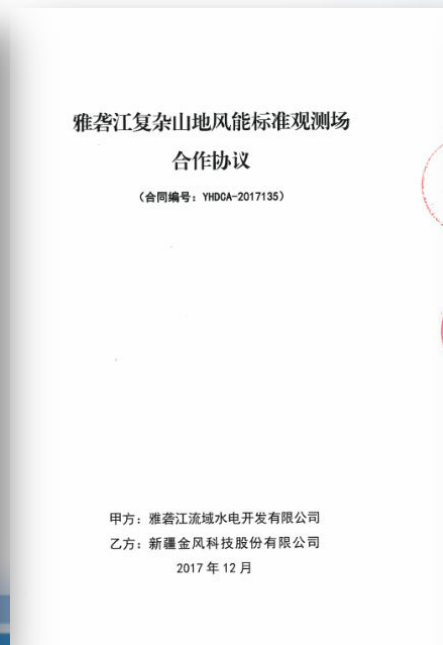
## 2. Solidifying the fundamentals of development theory and practice for base development.

➤ Advancing the construction of the clean energy base in the Yalong River and promoting its intelligent transformation and upgrading. The following issues were proposed to be addressed in the third Yalong River Joint Fund:

- Complementary Green and Clean Renewable Energy Development Technology in Large-scale Basin
- Key Technologies for the Intelligent Construction and Operation of Large-scale Basin Hydropower Projects

研究方向	研究内容
大型流域水风光储互补绿色清洁能源开发技术	<ul style="list-style-type: none"> <li>(1) 先进风力和光伏发电</li> <li>(2) 可再生能源制氢/储氢及氢能综合利用</li> <li>(3) 适应新型电力系统的新型储能系统</li> <li>(4) 流域水风光储多能互补清洁能源基地建设运营</li> </ul>
大型流域水电工程智能建设与运行关键技术	<ul style="list-style-type: none"> <li>(1) 水电工程智能建造和质量控制</li> <li>(2) 工程建设现场智能安全管控</li> <li>(3) 水电工程运行性态智能监控</li> <li>(4) 库区及枢纽区地质灾害智能监控</li> <li>(5) 水电工程水下智能检测及修复</li> <li>(6) 流域水资源智能精细化预测与多目标调度</li> <li>(7) 水电站机电设备/发电机组智能监控</li> <li>(8) 水电站安全智能管控</li> </ul>

- Strategic cooperation with Huawei and collaborating with Jinfeng Technology to establish a wind energy standardized observation site
- Participated in a sub-project of the national key research and development program



During the 14th Five Year Plan period, Yalong Hydro actively promoted the construction of hydro, wind and solar integration demonstration projects.

- June 2022, the Laba Mountain Wind Power Project (258 MW) has started construction
- July 2022, the Phase I Solar Project (1 GW) of the Lianghekou Hydro and Solar Complementary Project has started construction
- Nov. 2022, the Jinping Hydro and Solar Complementary Solar Project (1.17 GW) has been filed for approval





On June 25, 2023, the first phase of the largest and highest-altitude solar-hydro complementary project in the world, the Kela Solar Power Station, was officially put into operation and began generating electricity.

This significant event received extensive media coverage, with reporting from China Central Television news.



Eight key pumped storage power stations will serve as the regulation power sources for the integrated development of hydro, wind, and solar energy resources in the Yalong River basin.

- In December 2022, the Lianghekou Hybrid Pumped Storage Power Station (1.2 GW) received approval and commenced construction in the same month.
- The Daofu Pumped Storage Power Station (1.8 GW) is currently advancing pre-construction work and is about to receive approval for construction.

### 四川省发展和改革委员会文件

川发改能源〔2022〕714号

四川省发展和改革委员会  
关于雅砻江两河口混合式抽水蓄能电站  
项目核准的批复



- 1 Development and Innovative Practices in Hydropower Resource Utilization**
- 2 Integrated Development Practices of Hydro, Wind, and Solar Energy**
- 3 Integrated Development Recommendations**
- 4 Conclusions**

## 1. Accelerating the large-scale development of clean energy and exploring innovative hydro-wind-solar integrated development model

The "14<sup>th</sup> Five-Year Plan" mandates the creation of clean energy bases like the Yalong River, Upper Jinsha River, and Lower Jinsha River. Through integrated hydro-wind-solar development within the basin, leveraging hydropower's energy storage capabilities, it aims to efficiently scale and seamlessly integrate wind and solar resources. This approach transforms intermittent renewables into high-quality electricity, aiding China's large-scale clean energy development.

To prevent fragmented development and maximize resource use, it's recommended to innovate hydro-wind-solar integrated development mode, improving efficiency and serving as a model for rapid, high-quality renewable energy growth.

## 2. Accelerating the construction of the power grid to promote the coordinated development of generation and transmission

China's uneven clean energy distribution, characterized by a mismatch between generation and consumption, coupled with a grid structure of long-distance transmission and weak links, leads to curtailment issues in specific regions. With the rapid expansion of integrated hydro-wind-solar projects nationwide, efficient transmission line planning and construction are paramount.

Adhering to the "Three-in-One" principle, encompassing integrated hydro-wind-solar bases, hydropower regulation capacity, and transmission lines, it is crucial to identify consumption markets for these bases. Simultaneously, synchronized planning for power generation and the electricity grid ensures coordinated design and efficient renewable energy utilization.

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In the development of hydropower in the Yalong River basin, Yalong Hydro has explored and established the development model of "one entity, one river." It has accumulated rich experience in the coordinated development and utilization of cascade hydropower stations in the basin.

In this new development stage, the integration of renewable energy sources, primarily hydro, wind, and solar, is the path to achieving high-quality development of renewable energy. Yalong Hydro continues to expand the concept of "one entity, one river" and will further promote the construction of the integrated water-wind-solar demonstration base, making greater contributions to the development of clean energy in China.

*Contributing Green and Clean Energy*

*Serving National Strategic Development*

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*Thank You!*

