Energy Storage - Battery Technology Innovation to Overcome Power Challenges
Narada ESS - Lead-Carbon Battery



Narada 南都电源

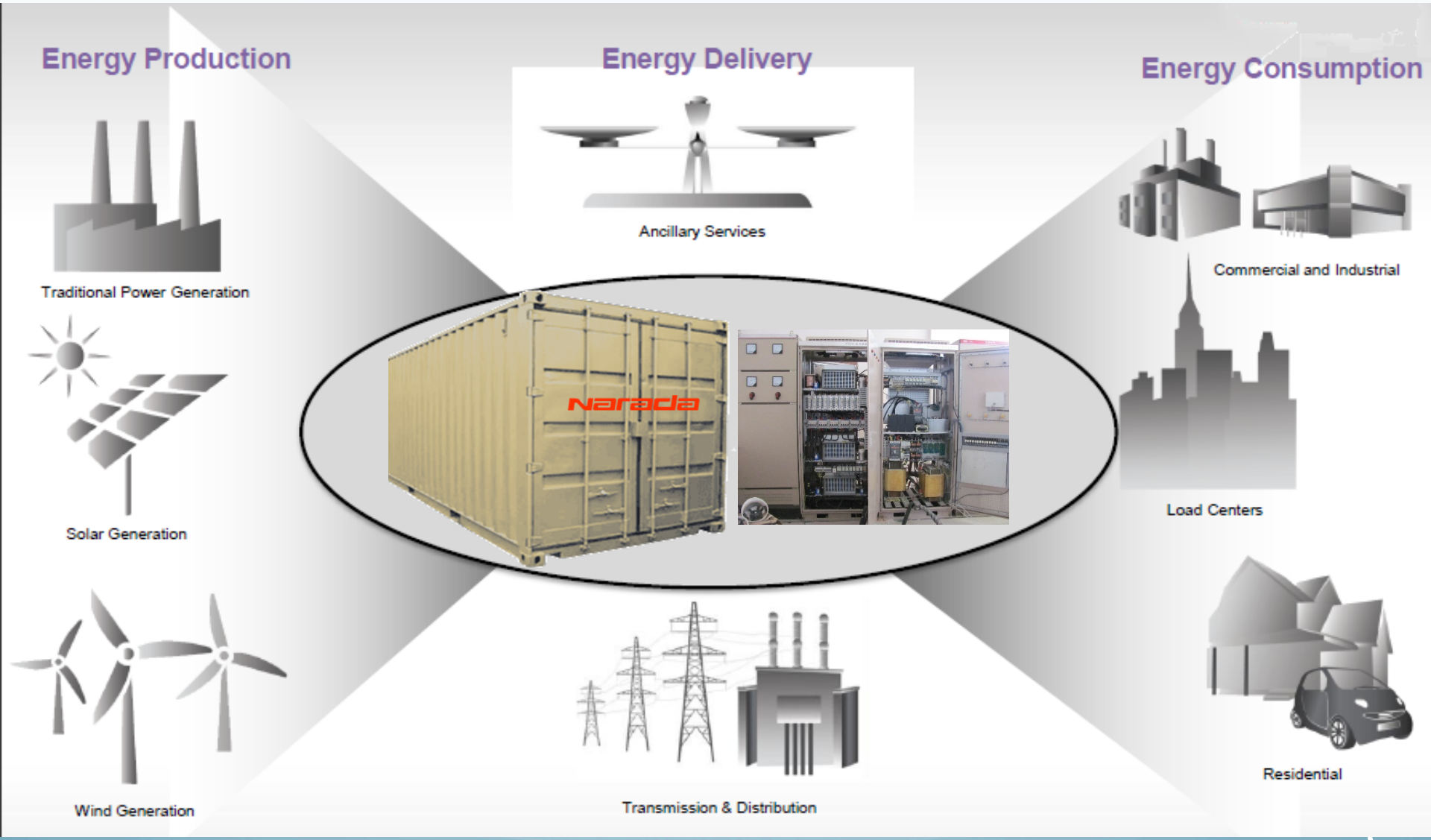
GSMA MYANMAR, 29 MAY 2014

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- Opportunities and Challenges for Microgrid ESS
- Principles and Features of Lead Carbon Batteries
- Lead Carbon Battery ESS
- Narada Lead Carbon Battery ESS

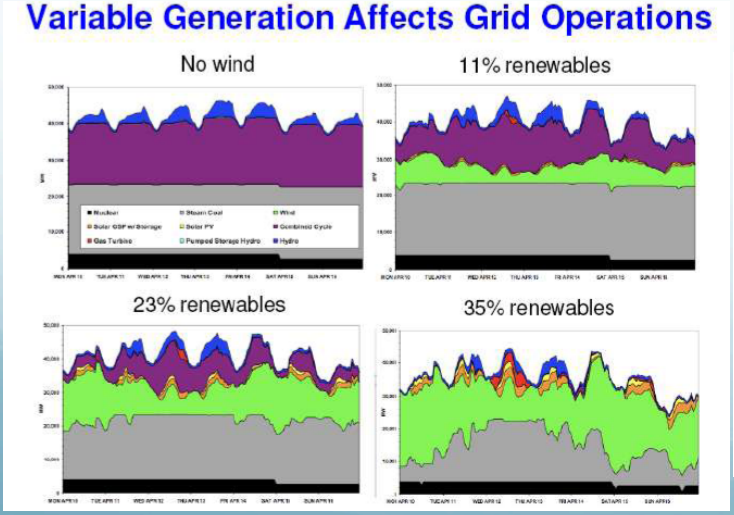
EES- Core of Smart Grid

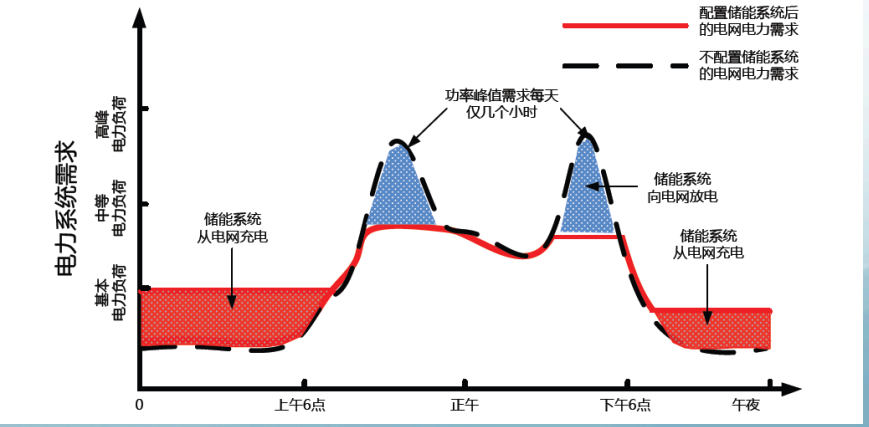


EES- Core of Smart Grid

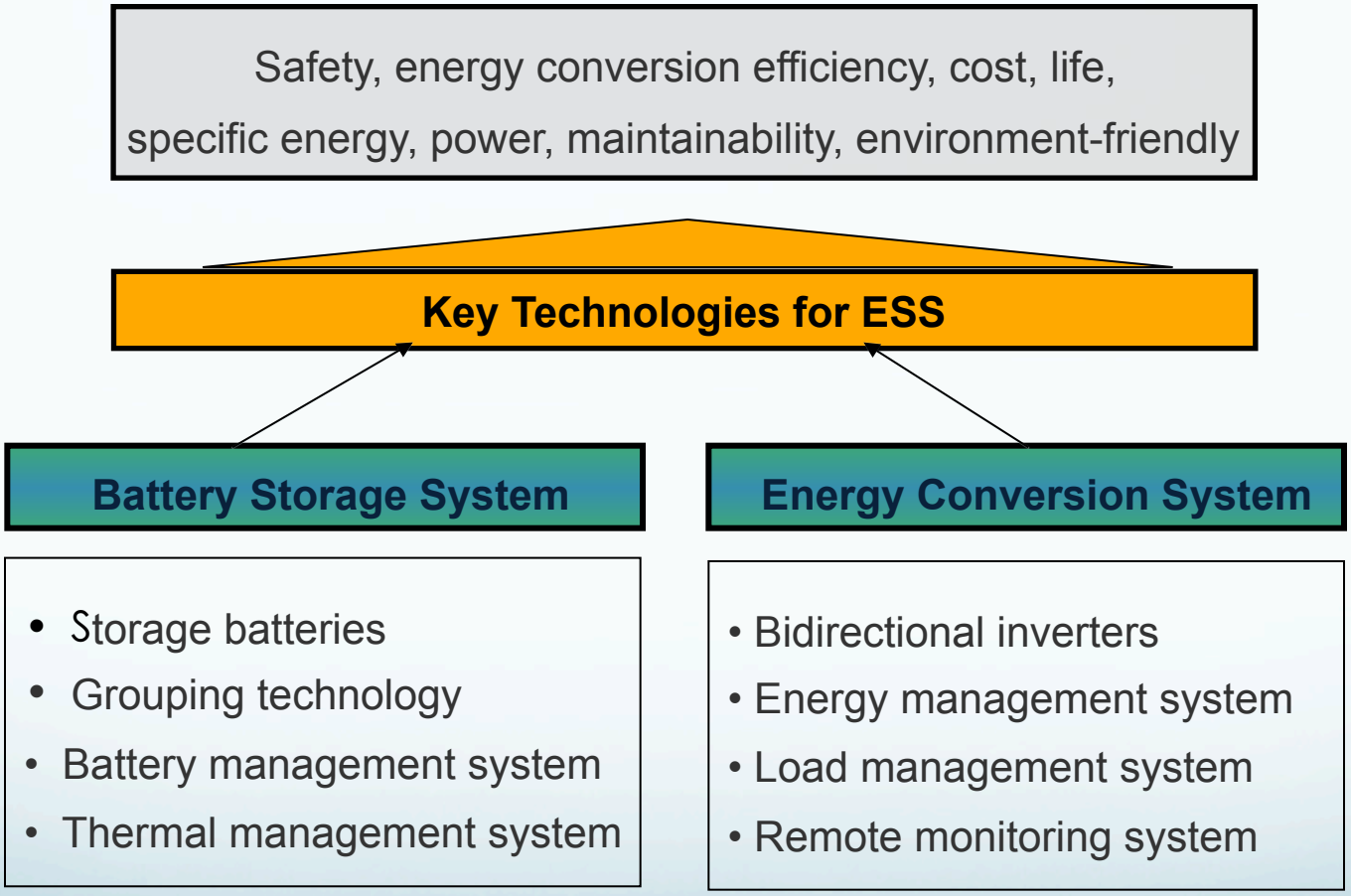
Significance of EES:

