The Need for Robust Thermal Management Systems (TMS), Not Just BMS

Russ Weed, CleanTech Strategies LLC

2019 ESS Safety & Reliability Forum - US DOE Energy Storage Systems Program
March 7, 2019

Sandia National Laboratories

Pacific Northwest National Laboratory

Oak Ridge National Laboratory

Russ Weed - CleanTech Strategies LLC

- **Business & Project Development, Marketing & Sales, Legal Management**
- VP BD & Marketing, GC at vanadium flow battery co. UET
- Sold $18MM of UET systems and negotiated additional $11MM
- VP BD at GE subsidiary with $1B annual revenue, GC at GE division with $425MM annual revenue
- CleanTech Strategies LLC consultancy established 2018
- Clients include Hotstart, with 77 years of expertise providing thermal management systems (TMS) for the generator, oil & gas, rail, truck & bus, heavy equipment, marine, and now energy storage markets

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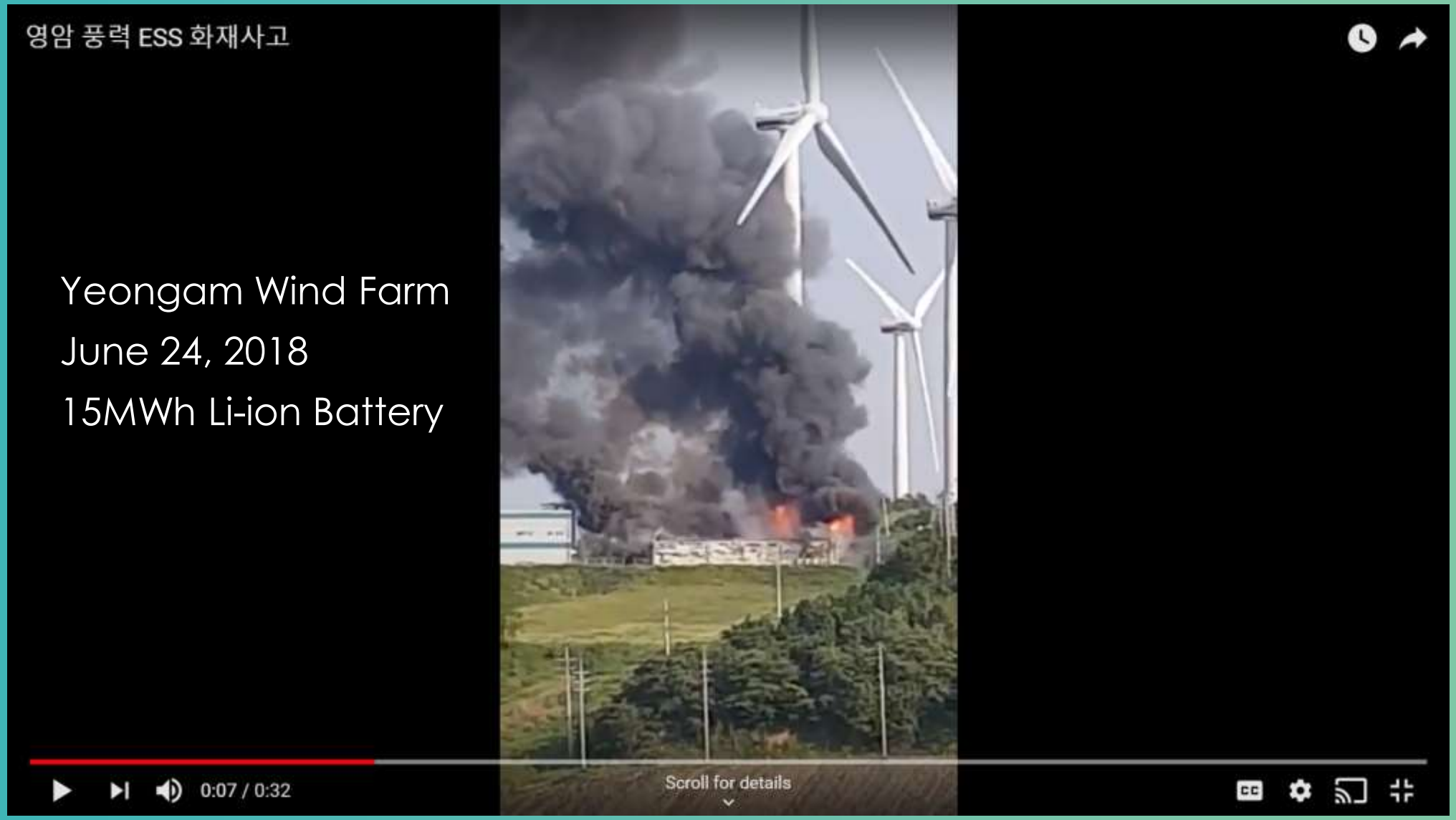

