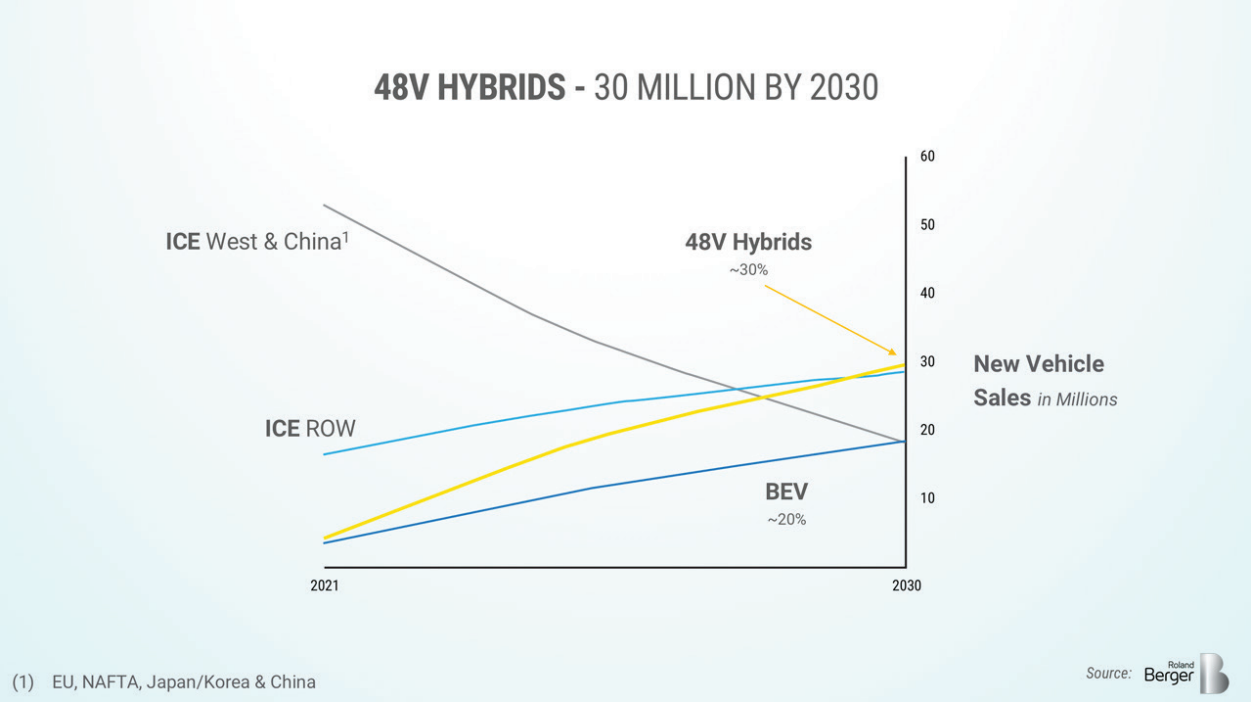
My objective is to share our understanding at Gridtential about the needs for battery performance from the emerging 48V platforms worldwide, and also about prospects for improving battery systems.

Whether your target is to save money, save the planet, or both, the real 20% reduction in emissions and costs through the efficiency from the advanced engineering in 48 volt system hybrids is terrific.



First, a couple pictures of the forecast evolution of vehicle platforms. And the data behind these graphs is courtesy of the Roland Berger consulting group.

This graph depicts the share of new vehicles out to 2030 whereby the 48V hybrids reach nearly 30 million, or about 30% of all new vehicles, and about 50% higher than the forecast demand for pure EVs at that time worldwide.

Also, in this chart, I have split the forecast trends for traditional ICE engine platforms into the Western markets plus China vs. the Rest of World, which is principally the developing markets, to illustrate a potential further growth opportunity for 48V platforms.

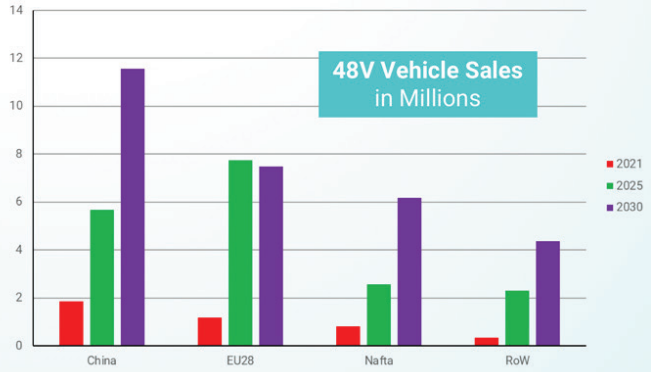
Traditional ICE engines in Western markets plus China are forecast to decline notably. Yet, in developing markets, the demand for transportation solutions, like all other products, are highly influenced by affordability, complemented in this case also by electricity availability.

