弗尔赛能源
FORESIGHT ENERGY

通信用燃料电池应急/备用电源的开发与应用实践

R & D and Application of the Fuel Cell Backup/Emergency power

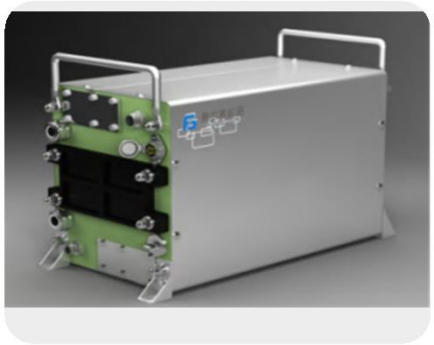
2015.05 武汉

WWW.FORESIGHT-ENERGY.CN

主要内容

- 产品研发 R&D
- 生产与检测配套能力 Manufacture & Testing
- 产品应用 Product & Application

有关弗尔赛 About Foresight



弗尔赛 Foresight

燃料电池电堆（模块） Fuel Cell Stacks Provider&

燃料电池固定式发电 Stationary Power Integrator

规模化的燃料电池电堆应用量

Most Fuel Cell Stacks in the Field

长期运行考核，数据积累充分

Most Hours of Runtime

规模化的通信电源系统运行网络

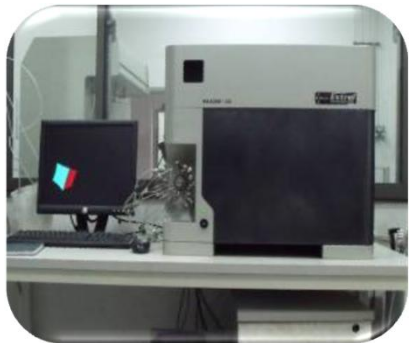
MOST Deployed Backup power

规模化的燃料电池增程器模块应用

Most Range-Extenders in Application

测试分析能力 Capability of Testing

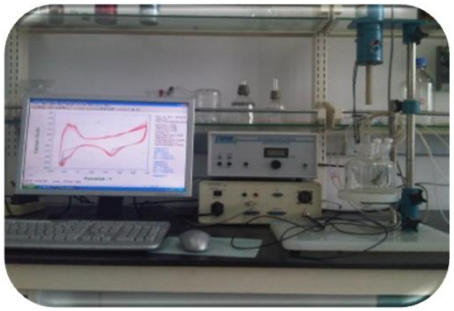
零部件和材料自动化测试装备
Automatic Test bench for parts and Materials