https://www.youtube.com/watch?v=uyuiWywTL8Q

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https://www.youtube.com/watch?v=3A_G-yOWYT4
http://imnews.imbc.com/replay/2018/nwtoday/article/4651469_22669.html
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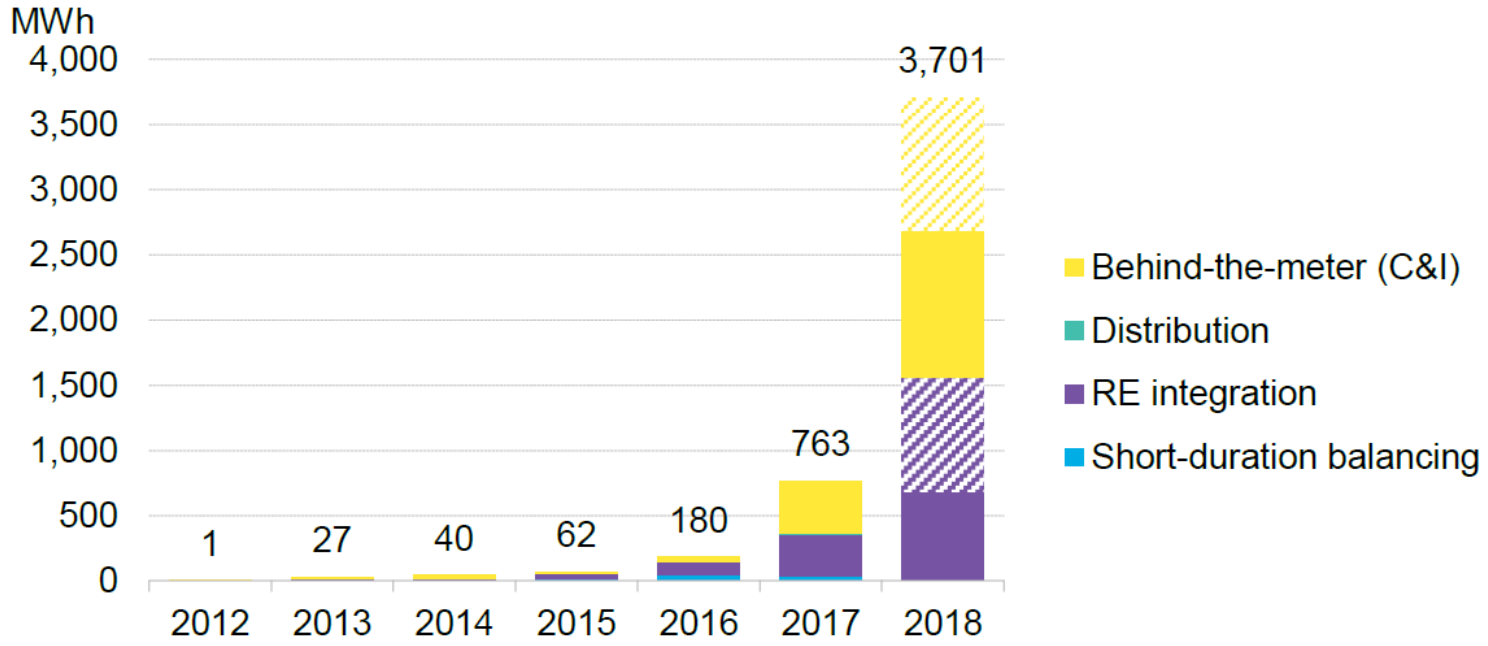
ESS Laboratory for the World - South Korea