My guess is that as we progress saving money and emissions with 48V systems in the West and China, it could translate to an even larger shift to 48 volt systems with smaller, lighter engines in developing markets due to the low costs to implement the 48V technology, and the fuel cost savings.

REGIONAL DEMAND FOR 48V

in Millions

	2021	2030	GROWTH
CHINA	1.8	11.5	6x
EU 28	1.2	7.5	6x
NAFTA	0.8	6.2	8x
REST	0.3	4.4	15x
TOTAL	3.4	29.6	9x



China & EU lead, yet high 48V growth globally

Source: Roland Berger

By region, the implementation of 48V systems is being led in China and the EU based on regulations for emission reductions and other factors. Weighing heavily also in the EU is the higher value of the 20% reduction in fuel cost when the costs per liter or gallon are 2X, 3X or more than the cost of fuel in the US and elsewhere.

The data behind this chart, again from Roland Berger, highlights the slowing of 48V growth in the EU later in the decade in favor of EVs, while the growth of 48V hybrids is accelerating in North America and the Rest of the World.

HIGH LEVEL BATTERY GRADES TODAY

IMPROVEMENTS WILL BE MADE

	Popular Lithium			Advanced Lead
	LFP	*NMC*	*LTO*	
Power	B	B	A	A
Energy	B	A	C	C
Charge Acceptance	A	A	A	B
Cycle Life	B	C	A	C
Cost	C	C	F	B
Safety	C	D	B	A
Sustainability	F	F	F	A+

Grading references **A)** Excellent **B)** Above Average **C)** Average **D)** Fair **F)** Poor/Fail

Before going to details on battery demands, I will share my biases and high level assessment of where the battery systems stack up. And at this point, I will share I have two important personal investments, one in a lithium materials company, Albermarle, and one in an advanced lead battery technology company, Gridtential. So, I believe in the future of both systems.

First to comment on the strengths - Lithium solutions with their higher energy capability and light weight, really deliver value for many use profiles. And lead based batteries offer uniquely high power capability matched with proven recyclability and low costs.

Though the three lithium battery systems shown vary widely in energy density, cycle life and cost, they all need much further progress in Safety and especially recycling for Sustainability.

And lead battery systems need real progress in energy density, cycle life and charge acceptance rates. In short, I believe both battery systems will further improve and share significant growth across the transportation, industrial and renewable-linked industries.

48V BATTERY REQUIREMENTS

	P0-P1	P2+	Chemistry Advantage Today
Battery Voltage Range	38 – 52 V	38 – 52 V	Pb & Li
Minimum Recharge Power	9-15kW	16kW+	Li
Minimum Capacity	200 Wh	400+ Wh	Pb & Li
Minimum Discharge Power (10 seconds)	9 kW	11kW+	Pb
System Weight	≤ 8 kg	≤ 10 kg	Li
Minimum Operating Temperature	-30℃	-30℃	Pb

Lithium today due to charge acceptance, mass, & available 48V packs

Shown here is our understanding of the battery needs for 48V hybrid systems as they progress to more powerful platforms from the so-called mild hybrid to even full hybrid functionality across short ranges.

Initial platforms have favored lithium batteries because of their charge acceptance, lighter weight and effective packaging to 48 volts, as available advanced lead options even if attractive in discharge power, cost and temperature range just were too bulky and heavy, and also needed a better recharge rate.

We also have to acknowledge the evolution in the 48 volt platforms may place added and higher demands on batteries than we know today. Continental's announced new 30 kW motor for 48 volt full hybrids is just one example.

Also, we understand these systems will continue to be complemented with a smaller, lighter, 12 volt auxiliary battery.

48 VOLT FOR TRUCKING – How Fast, How Far?

Medium Duty Trucks Can Reduce Costs & Emissions
- *First systems similar to auto P0 functionality*
- *Evolution to P2+ quickly drafting on auto progress for urban delivery*

Recharge Power Needs: ~15kW+, similar to auto

Discharge Power Needs Much Higher for Larger Motors

Weight and Volume Constraints Less Critical than Auto

Advanced Lead Solutions Will Rival Good Lithium Solutions

Another example where the demand on the battery will evolve is across the emerging market for 48V solutions into medium duty trucks.