质谱仪(气体分析)
Mass Synchrometer

色谱仪(气体分析)
Chromatograph

比表面分析仪(催化剂表征)
Specific surface analyzer



RDE 及电化学工作站
（催化剂表征）
RDE &Electrochemical
workstation

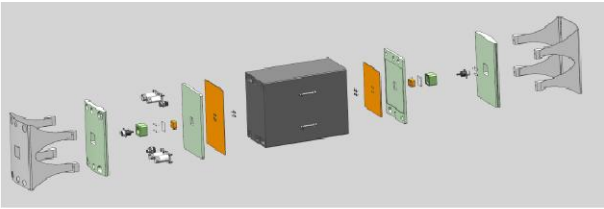
双极板测试仪
Test Bench
for Bipolar Plate

3D显微成像测试仪
3D Microscopic Imager

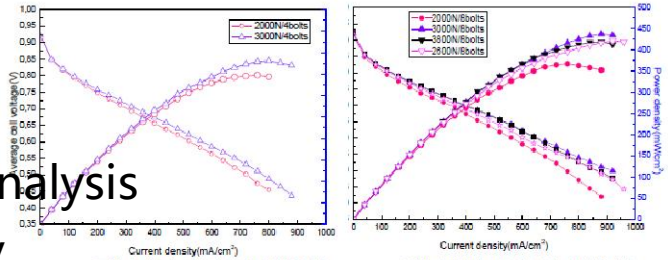
电堆测试平台
Stack Test bench

单电池测试平台
Cell Test bench

研发核心 Focus of R & D

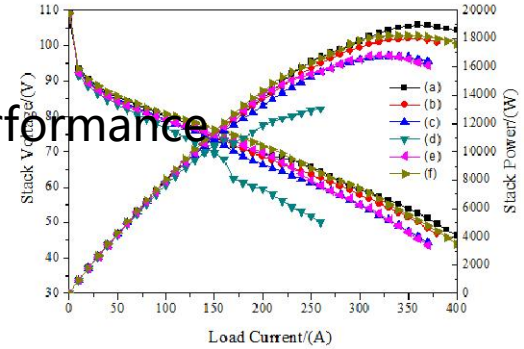


- **电堆集成设计 Stack Integration**
  - ✓ 膜电极评价 Evaluation of MEA
  - ✓ 双极板设计 Bipolar Plate Flow field Design and Material Promotion
  - ✓ 结构设计 Structure of fuel cell stack
  - ✓ 密封技术 Sealing Technology
  - ✓ 紧固技术 Fastening Technology and Forcing Analysis
  - ✓ 加速老化测试 Accelerate Aging Testing Technology



图(a) 4螺栓组态下不同装配扭矩电堆性能曲线 图(b) 8螺栓组态下不同装配扭矩电堆性能曲线

- **系统集成 System Integration**
  - ✓ 系统匹配 Optimum Match Design for BOP
  - ✓ 工作条件 Effect of Operation Condition on Stacks Performance
  - ✓ 关键零部件开发 Design and Develop of Key Components
  - ✓ 建模仿真与控制 Modeling , Simulation and Control
  - ✓ 在线诊断技术 Online Diagnosis on Fault and Degradation
  - ✓ 生产装备 Automatic Manufacture and Testing Equipment

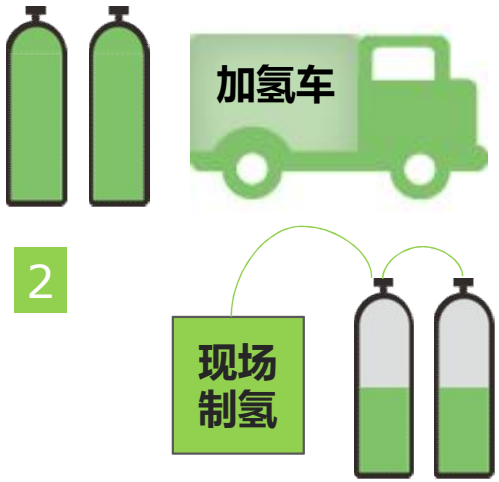


- **运维与保障技术**
  - ✓ 远程监控 Remote Control and Monitoring
  - ✓ 运维管理 Operation and Maintenance
  - ✓ 氢气配送 Delivery of Hydrogen

供氢与制氢体系 Hydrogen Production, Delivery & Storage

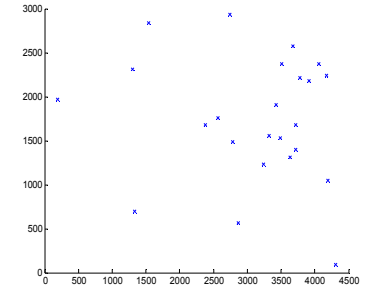
- 研发重点 Technology Focus
  - ✓ 供氢地域分析 Analysis on Regional Hydrogen Availability
  - ✓ 供氢方式选择 Hydrogen Supply Technology
  - ✓ 路径规划 Dynamic Route Planning
  - ✓ 监测与调度 Online Monitoring and Schedule

1 氢气配送系统 Delivery

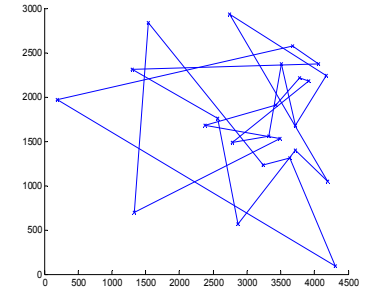


现场制氢、储氢系统
Onsite Generation and Storage

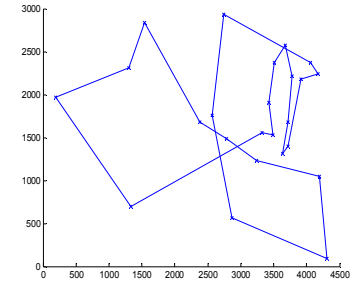
基站地点及分布
Station Distribution



随机路径 Random Path



优化路径 Optimal path



自主知识产权 Intellectual Property

- ✓ 申请专利 140 多项，涵盖燃料电池发电系统、燃料电池测试及关键零部件等多个技术领域
  140 patens applied for power system, components and testing technology
- ✓ 已获得授权发明专利9项、实用新型专利 60 项、外观设计专利 9项
  9 innovation patents，60 utility model patents and 9 design patents authoried