Bloomberg New Energy Finance

The Fire Risk of Batteries - A Delicate Balancing Act

August 23, 2018

Figure 2: Energy storage uptake in Korea



Source: Bloomberg NEF, MOTIE Note: Diagonal pattern are estimated numbers for 2H 2018

RPS & REC Laboratory for the World - South Korea

Renewable Energy Credits (REC's) in South Korea Under its Renewable Portfolio Standard (RPS)

updated in Nov. 2017

Type	REC Weight	Installation Details	
Solar	1.2	on land	below 100 kW
	1.0		100 - 3,000 kW
	0.7		over 3,000 kW
	1.5	on buildings or existing structures	below 3,000 kW
	1.0		over 3,000 kW
	1.5	Over water	
	1.0	Others	
	5.0	**ESS installed with Solar**	**until 2018.06.30**
Other renewables	0.25	IGCC, gas by-products	
	0.5	Waste, landfill gas	
	1.0	Hydro, land-based wind, bio, RDF, waste based gas, tidal (with seawall), etc	
	1.5	wood-based bio, ocean wind (less than 5km), hydro thermal	
	2.0	Fuel cell, ocean current	
	2.0	ocean wind (over 5km), geothermal, tidal	Fixed
	1.0-2.5	(w/o seawall)	Mobile
	5.5	**ESS installed with Wind**	**2015**
	5.0		**2016**
	4.5		**2017 and until 2018.06.30**

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Table 1: Energy storage fire incidents

Project	Country	MW	MWh	Capacity affected (MWh)	Application	Technology	Battery provider	Installation date	Incident date
Asia Paper Sejong Energy Storage Project	Korea	–	18	18	Peak management	Lithium-ion	Samsung SDI	Under construction	July 2018
DaeMyoung GEC Geochang Energy Storage Project	Korea	9.6	9.6	9.6	RE integration	Lithium-ion (NMC)	Samsung SDI	Dec 2015	July 2018
Haenam Songji Energy Storage Project	Korea	–	3	3	RE integration	Lithium-ion	LG Chem	Dec 2017	July 2018
CNPV Power Korea Gunsan Saemangeum Energy Storage Project	Korea	–	19	19	RE integration	Lithium-ion	LG Chem	Dec 2017	June 2018
DaeMyoung GEC Yeongam Energy Storage Project	Korea	4	15	15	RE integration	Lithium-ion (NMC)	Samsung SDI	Dec 2015	June 2018
KEPCO Gwangyang Energy Storage Project Phase I	Korea	24	12	12	Frequency regulation	Lithium-ion (NMC)	Samsung SDI	Feb 2016	May 2018
MOTIE Gochang Energy Storage Pilot Project	Korea	54	31	17	RE integration	Lithium-ion	Top Battery	–	August 2017
Engie Drogenbos Energy Storage Pilot Project	Belgium	6	20	6**	RE integration	Lithium-ion*	Unknown	Jul 2017	Dec 2017
Arizona Public Service Co Electrovaya Energy Storage Project	Arizona, U.S.	–	1.5	1.5	RE integration	Lithium-ion	Electrovaya	Feb 2012	Nov 2013
First Wind Kahuku Energy Storage Project	Hawaii, U.S.	15	4	4	RE integration	Lead-based battery	Xtreme Power Inc.	Mar 2011	Aug 2012
Mitsubishi Material's Tsukuba Energy Storage Project	Japan	2	14	14	–	Sodium sulphur	NGK Insulators	–	Sep 2011

*Source: Bloomberg NEF, Korea Ministry of Trade, Industry and Energy Note: RE stands for Renewable Energy *This is a technology pilot program. Engie will start by testing lithium batteries from four different manufacturers under the same conditions, for a total power of 6MW. After which storage technologies such as compressed air, flywheel, redox flow batteries will be tested. ** The fire only impacted part of the project but a specific MWh is unknown. Three providers had installed systems at that point and only one was impacted so we have assumed 6MWh.*