We think that recharge requirements may be only modestly higher than seen on light vehicles, yet the discharge requirements to aid acceleration of the heavier vehicles and to sustain other functions in both gasoline and diesel options will be much higher. The weight trade-off may also be different than on light vehicles.

48V LITHIUM BATTERIES

NO PERFECT FIT YET

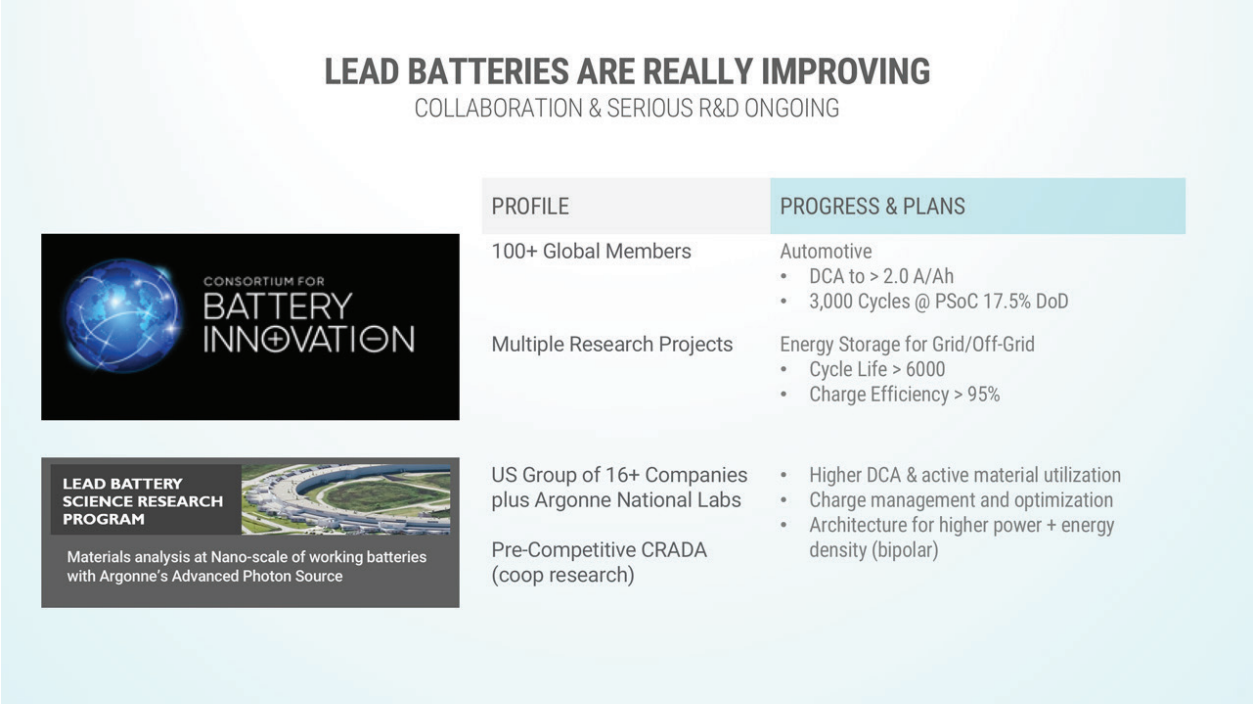
	LFP	NMC	LTO
Maximum Recharge Rate	1C	1C	5C
Energy Density	90-120 Wh/kg	150-220 Wh/kg	50-80 Wh/kg
Discharge Power Density	1800-2500 W/kg	500-1000 W/kg	3000+ W/kg
Cycle Life @ PSoC	2000+	2000+	7000
Thermal Stability	Moderate	Poor	Good
Cost	$500 / kWh	$300 / kWh	$1000 / kWh

- NMC leads 48V market due to cost sharing with BEVs, yet poor for power
- LFP is a good compromise, but poor for low-temperatures
- LTO has high performance, but cost prohibitive
- All Lithium chemistries MUST improve recyclability and safety

Shown are the three main contenders for lithium 48V batteries: lithium iron phosphate (LFP), nickel manganese cobalt (NMC), and lithium titanate (LTO). Each have their particular attributes especially around the critical power density and recharge rates, and yet each has some drawbacks to wide implementation as shown.

Battery engineers and scientists are racing to improve performance and costs. There is a tremendous amount of focus and investment to reduce the cobalt content, improve the robustness of the current collector, and to develop affordable solid state designs.The timing, cost and trade-offs implied by these improvements is hard to forecast.