序号	名称	性质	专利号
1	发动机空气净化器	发明专利	ZL200610030291.4
2	一种质子交换膜燃料电池双极板及其制造方法	发明专利	ZL200910199968.0
3	燃料电池双极板气密性测试系统	发明专利	ZL201010147807.X
4	燃料电池电堆模块的封装方法	发明专利	ZL201010153563.6
5	一种基于燃料电池的备用电源系统的控制方法	发明专利	ZL201010144160.5
6	一种基于燃料电池的应急发电车	发明专利	ZL201010208177.2

基于DOE加速老化工况的测试 AST Based on DOE Standard

测试步骤 Test Protocol

步骤	时间(s)	C_{XX}	步骤	时间(s)	C_{XX}
1	15	OCV	9	20	C_{75}
2	25	C_{80}	10	15	C_{88}
3	20	C_{75}	11	35	C_{80}
4	15	C_{88}	12	20	C_{60}
4	24	C_{80}	13	35	C_{65}
6	20	C_{75}	14	8	C_{88}
7	15	C_{88}	15	35	C_{75}
8	25	C_{80}	16	40	C_{88}

- 严格按照DOE标准定义工况进行

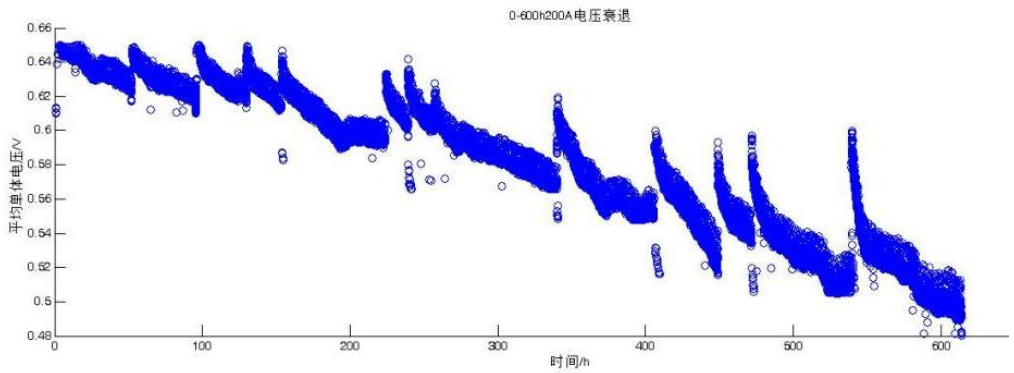
Lifetime test in strict accordance with protocol proposed by US. DOE

- 电堆按照系统设计的额定工作条件进行

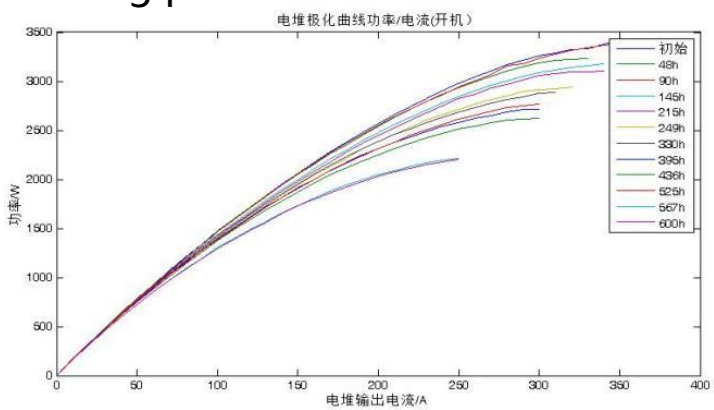
Operated under rated condition

- 600小时候达到定义的10%性能衰减

Achieved 600 hours ' lifetime with 10% degradation of performance at rated working point