4%

Proportion of total lithium-ion capacity installed in Korea in 2017 and 1H 2018 impacted by the fires

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NEXCERIS
where energy meets environment

Update on Korean ESS Market
December 5, 2018

Update on Korean ESS Fires

State of ESS in South Korea

- More than 14 reported fires in the past calendar year with >30 suspected.
- Fires have continued after summer heat wave. Most recent fire was on November 21, 2018.
- [VIDEO]
- Fires have reached the mainstream news and are part of the Korean news cycle.
- Government reaction has increased.

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LG Chem stops ESS operation in the wake of a series of fires

Lee Jun-sung | 승인 2019.01.17 10:49 | 댓글 0

LG Chem

LG Chem requested the shutdown of energy storage systems (ESS), which use its own batteries, on Jan. 15, according to the Elec. Times.

There have been eight fires in ESSs that use LG Chem's batteries since November last year, and ESSs that use the company's batteries have caught fire on Jan. 14 and 15 in a row.

A fire broke out at 4:16 p.m. on Jan. 15 at the solar energy-linked ESS located in Jangsu-eup, Jangsu-gun, North Jeolla Province. Another fire broke out in the ESS, which was installed at the Kiswire Plant in Yangsan, South Gyeongsang Province in the morning of the previous day.

LG Chem is known to have notified companies of the stoppage of ESS operation after a series of fires. It seems that LG Chem has decided to stop operating ESS after recognizing the seriousness of the situation and to find a solution.

"We are currently trying to come up with proper measures related to the series of fires," said an LG Chem official.

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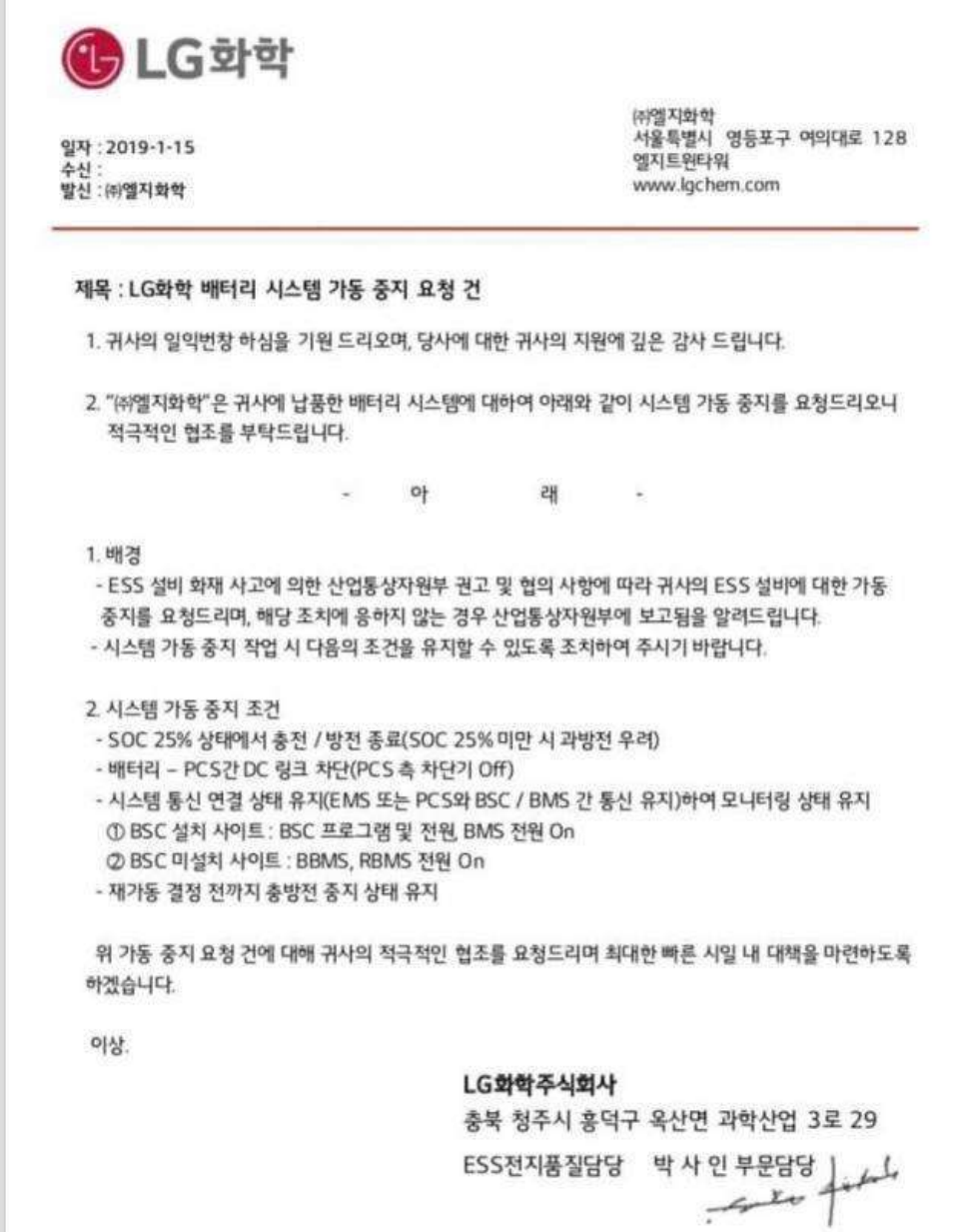