- Mitigate peak and valley difference to maintain quality power generation, improve efficiency of conventional grid
- Reduce investment in backbone network expansion, saving substantial resources
- Stabilize renewable energy integration, mitigate the unpredictability of wind and solar power generation, improve power supply quality
- Enhance grid security, increase back-up power in case of failures in transmission or distribution network
- Enhance black-start safety and decrease failure rates





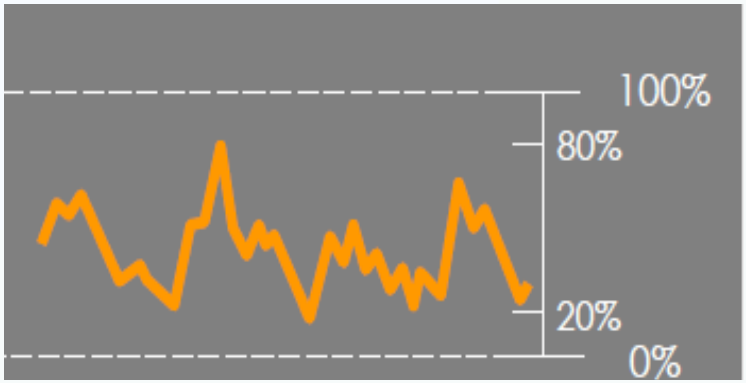
Key Technologies for ESS

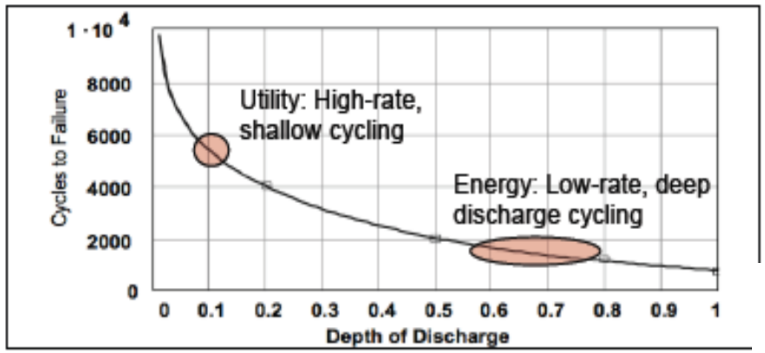


Requirements of Batteries for Large Scale ESS

- Capacity
- Economy
- Security
- Cycle life
- Energy conversion efficiency

Variable duties with changing market demand



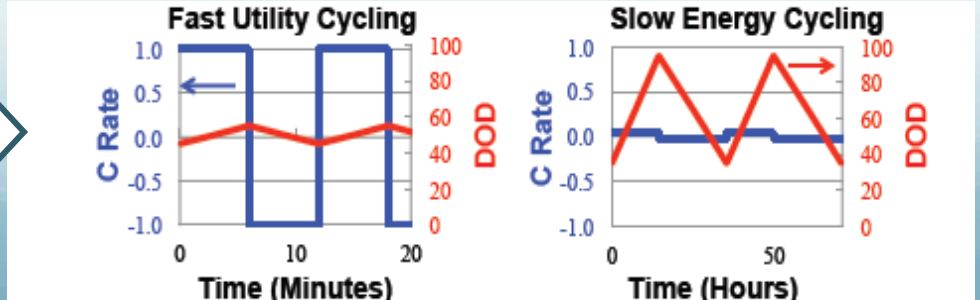


- In emerging markets, lead-acid batteries need to run in PSOC cycling duty (20% to 80% SOC) to ensure affluent power output and good charge acceptance under these

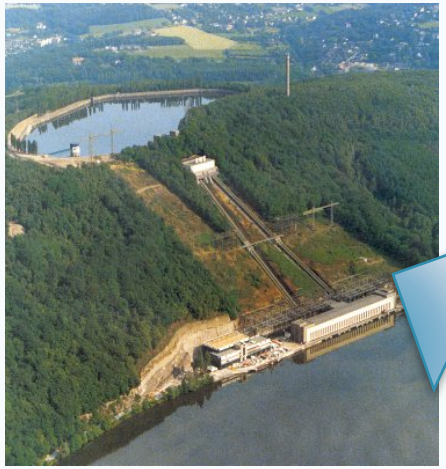
Sandia National Laboratories

Fast Power Cycling

Slow Energy Cycling

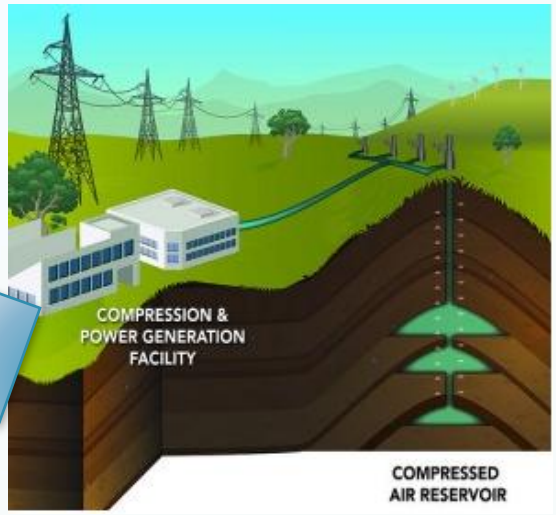


What to do with all this energy?