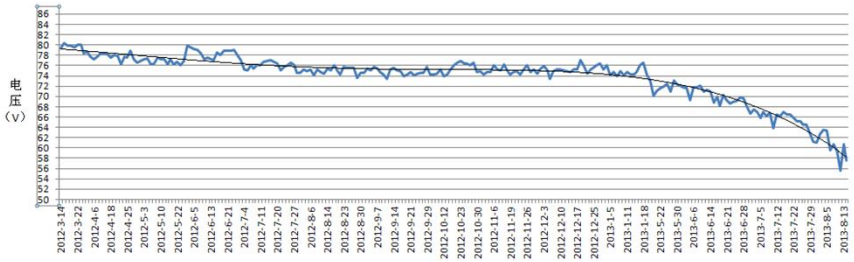


600小时总体衰退特征
Character of degradation

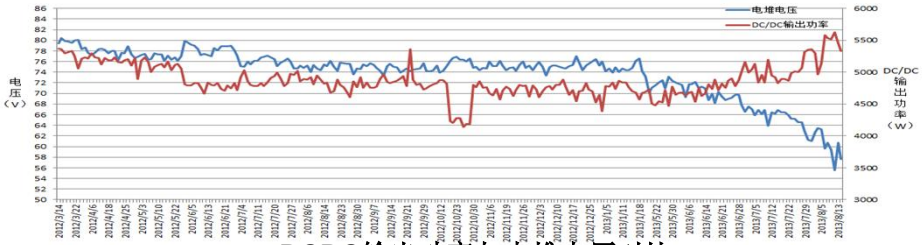


功率特性
Character of OutputPower

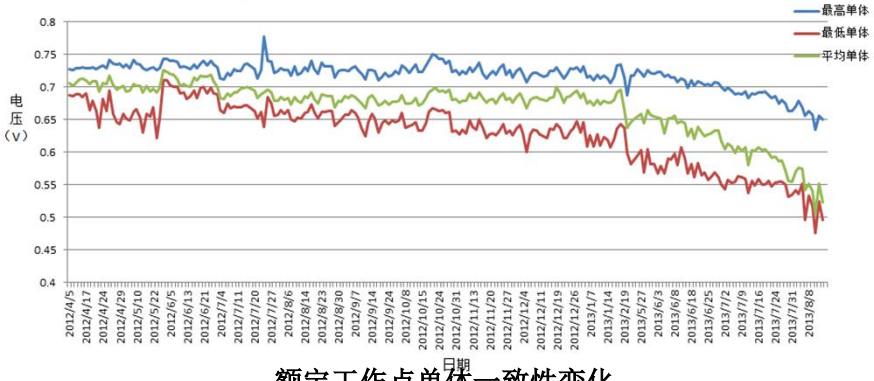
第一代样机示范运行2000小时（5年在线运行）
Demonstration in 2000hrs of 1st Generation（5years Onsite）



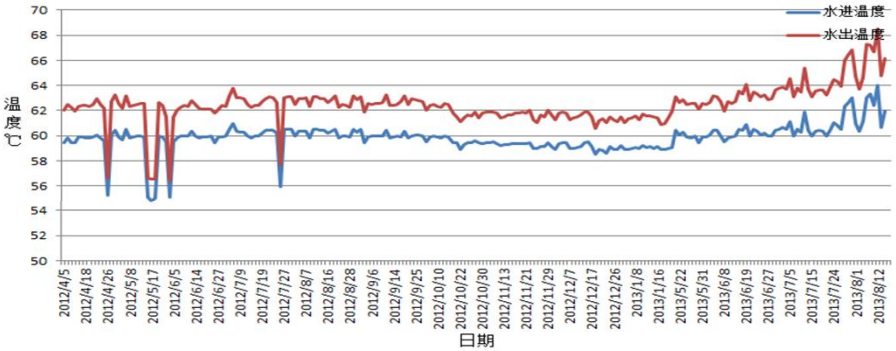
额定工作点电堆电压衰减
Output Voltage @ Rated Power



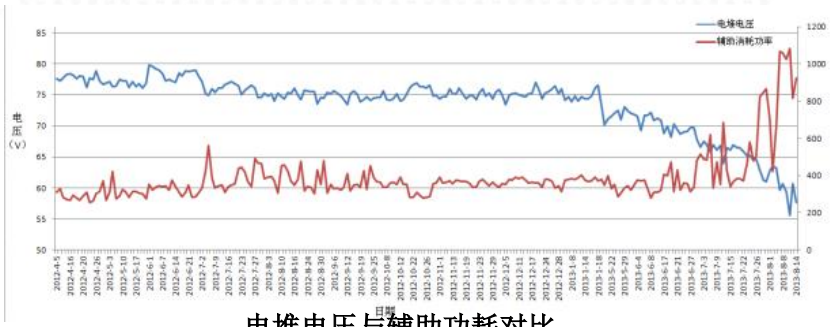
DCDC输出功率与电堆电压对比
DCDC Output Power VS. Stack Voltage