LG화학

일자 : 2019-1-15
수신 :
발신 : ㈜엘지화학

㈜엘지화학
서울특별시 영등포구 여의대로 128
엘지트윈타워
www.lgchem.com

제목 : LG화학 배터리 시스템 가동 중지 요청 건

1. 귀사의 일익번창 하심을 기원 드리오며, 당사에 대한 귀사의 지원에 깊은 감사 드립니다.

2. "㈜엘지화학"은 귀사에 납품한 배터리 시스템에 대하여 아래와 같이 시스템 가동 중지를 요청드리오니 적극적인 협조를 부탁드립니다.

- 아 래 -

1. 배경
- ESS 설비 화재 사고에 의한 산업통상자원부 권고 및 협의 사항에 따라 귀사의 ESS 설비에 대한 가동 중지를 요청드리며, 해당 조치에 응하지 않는 경우 산업통상자원부에 보고됨을 알려드립니다.
- 시스템 가동 중지 작업 시 다음의 조건을 유지할 수 있도록 조치하여 주시기 바랍니다.

2. 시스템 가동 중지 조건
- SOC 25% 상태에서 충전 / 방전 종료(SOC 25% 미만 시 과방전 우려)
- 배터리 – PCS간 DC 링크 차단(PCS 측 차단기 Off)
- 시스템 통신 연결 상태 유지(EMS 또는 PCS와 BSC / BMS 간 통신 유지)하여 모니터링 상태 유지
  ① BSC 설치 사이트 : BSC 프로그램 및 전원, BMS 전원 On
  ② BSC 미설치 사이트 : BBMS, RBMS 전원 On
- 재가동 결정 전까지 충방전 중지 상태 유지

위 가동 중지 요청 건에 대해 귀사의 적극적인 협조를 요청드리며 최대한 빠른 시일 내 대책을 마련하도록 하겠습니다.

이상.

LG화학주식회사
충북 청주시 흥덕구 옥산면 과학산업 3로 29
ESS전지품질담당 박 사 인 부문담당

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"Request to Stop the Operation of LG Chemical Battery Systems

1. We wish your company success
2. We, LG Chemical, are requesting to stop the operation our battery system as follows. Please cooperate as follows.