Pumped Hydro



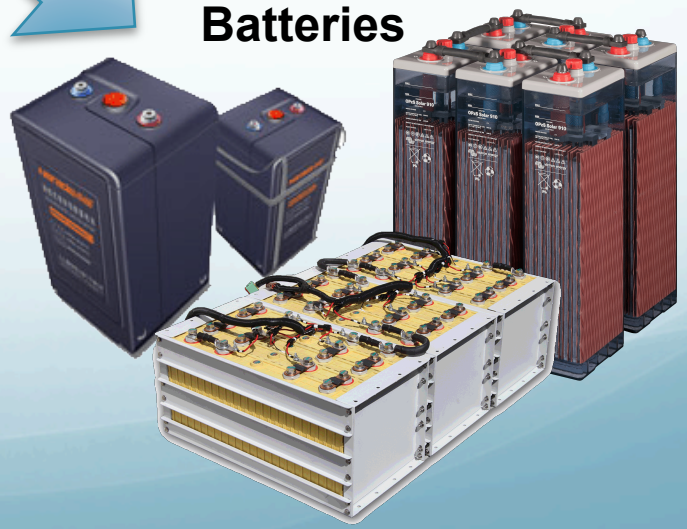


Compressed Air



Thermal energy storage

Batteries

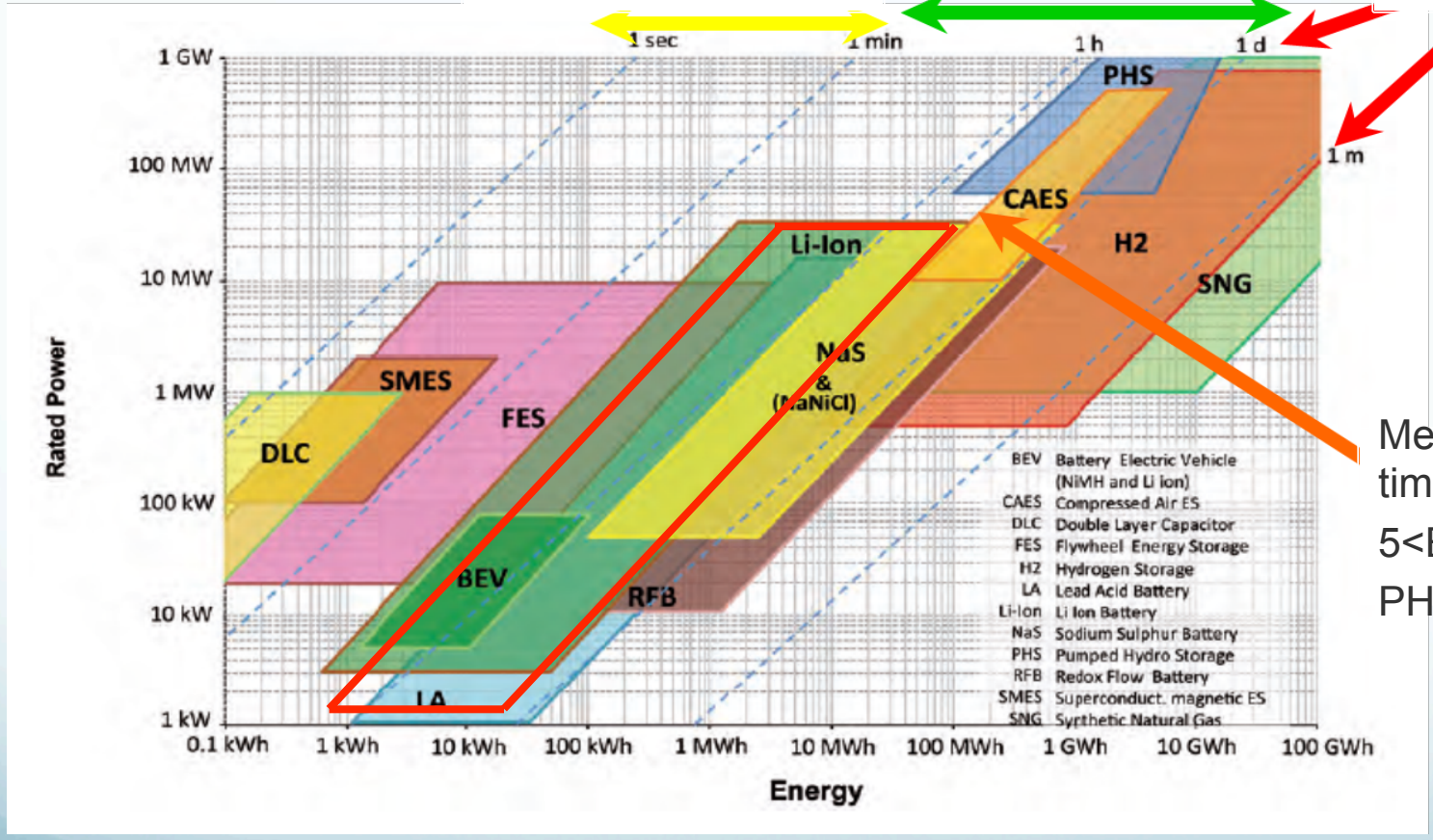


Comparison of Various ESS Technologies in Scale

Short time discharge
Energy/power<1
DLC\SMES\FES

Medium time discharge
1<Energy/power<10
FES\LA\Li-ion\NaS

Long time discharge
10<Energy/power
H2\SNG

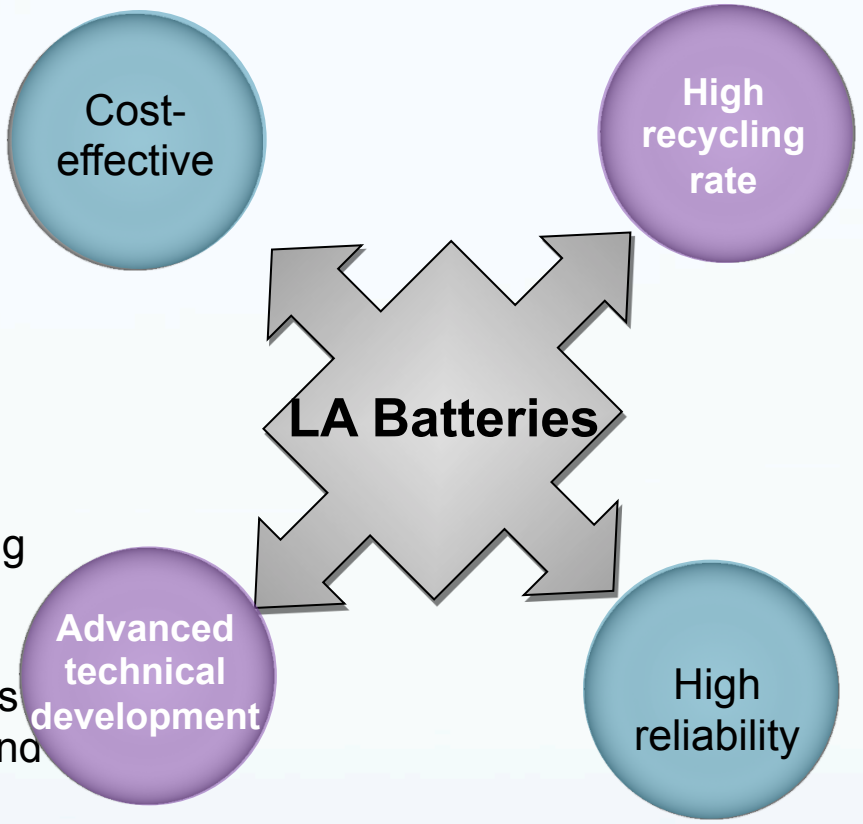


Medium and long time discharge
5<Energy/power<30
PHS\CAES\RFB

- The energy and power capacity of Lead Acid Battery is comparable to lithium and sodium sulfur
- Economic concerns are the key to higher power or more energy.

Lead Acid Batteries Remain Irreplaceable as Power Supply Products in the Future

at present, lead-acid batteries are still the most cost-effective



up to 95% recycling rate, the highest in secondary batteries

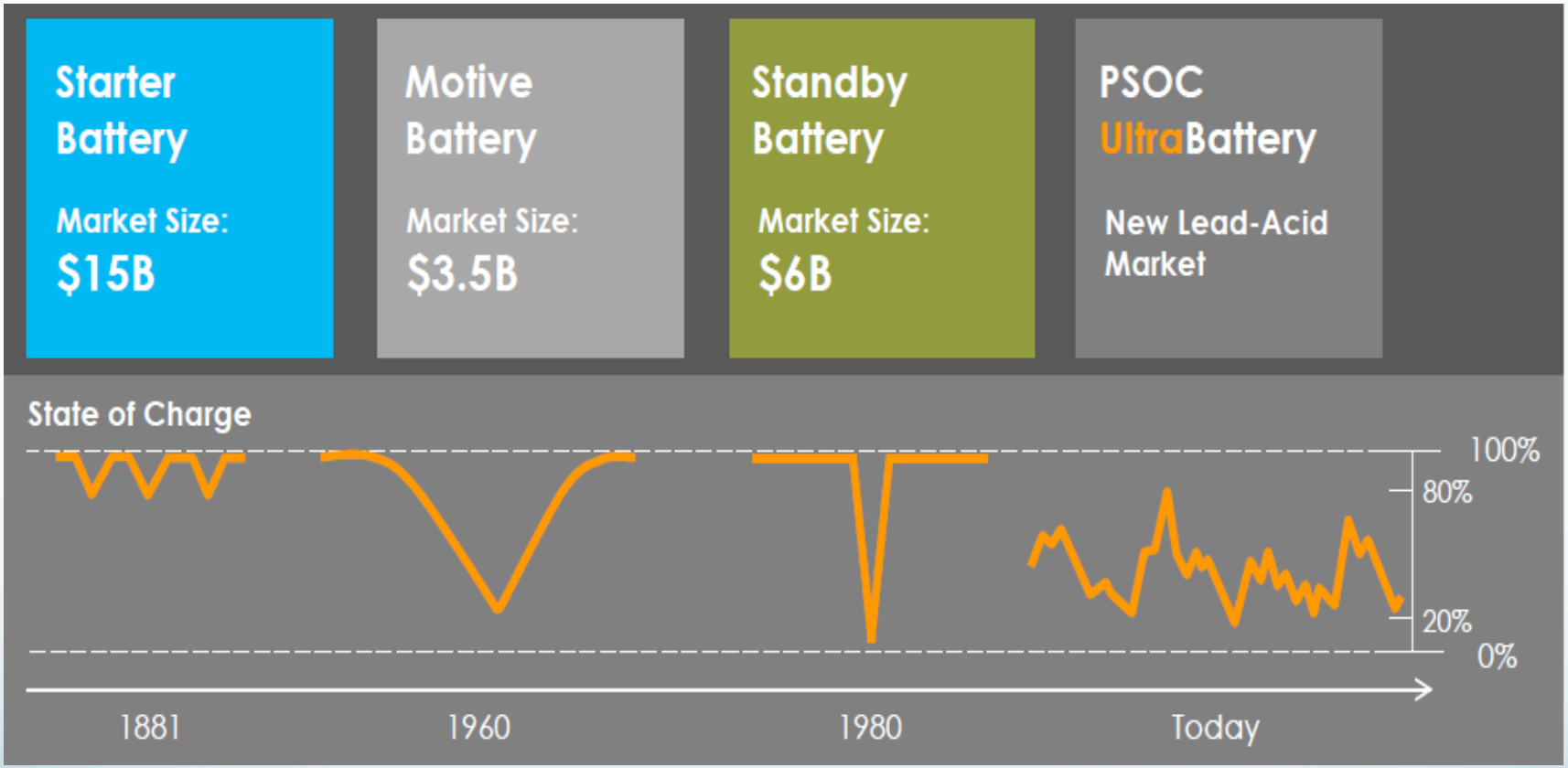
in recent years, emerging LA technologies have significantly beefed up its performances such as higher specific energy and satisfactory service

With proven mature application records for more than100 years since invented in 1859, LA is of high safety and reliability

- There is no outdated industry but less developed technology, employed advanced technologies, lead-acid battery will remain a major player in stationary and energy storage applications.
- There is no polluting industry but polluting plants, with forceful and reasonable measures, lead-acid pollution can be preventable and under control

The New Dimension in a Lead Acid World

Veriable duties with changing market demand



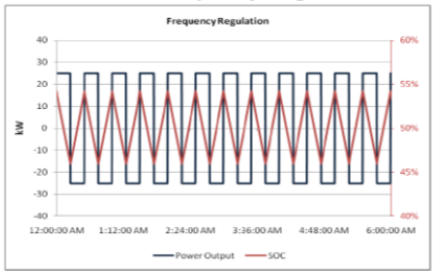
- In emerging markets, lead-acid batteries need to run in PSOC cycling duty (20% to 80% SOC) to ensure affluent power output and good charge acceptance under these scenarios.