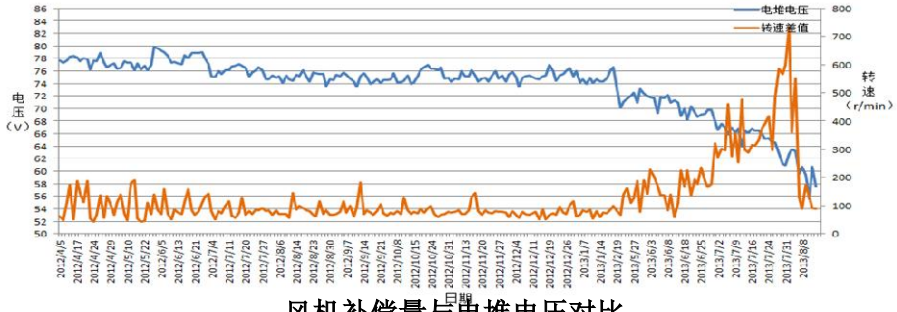
额定工作点单体一致性变化
Uniformity of Cell Voltage



额定工作点冷却水温度变化
Temperature of Coolant @ Rate Power



电堆电压与辅助功耗对比
Output Voltage VS. Parasitic power



风机补偿量与电堆电压对比
Stack Output Voltage VS. Air Flow

主要内容

- 产品研发 R&D
- 生产与检测配套能力 Manufacture & Testing
- 产品应用 Product & Application

厂区 Plant Area

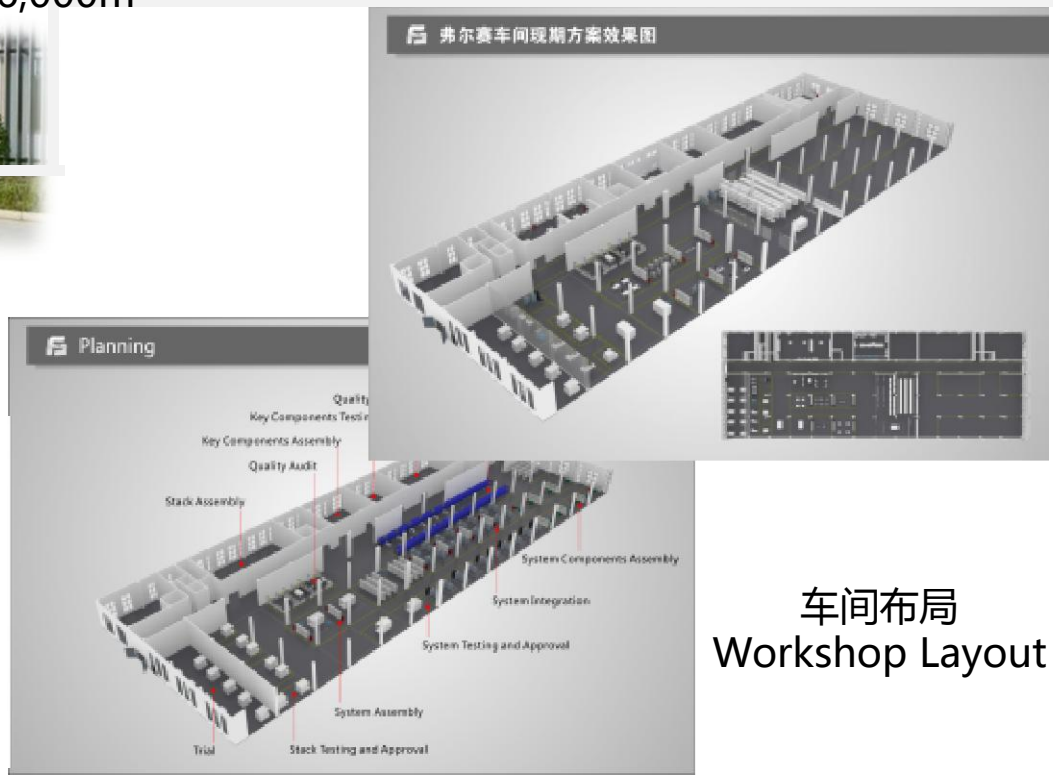
- 昆山工厂建筑面积28000m^2，生产车间 9000m^2 ，研发与测试中心面积6000m^2