1. Background
- Following the recommendation by the Ministry of Trade, Industry and Energy to discontinue the operations of ESS systems after recent fire incidents, we are requesting your company to stop operation of the ESS system. We want to also inform you that if your company does not comply, it will be reported to the MoTIE.
- When you stop the operation of ESS system, please maintain the following conditions:

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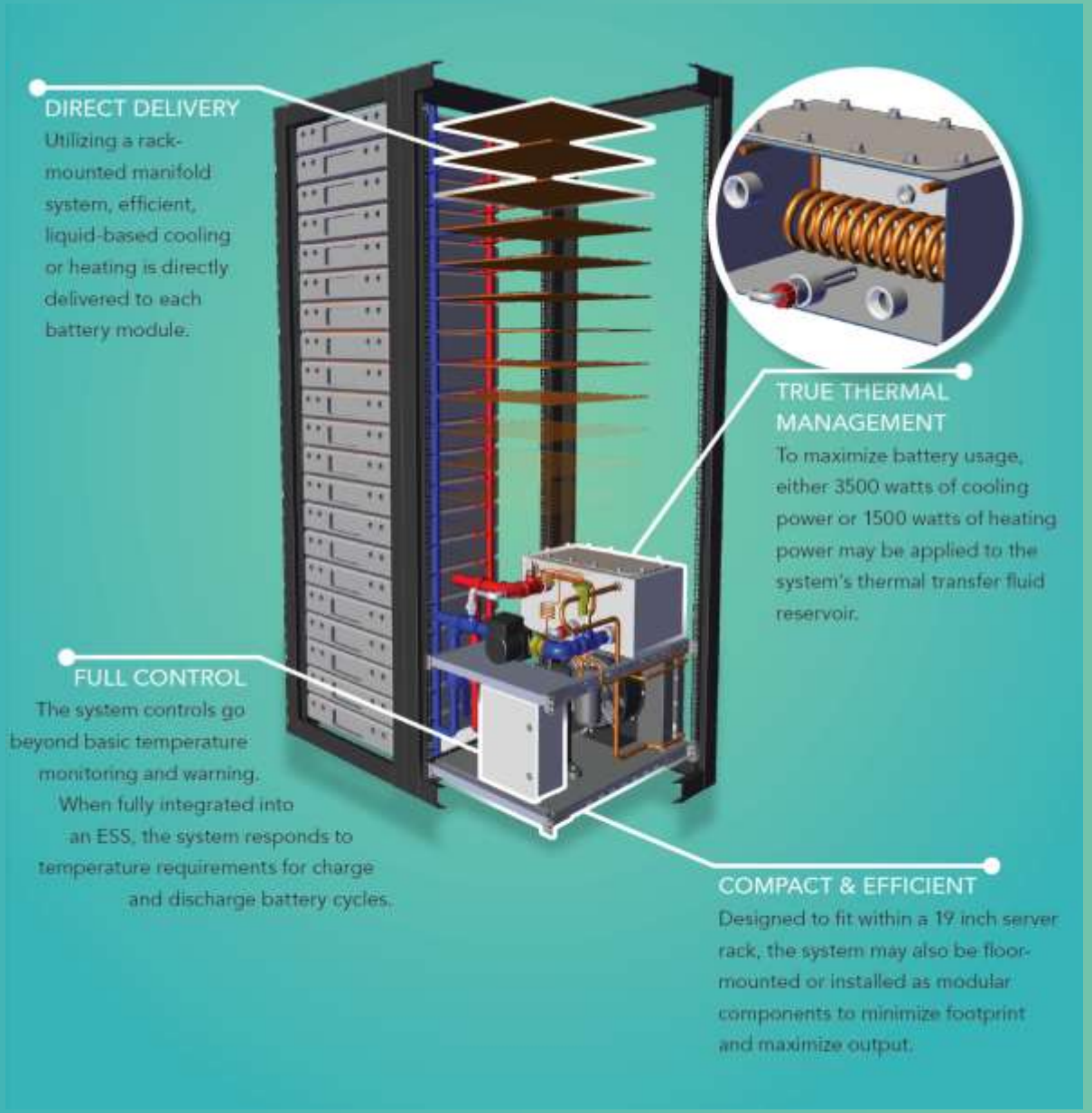
"2. Conditions to Stop the System
- stop charging/discharging of system at SOC 25% (there is a possibility of over-discharge below SOC 25%)
- disconnect the DC link between battery and PCS (shut off PCS side connection switch)
- leave on the communication system (maintain communications between EMS or PCS and BSC/BMS) to continue monitoring.
  1) sites with BSC: BSC program and power, BMS power on
  2) sites without BSC: BBMS, RBMS power on
- please do not charge or discharge until a decision is made to restart the operation

Please cooperate with us on this request to stop the operation, and we will find an appropriate resolution to this situation as soon as possible."