ESS Applications and Corresponding Requirements on Batteries

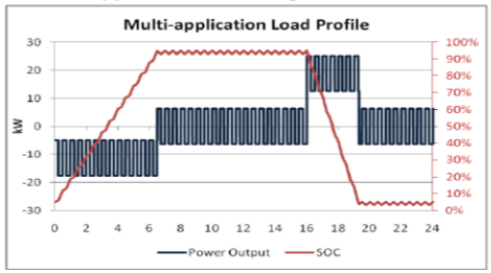
Sandia National Laboratories

IEC

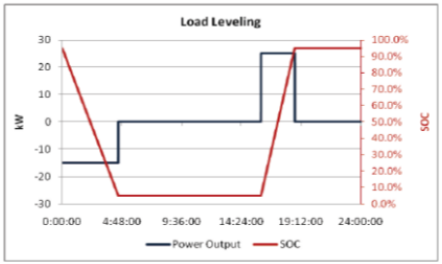
State of the Art: Frequency Regulation



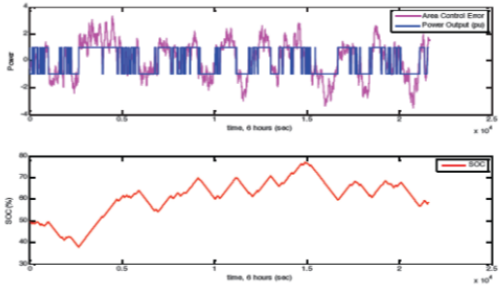
Stacked Applications: Working with KEMA



State of the Art: Load Leveling



Stochastic Application Modeling:



Requirements on Batteries

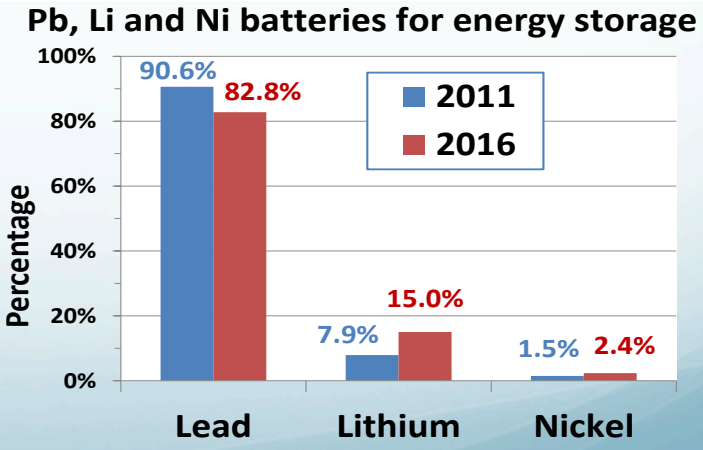
- Good storage durability under various application scenarios
- High energy conversion efficiency
- Good safety and reliability for large scale energy storage
- High returns on investment

Waveform testing employed by Sandia National Lab including frequency regulation, load levelling, stochastic application modeling.

Comprehensive comparison of Various ESS Technologies

	Cycle life	Safety	Scalability	Economy	Energy Efficiency
Regular lead acid battery	★★	★★★★	★★★★	★★★	★★
Super capacitor	★★★★	★★★	★★	★★	★★★★
Lithium ion	★★★	★★	★★	★★	★★★★
Vanadium redox flow battery	★★★★	★★★	★★★★	★★	★★★
Sodium sulfur	★★★	★	★★★	★★★	★★

- None of the ESS technologies can fully meet the five key terms in current phase.
- Lead-acid batteries are superior to other technologies in safety, reliability scalability and cost efficiency with absolutely large market share in this field.



**Source: John Craig, BCI, State of the Industry, 124 BCI Convention, Phoenix, AZ (USA), 2012

Lead Carbon-The Game Changer

Features of Lead-carbon batteries

With combined advantages of both lead-acid batteries and super capacitors , lead carbon batteries, in which sulphation of negative plate is effectively depressed, are significantly improved in high rate charge and discharge performance and cycle life under PSOC.

Obama Administration funded lead carbon

Lead-Carbon: A Game Changer for Alternative



Applicant	Fund M$	Project description
Exide Technologies with Axion Power International	34.3	Advanced lead acid battery manufacturing based on lead carbon technology, meeting the demand for micro and mild HEV
East Penn Manu-facturing Co.	32.5	Ultra battery manufacturing (combination of lead acid and super capacitor) meeting the demand for micro and mild HEV

What does Lead Carbon mean?

a) **Replace ALL NAM in the negative plate by high surface area carbon**

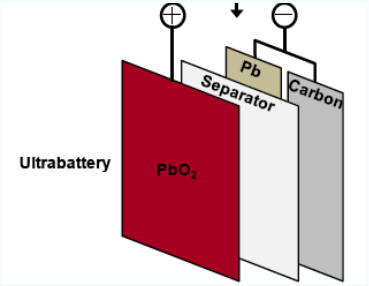
- perfect cycleability, high specific power
- Axion Power





b) **Replace PART of the NAM by carbon**

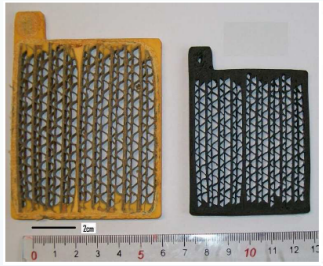
- superior cycleability, good W/kg
- CSIRO, Furukawa, East Penn

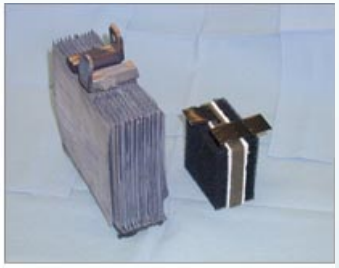




c) **Replace all the GRID or part of it by 3D carbon structures**

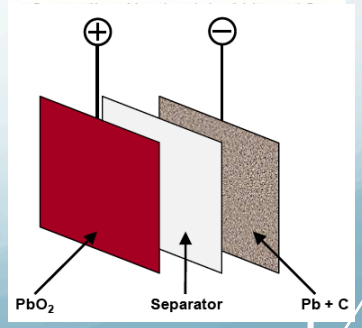
- high specific power, high specific energy, excellent cycleability
- Warsaw University, Firefly Energy, CEA-INES





d) **Add CARBON POWDER to the NAM**

- optimized Pb grid, NAM pasted to the grid, modified paste recipes
- excellent HRPSoC cycleability
- developed in ALABC programs, produced by several companies