Foresight plant in Kunshan covers 28,000m^2，production workshop more than 9,000m^2，test center and office more than 6,000m^2

具备中等规模的生产、测试和研发能力

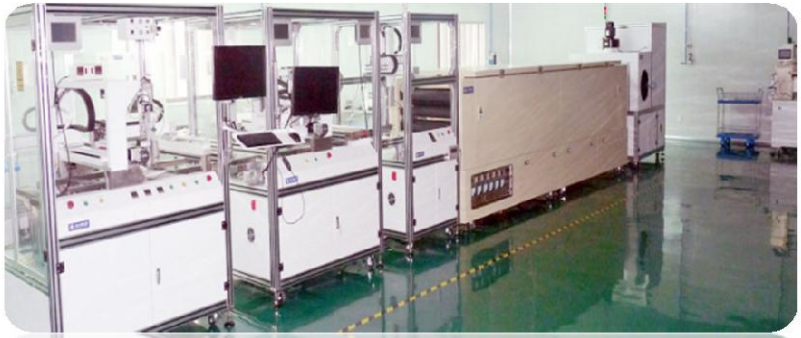
Foresight has a middle-scale manufacture ability and the facility of product R&D, testing and production

生产车间
Workshop



车间布局
Workshop Layout

产线与检测设备 Manufacture and Testing Equipment



双极板自动化生产线 Product Line of Bipolar Plate

自动涂胶设备
Automatic Sealing Station

激光检测设备
Laser Detection Station

气密性检测设备
Gastight Test Bench

系统组装流水线
System Assembly Line

- ●年产能6000kW，50000套单体；Year Capability：6000 kW，50000 sets cell
- ●自动化完成关键过程; Automated complementation of key process
- ●具备自主知识产权的生产设备； Designed by Foresight under issued patent
- ●质量和一致性控制；Quality and Conformability confirmed

燃料电池电堆及系统测试能力 Testing Capability

电堆检测能力
Testing Capability for Fuel Cell Stack

系统测试能力
Testing Capability for Fuel Cell Power System

主要内容

- 产品研发 R&D
- 生产与检测配套能力 Manufacture & Testing
- 产品应用 Product & Application

Technical roadmap

- 基于近10年的车用燃料电池技术积累，于2009年开始燃料电池电源产品开发；

Foresight started to R&D on fuel cell power system since 2009 based on about ten years experience on fuel cell engine.

- 提供超过200套电堆用于示范运行，包括世博会、亚运会和大运会

More than 200 units of fuel cell stacks provided by Foresight have been successfully demonstrated in 2010 Shanghai EXPO, 2010 Asia Games, and 2011 World University Games.

Start One

Start Three

Olympics, Beijing

Demo in California

EXPO, Shanghai

World University Games

2001

Prototype fuel cell vehicle

2005

Bibebdum ,France

2008

Powertrain Bench

2009

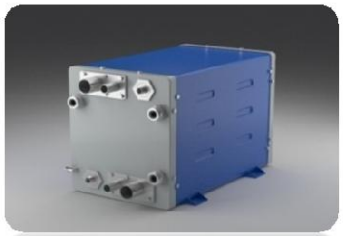
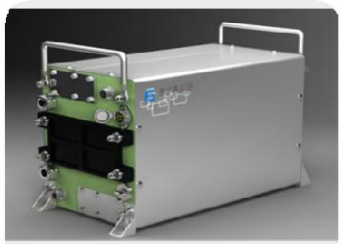
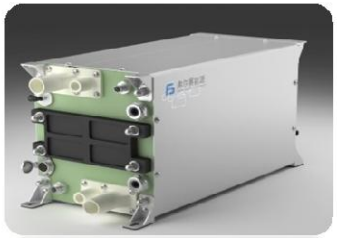
2010