Liquid TMS Should Be The Standard for Li-ion ESS



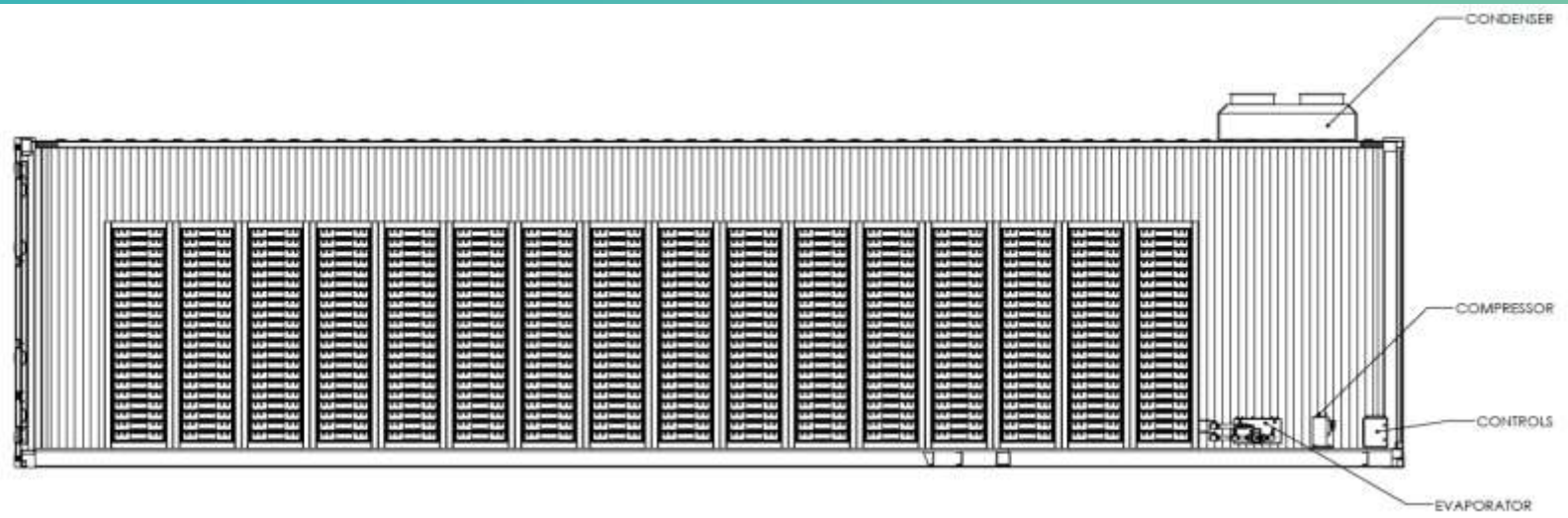
Liquid TMS Should Be The Standard for Li-ion ESS

CO-LOCATED CONFIGURATION

TMS System can be located anywhere within enclosure or equipment room for installation flexibility.

REDUNDANT SYSTEM CONFIGURATION

Spare TMS Sytem is plumbed into the entire rack. Electronic valves and controls can detect faults, isolate malfunctioning systems, and substitute stand by units, with no service call.



MODULAR SYSTEM CONFIGURATION

TMS System can be installed with individual components located anywhere in enclosure or equipment room for maximum installtion flexibility. We will work with your engineers to provide custom mounting, wiring, and plumbing solutions that can be designed to fit wherever you have free space.

Thank you

To Drs. Imre Gyuk, Babu Chalamala, Vince Sprinkle, and the DOE, Sandia, and PNNL teams