Advanced Lead-Carbon Battery ESS



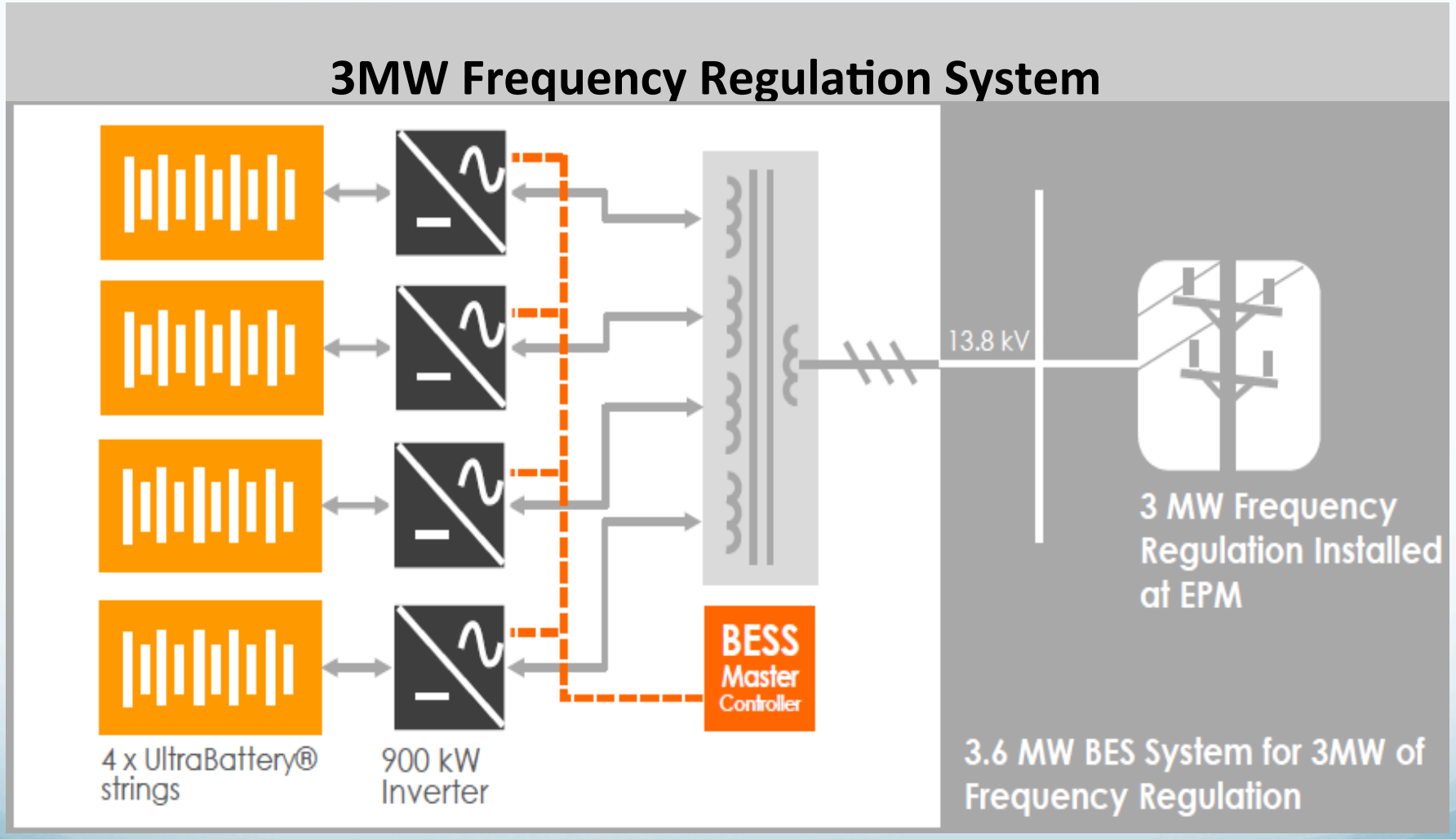




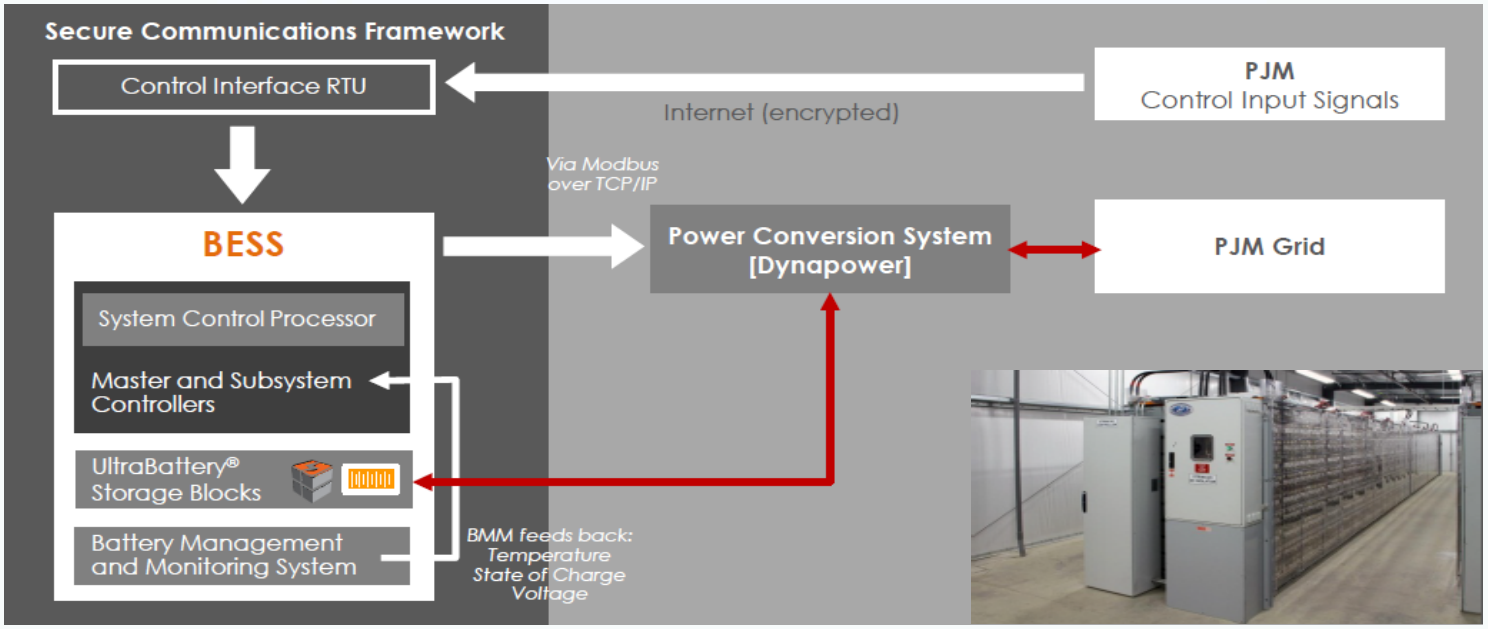
- Peak shaving
- Distribution storage
- Frequency quality
- Renewable supply
- Transmission service
- load leveling

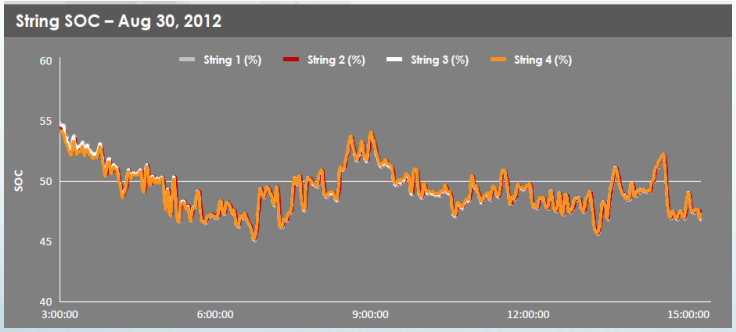


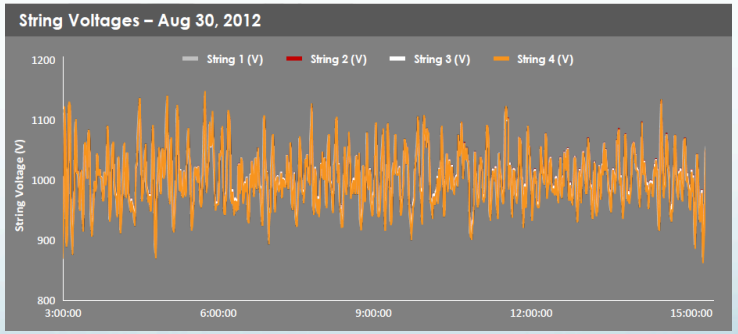
Electrical Single Line Diagram



Communications Framework



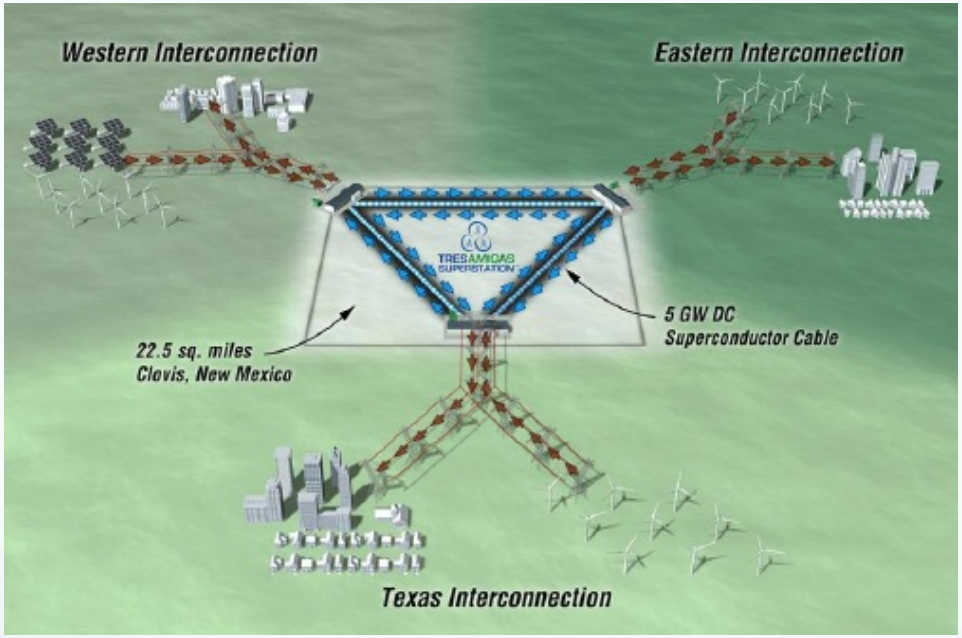




- Including system control processor, master and subsystem controllers, ultra battery storage blocks, battery management and monitoring system (voltage, state of charge, temperature)

Advanced Lead-Carbon Battery ESS

Application of advanced storage batteries in Superconductor Cable Station project



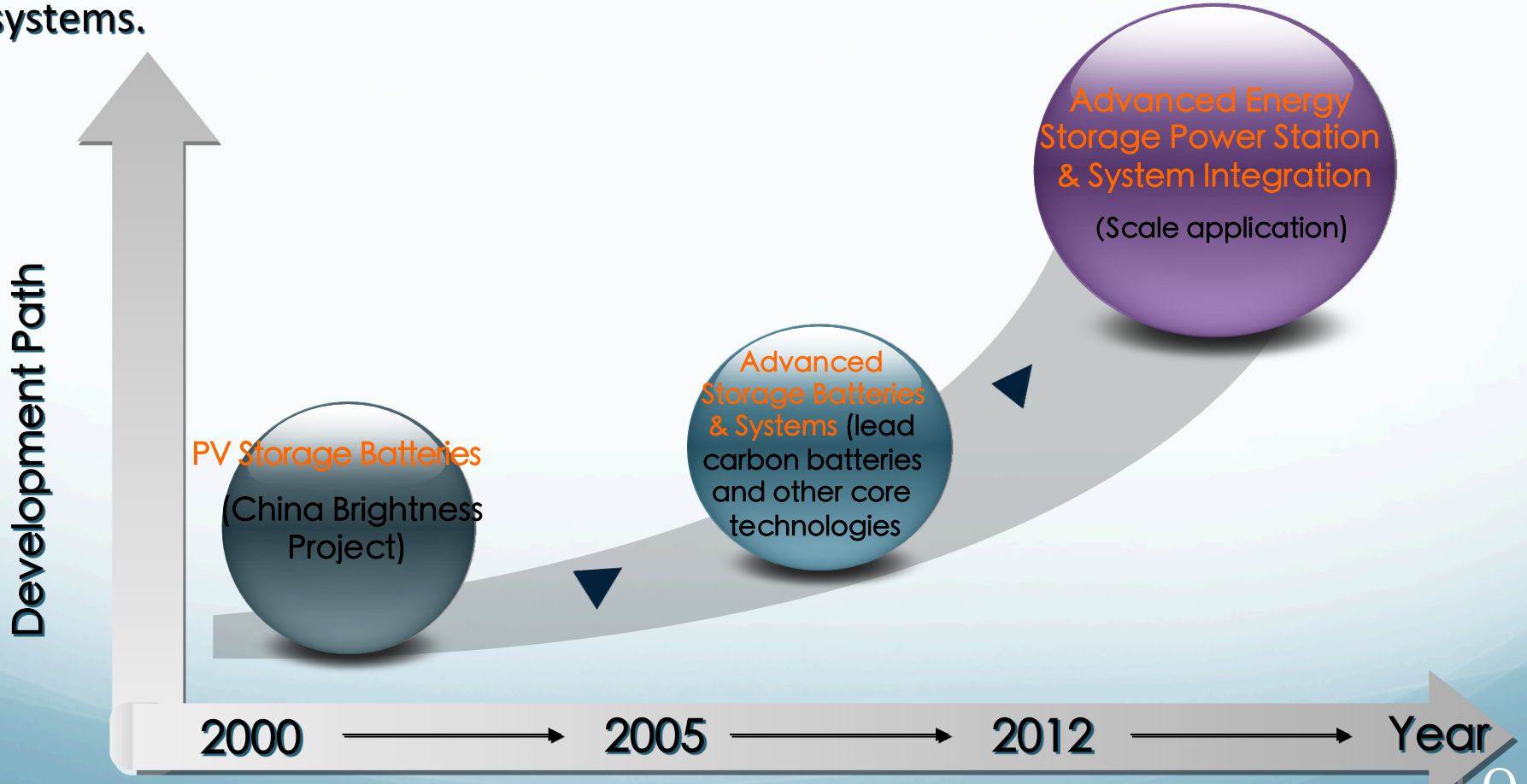
Location: Clovis, NM
Power: ~100 MW / ~200 MWh
Completion Date: Q2 2013

- Ancillary Services
- Wind Firming
- Shaping

By implementing an estimated 100 MW/ 200 MWh DPR (Dynamic Power Regulation System) , the Super Station will deliver a reliable supply of renewable power amongst America's three power grids, the Eastern, Western and Texas Interconnections.