Clearly safety, sustainability, and ethics along the supply chain will need a lot more real progress, and the industry is working on that. On the safety issue, fires in transport, or with vehicle accidents, or in other recycling streams and at landfills, attest to the challenges to be addressed.



For years lead batteries have performed reliably in vehicle starting and in deep cycle applications, but admittedly did not adapt quickly to dramatically changing needs and duty cycles across transportation and industrial applications. And lithium batteries showed there was another option.

That is clearly changing with significant 'pre-competitive' collaborative R&D in the US and worldwide for the improvement in lead batteries. Shown are the achievable targets set for dynamic charge acceptance and cycle life improvements directly applicable to the 48V hybrid systems by the global CBI group, or Consortium for Battery Innovation, which has over 100 members.

In the US, joint work by the LSBR, or Lead Science Battery Group with Argonne National Labs' Advanced Photon Source is evaluating materials at the nano-scale within working batteries. And it is opening up numerous pathways for further improvement now. This work is progressing in three principle areas: active material improvements, charge management and battery architecture.

COMPLEMENTARY LEAD DEVELOPMENTS

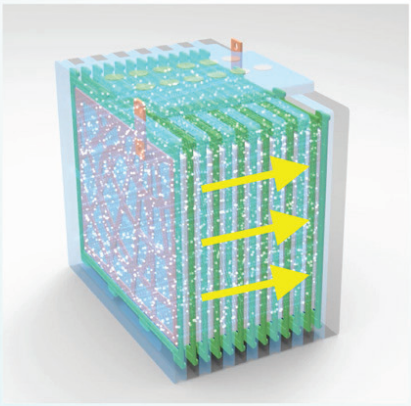
	Active Material	+ Architecture (bi-pole)
Dynamic Charge Acceptance	0.4 - 1.0 A/Ah	3 – 4 A/Ah
Energy Density up from 35 Wh/kg.	>40 Wh/kg.	>50 to 60 Wh/kg
Discharge Power Density up from 500 W/kg.	>600 W/kg	>1400 W/kg
Cycle Life @ PSOC, 17.5% DoD	Real Progress	3,000 +
Water Loss in New APPS	In research	Better, less side reactions
Higher voltage (to 48V) designs	–	12V to 48V today

Can easily adapt existing lead and solar capacity
Gigafactories already exist

Here is a closer look at the progress around improvements in the Active Material, or recipes to enable optimum lead sulphate crystal evolution for charge acceptance and life, plus new additions, like carbon. Separate is the improvement achievable with a notably different battery architecture known as bi-polar batteries. These pathways for lead battery improvement are complementary enabling potential performance many experts did not believe feasible just a few years ago.

Beyond unique prospect improvements in charge acceptance, power and energy density and cycle life, lead batteries for the first time can also now be packaged conveniently beyond 12 volts up to 48 volts in a single block with the bi-polar construction.

SILICON BI-POLE + PROVEN LEAD



Cross section of Silicon Joule® bipolar battery depicting uniform current flow

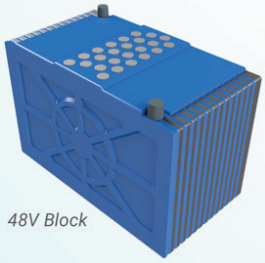
Silicon Joule® bipolar architecture
Low-cost wafers with improving lead chemistry

- **Bipolar batteries offer:**
  - Simplified assembly/construction to 48V
  - Higher discharge power & faster recharge due to improved current flow
  - Reduced impedance
  - Decreased weight (>33%) thru removal of non-reactive lead
- **Silicon wafers offer:**
  - High volume & low-cost supply chain
  - Helpful thermal and mechanical properties with light weight

A number of companies are now investing in the development and commercialization of bi- polar batteries, and what is common is the more efficient uniform current flow, direct and horizontally across the full electrodes rather conducting through the grid and strap structures in the legacy 12 volt batteries. These constructions provide dramatically improved discharge and recharge characteristics and weight reduction. And they also allow packaging into small higher voltage batteries, without the more complicated battery management and packaging required for lithium batteries.

Gridtential's approach is to use stable, low cost treated silicon wafers as the bi-plate material which are treated with a thin lead layer to facilitate efficient conductivity and longer life.