2011

2012

Backup power

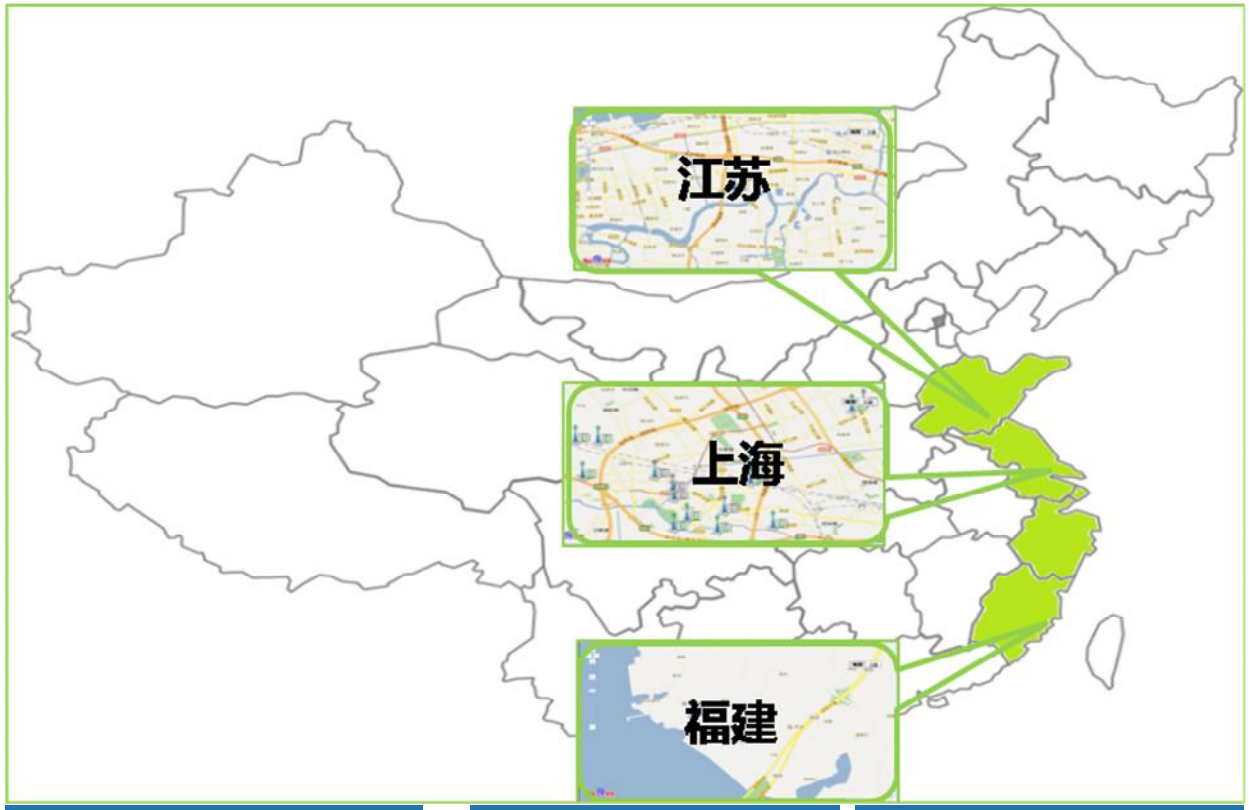
电堆产品线 Product line for Fuel Cell stacks

	2010	2011	2013	2014
电堆模块 Stacks Module				
应用 Application	  SHANGHAI Expo; Asian Games Guangzhou	 World Universiade Shenzhen	 Huaqiao City Shenzhen	 Shanghai China Post
额定功率 Rated Power	5-7kw	5-7kw	5-7kw	13kw
数量 Unit Deployed	120+60	60	30	30

备用电源产品Product line for power systems

	2010	2011	2012	2013	2014
备用电源 Backup Power	 Prototype	 V1.0	 V1.1	 V2.0	 V2.1
应用 Application		 China Telecom	 China Mobile	 China Unicom	 China Mobile
额定功率 Rated Power	5kw	5kw	5kw	5kw	3~5kw
数量 Unit Deployed	-	1	10	33	45

应急备用电源产品应用分布 Distribution of Fuel Cell Backup Power



弗尔赛与联通、移动、电信共同在华东沿海省市形成百余套燃料电池应急/备用电源的应用规模，并在上海嘉定区形成区域化规模供氢及运维网络。

Cooperated with China Telecom, China Mobile and China Unicom，about 100 set of fuel cell backup power provide by Foresight have been demonstrated onsite in east China, and a hydrogen supply network has been setup.