Development Path of Narada's ESS Technologies

- Narada Power source has 10+ years experience in research and application of ESS technologies, has mastered ranges of technologies from ESS products to integrated systems, capable of delivering comprehensive solutions for various ESS systems.



Narada hosted Micro-Grid Energy Storage Forum Session

鳳凰網 财经 finance.ifeng.com 凤凰网财经 > 证券 > 上市公司 > 正文

南都电源：布局微网储能 发展绿色能源

Narada Power Source: Microgrid Energy Storage Layout and Green Energy Development

全景网11月22日讯 能源是社会发展的核心动力。随着生活环境的变化，绿色新能源越来越受到人们的关注，“微网储能”这一新兴产品也渐渐进入人们的视线。作为国内储能领域先驱的南都电源[11.61 -0.60% 股吧 研报]，昨天在杭州临安举办了“微网储能高峰论坛”，重点围绕“微网储能”这一新兴领域展开讨论。

南都电源(SZ:300068) 自选股
最新价：11.61 ▼ 0.07 0.6%
行情走势 大单追踪 资金流向
最新研报 公司新闻 最新公告
个股股吧 优股预测 龙虎榜

微网储能是由分布式电源、储能装置、能量变换装置、相关负荷和监控、保护装置汇集而成的小型发配电系统，它是能实现自我控制、保护和管理的自治系统。

公司总经理陈博表示，南都电源很早之前就开始积累微网储能这一方面的技术，并且企业自身也在实际中应用与体验该项技术，目前已经积累了非常丰富的经验，处于一个比较领先的地位，公司会加快对这一领域经验与技术的积累。同时，公司也积极参与一些国家示范项目的建设，从中既可以展示南都的产品，又可以积累更多的经验，并且能够与客户进行共同研讨和发展，更好地服务于微网储能这一项目的应用。

目前，在国家新能源示范城市吐鲁番示范区屋顶光伏电站暨微电网试点工程储能电池系统招标中，南都电源成为该项目唯一中标单位。该项目作为国内首个微电网示范工程项目，拥有国内众多的“第一个”：它是国内第一个新能源示范城市兆瓦级储能项目；第一个铅炭电池批量用于储能应用的项目；第一个由南都电源公司独立承担的完整的系统集成项目。该项目的中标为公司



President Mr. Chen Bo
Narada’s experience and technology accumulation are major driving forces for its leading performance in microgrid field





Narada was the only winning bidder of the BEES systems for the rooftop PV power plants, a microgrid pilot project in the state renewable energy demonstration city in Turpan.

Chief Engineer Mr. Wu Xianzhang
Energy Storage Technologies for Microgrid

Chief Scientist Mr. Herbert Giess
IEC 61427 Part 2: On-grid applications

Narada's Lead Carbon BEES System

Microgrid EES Solutions

- Industrially pioneering and exclusive micro-grid EES system in enterprise-class
- Cost effective, long-life, high reliability
- Mobile EES through modular approach
- Environment friendly & energy efficient
- Promote smart grid and renewable EES



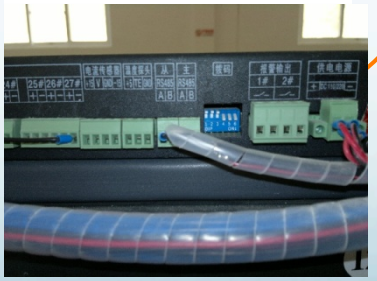
EES Battery blocks



PCS



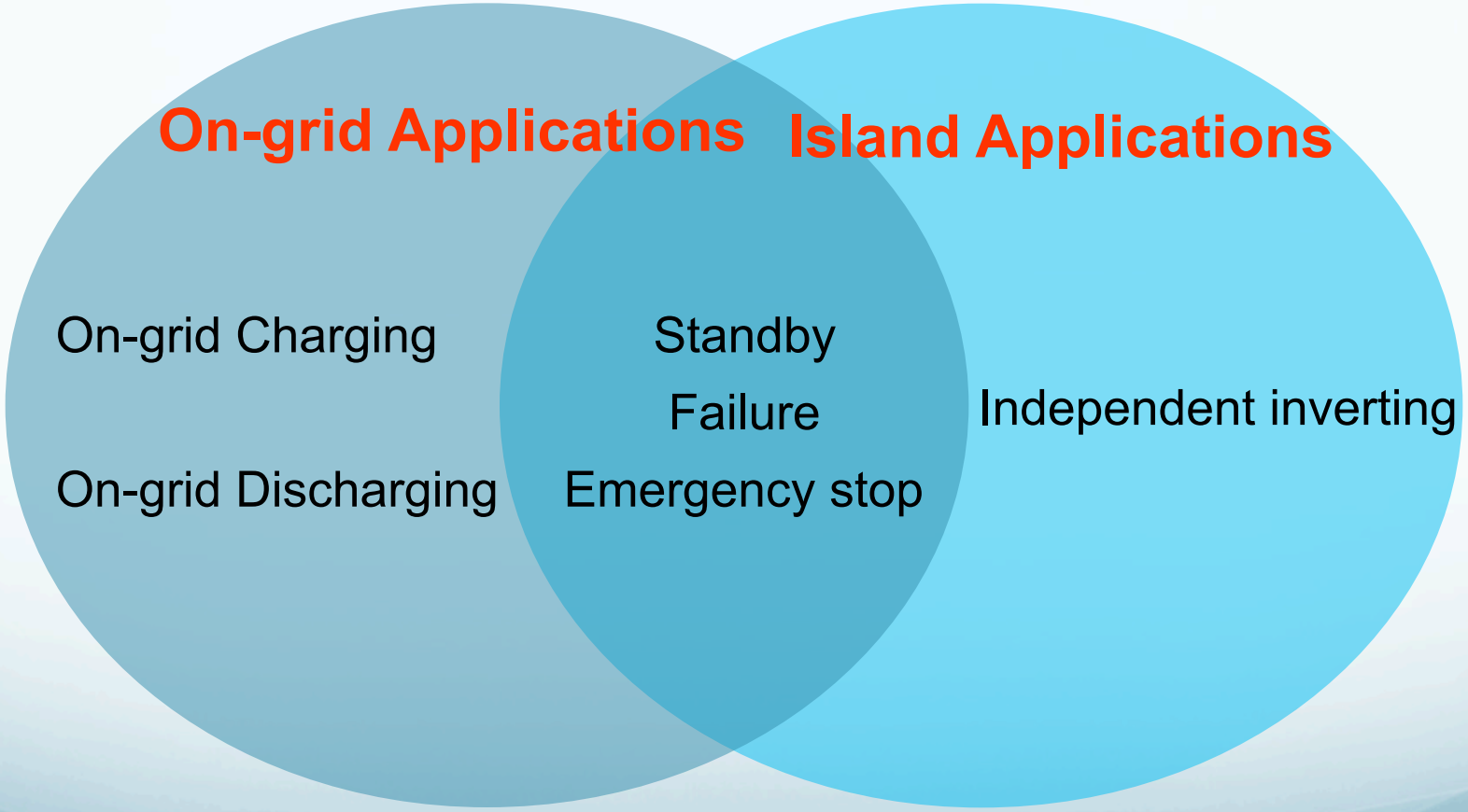
BMS



Monitoring system

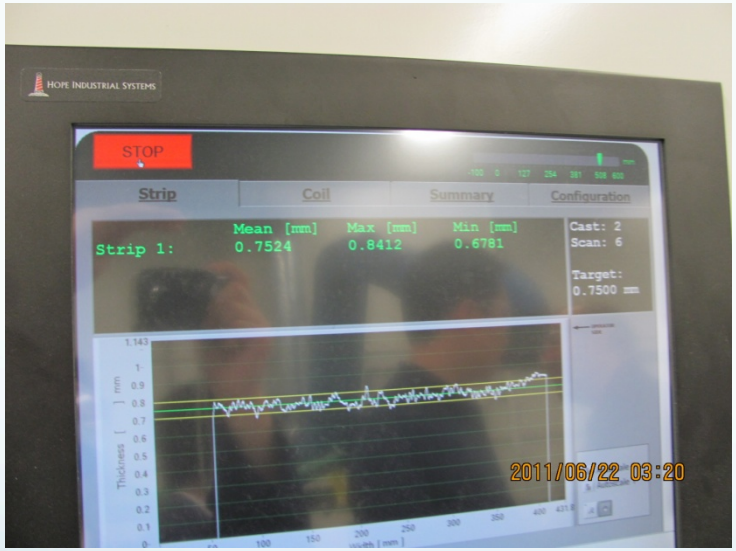


Running Mode of Battery ESS System

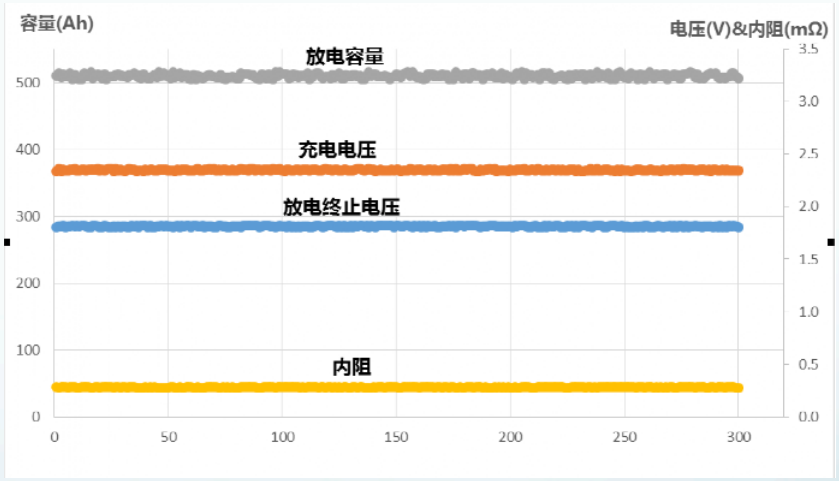


Battery Group Technology

- The key of battery group technology is to ensure the uniformity at the cell level to avoid “weakest link effect”, then high charging and discharging efficiency and longer service life achieved at the group level
- State-of-the-art equipment, meticulous control, reasonable selection are major contributors.



laser thickness controlling system



uniformity test of discharge capacity, charge voltage, end of discharge voltage and internal resistance

Battery Management System (BMS)Technology

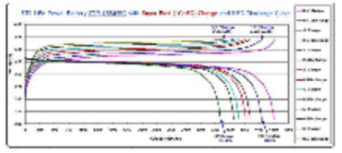
- High precision voltage measurement
- High precision current measurement
- High precision temperature measurement
- Large current nondestructive balancing
- Efficient balancing control strategy
- Multilayer safety protection
- Practical SOC estimation
- High reliability
- Intelligent BMS interface
- Historical event records

Longer service life at battery string level

Improved user experience

Enhanced battery safety

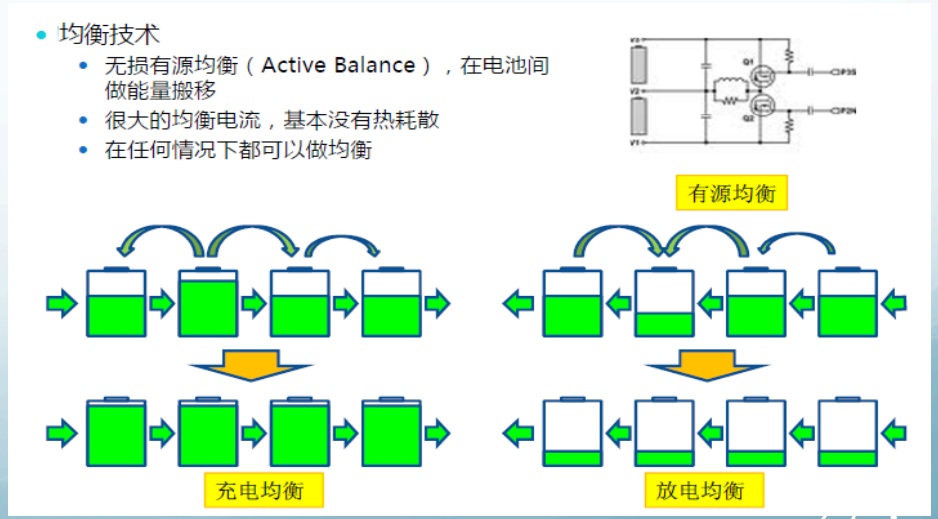
Convenient maintenance& inspection





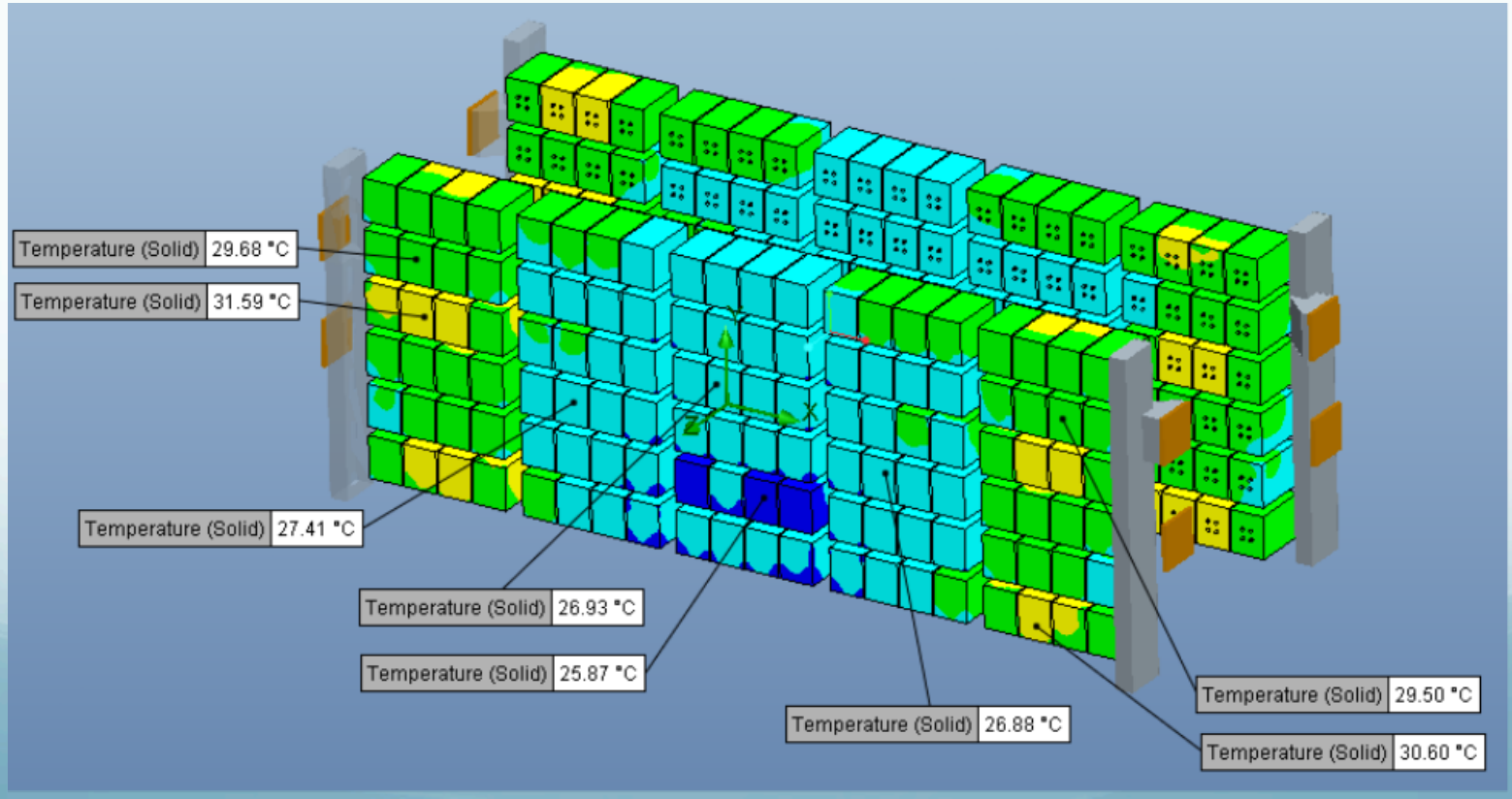


- Balancing Technology
- Nondestructive active balancing, energy transfer
- High balancing current almost no heat dissipation
- Balancing regardless of circumstances



Battery Thermal Management Technology

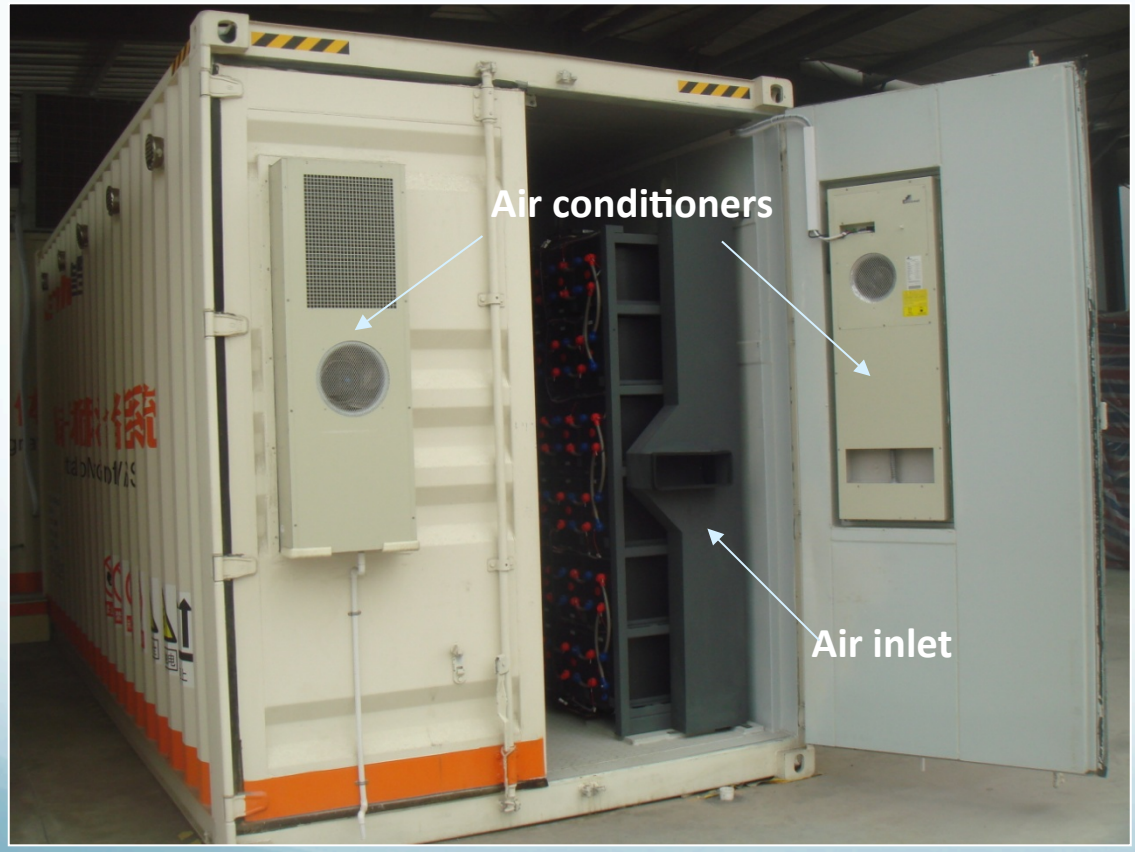
- Based on theories of air dynamics and hydrodynamics and tested after simulation and selection on large scale computer system, the unique temperature-regulated air supply system was designed and widely employed in the construction of BEES power stations