截至2015年3月11日，累计待机**16495**天；应急发电**1970**小时，累计发电量＞5MWh；2013年5月30日，嘉众翔基站市电供电线路突发故障，燃料电池应急电源系统自动运行，连续工作**17小时08分**，有效的保障了基站的通信正常。

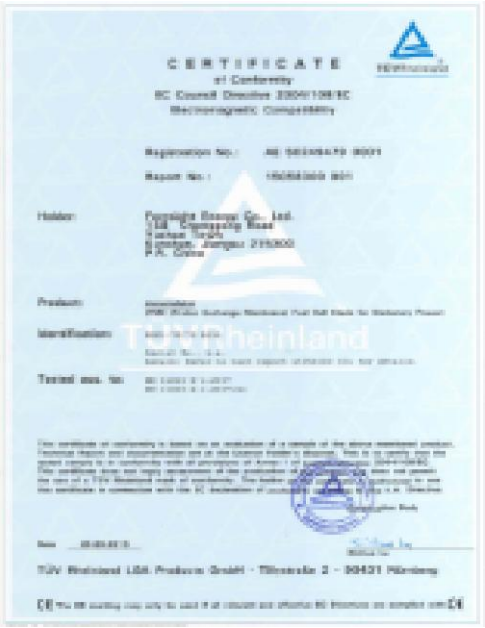
Up to 2015/3/11, accumulated operational time is more than 16,495 days, and naturally work time as emergency power more than 1970hrs, totally power output is more than 5MWh. The longest continuous work time is 17hrs and 8 mins.

移动上海傲源基站
China Mobile Base Station in Shanghai

移动苏州基站
China Mobile Base Station In Suzhou

联通厦门基站
China Unicom Base Station in Xiamen

反馈与认证 Feedback and Certification



三大运营商用户报告与检测证书
Feedback from 3 Telecom Operators

德国TUEV CE认证
CE Certification from TUEV

远程监控技术 Remote Control and Monitoring

- **技术优势 Advantage**
- ✓ 系统运行状态实时监控 Real-time
- ✓ 系统运行数据云储存 Cloud Storage
- ✓ 氢能源调度网络 Dynamic Schedule

网络监控平台
Network Platform

拓扑结构图

网络架构
Network Structure

智能移动终端APP实时状态监控界面图
Terminal of Mobile APP

通信基站现场供电典型案例 Case Study

◆2012年3月31日，移动嘉美基站片区突发断电事故，电力恢复时间不明，燃料电池备用电源自动启动运行，连续工作7小时，直到电力恢复。

◆2013年5月30日，因供电线路突发故障，导致嘉众翔基站电力中断，加之雨天电网维修不便，燃料电池备用电源自动运行，连续工作17小时08分，有效的保障了基站的通信正常。

◆2013年6月12日，陈村基站市电停电，燃料电池运行4小时52分。

◆2013年6月17日，刘五店基站市电停电，燃料电池运行6小时25分。

◆2013年7月21日，因雷阵雨天气影响，民丰基站市电停电，燃料电池备用电源自动启动运行，连续工作2小时53分，直到电力恢复。

◆2013年11月8日，6:41—13:38嘉美基站意外断电，运行8小时。

◆2013年12月30日。7:08---16:20泥岗基站意外断电，全程供电，换气6瓶，约9小时。

◆2014年1月21日，7:44---13:50纪家基站意外断电7小时，全程供电。

◆2014年3月20日，6:28---17:53望安基站意外断电11.5小时，全程供电。期间换气3瓶。

More than 50 sets system have been successfully activate by main power failure. These fuel cell power system have supplied effective power support for communication base stations.

参与标准工作 Participation in Standards and Codes

- **通信协会委员TC4** 行业标准起草单位 Member of China TC4
- **中国燃料电池标委会委员** 标准起草与制定单位 Member of China's fuel cell standard council
- **IEC/TC105中国代表** 国际燃料电池标准制定与核定 Member of IEC/TC105
- 正在起草参与制订的大陆标准8项 Participate in the building of 8 standards

中国通信标准化协会
China Communications Standards Association

SAC/TC342
全国燃料电池及液流电池标委会
fuelcell & flowbattery
全国燃料电池及液流电池标准化技术委员会
National Technical Committee 342 on Fuel Cell
and Flow Battery of Standardization Administration of China

- ◻20130103-T-339 “通信用氢燃料电池供电系统
- ◻GB/TXXX质子交换膜燃料电池备用电源 安全
- ◻YD/TXXX通信用氢燃料电池供电系统维护技术要求

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