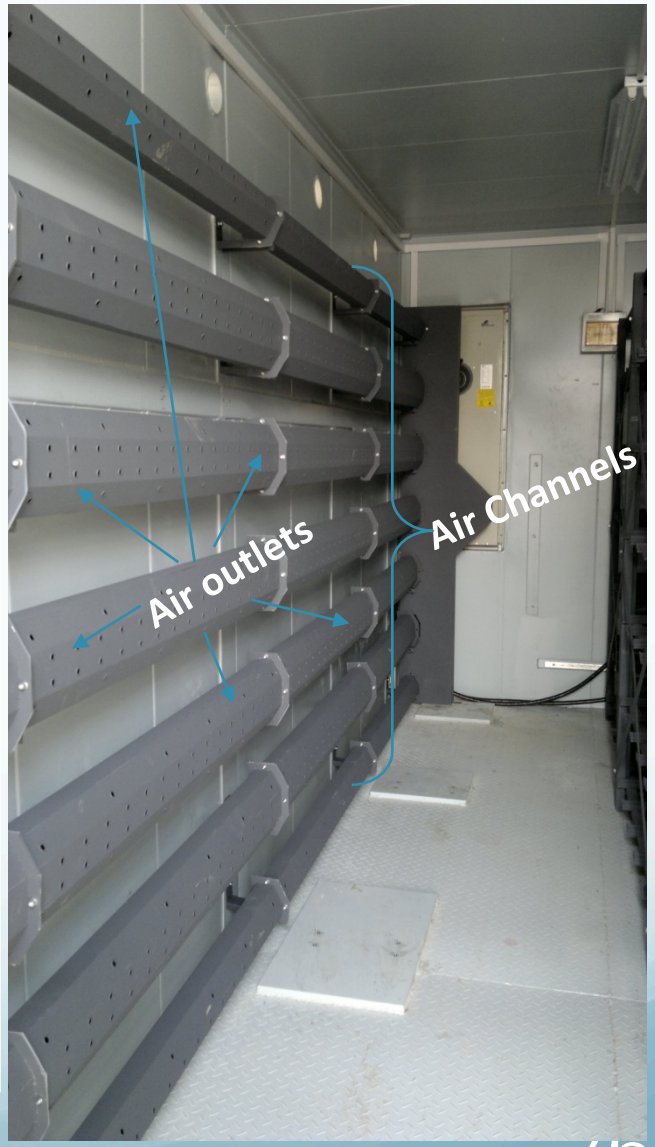


Battery Thermal Management Technology

Containerized battery thermal management system

(temperature difference < 5˚C at the cell level)





Modular Layout

- Optimized container design enables modular layout and mobility of the energy storage power station for emergency and disaster relief





Anti-corrosion, Anti-salt mist Treatment

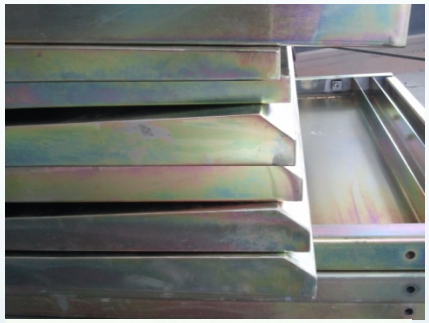


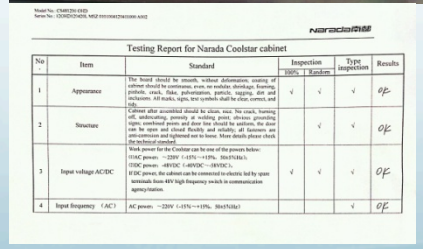
- **Anti-corrosion, anti-salt mist treatment:**

1. Tin filmed battery connection system
2. Special corrosion proof outdoor plastic powder sprayed after tin plating of racks and cabinets
3. Anti-salt mist test evidenced qualified treatment
4. Narada is experienced in anti-corrosion, anti-salt mist treatment of cabinets for energy storage and telecommunication application









Testing Report for Narada Coolstar cabinet

No	Item	Standard	Inspection 100%	Inspection Random	Type inspection	Results
1	Appearance	The board should be smooth, without deformation, coating of cabinet should be continuous, even, no nodular, shrinkage, foaming, pinhole, crack, flake, pulverization, particle, sagging, dirt and inclusions. All marks, signs, text symbols shall be clear, correct, and complete.	√	√	√	OK
2	Structure	Cabinet after assembled should be clean, neat. No crack, foaming, off, undercutting, porosity at welding point; obvious grounding signs; overbound points and door line should be uniform, the door can be open and closed flexibly and reliably, all fasteners are anti-corrosion and tightened not to loose. More details please check the technical standard.		√	√	OK
3	Input voltage AC/DC	Work power for the Coolstar can be one of the powers below: ①AC power: ~220V (-15%~+15%, 50±5%Hz); ②DC power: +48VDC (-40VDC~-58VDC); If DC power, the cabinet can be connected to electric led by spare terminals from 48V high-frequency switch in communication agency/station.	√	√	√	OK
4	Input frequency （AC）	AC power: ~220V (-15%~+15%, 50±5%Hz)			√	OK



2MWh PV-ESS Integrated Microgrid Power Station at Narada Facility





Capacity	2MWh
Power	0.5MW
Integrated Voltage	380V / 50Hz
Installed in	2011
Services	Peak shaving, power smoothing

** Hybrid Battery ESS System with Lead Carbon and Lithium ion batteries, for superior performance and high reliability

2MWh PV-ESS integrated micro-grid power station at Narada

- It is a pioneering enterprise micro network energy storage power station, implementing peak shaving and renewable energy access, optional for island or on-grid operation.
- System features-mobile modular containerized design,

  Lead Carbon/Li-ion battery hybrid energy storage technology
- Thermal management system was employed for the first time and integrated with advanced battery technology, BMS, grouping and other core technologies

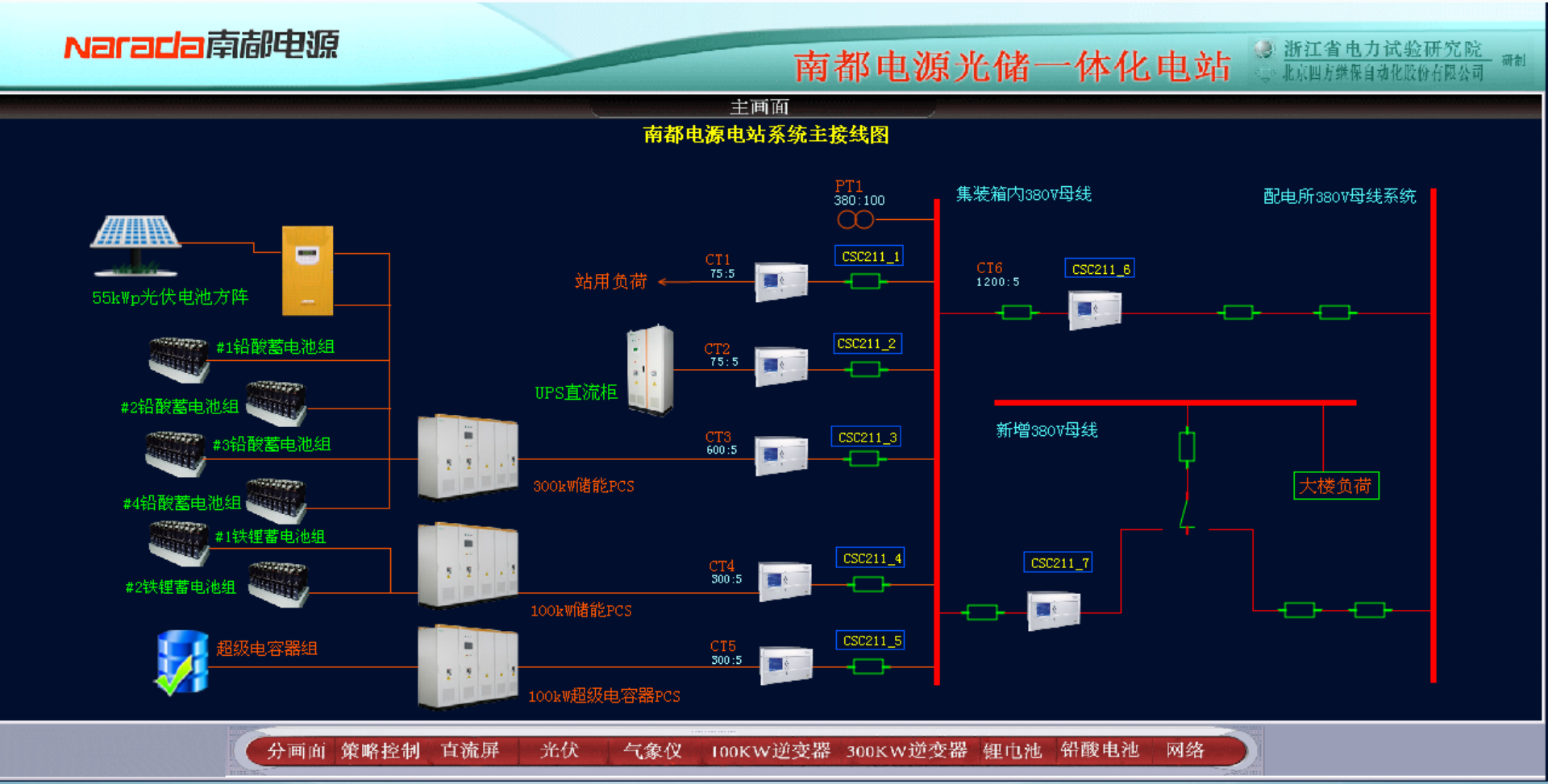






PV-EES integrated microgrid power station in Narada Facility

Electrical Single Line Diagram



Wind-PV-DG hybrid energy storage power station for Dongfushan Island

- The hybrid energy storage power station for Dongfushan Island is the first real world case in scale renewable energy storage in China, integrated wind, photovoltaic and ESS, boosted to run the island micro grid system. Technically difficult and complex, the project is of great significance in demonstration.



100KW Solar Panels



210KW Wind Turbine Generators



Narada BEES blocks

- The project was launched in 2011, the Battery ESS system has been running smoothly for 3 years.



Narada 南都电源

微网储能点亮世界 绿色能源驱动未来

Microgrid Energy Storage Lighting the World Green Energy Driving the Future