48V HYBRID WITH SILICON JOULE®



48V Block

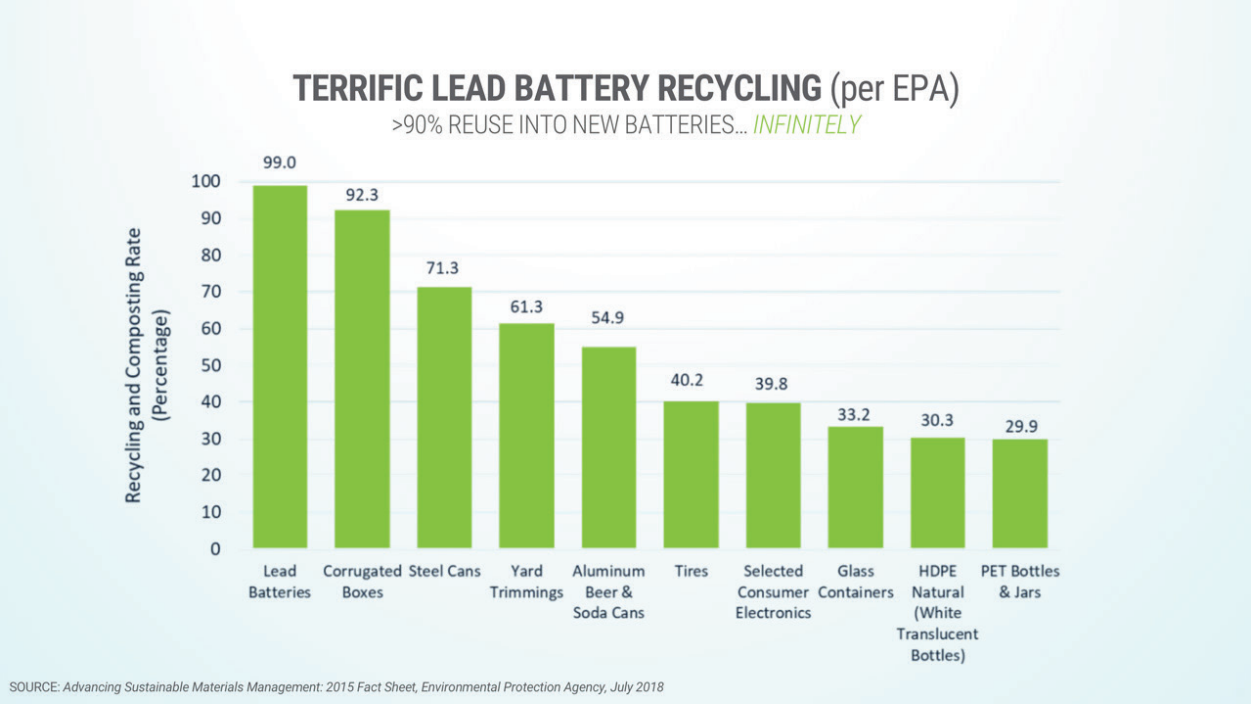
	48V Silicon Joule	48V LFP
Dynamic Charge Acceptance	3 A/Ah	-
Maximum Recharge Power (10s)	11 kW	16 kW
Energy Density	55 Wh/kg	48 Wh/kg
Power Density	1600 W/kg	1900 W/kg
Battery Weight	9.4 kg	8 kg
Capacity	470 Wh	384 Wh
Volumetric Density	96 Wh/L	73 Wh/L
Battery Volume	4.9 L	5.25 L
Battery Cost	$200 / kWh	~$500 / kWh

- *Silicon Joule provides a viable alternative for emerging 48V applications*
- *Partners are progressing toward commercialization*

This chart explains how Silicon Joule batteries compare to lithium iron phosphate designs for the 48 volt application. What is notable is the breakthrough levels of Power and Energy density achievable, while still notably reducing weight at low cost. And Gridtential, along with our battery company partners, are progressing toward commercialization.

Shown are the existing licensees of Silicon Joule technology. We are also progressing with other battery companies worldwide, and also leading automotive, battery and silicon suppliers to scale up production methods and install a robust low cost global supply chain.

The rollout of Silicon Joule technology is helped by the already existing GIGA -factories for solar wafers and lead batteries. Both require only modest adaption to existing very large scale capacity to handle the differentiated plates, without the potential billions being invested for alternate battery technologies. This further supports the low cost forecasts.



We all accept lead used in gasoline, paint and water pipes with hindsight was a mistake. However, when used in batteries, lead may actually be the best example in the world of a sustainable material.

This recent EPA report validated once again that lead batteries have the highest recycling rate of any consumer product. Yet, the story gets better in that over 90% of the contained lead, plastic, et al gets reused directly into new high performing new batteries....infinitely. Yes, the lead does not wear out or break down, and the modern recycling and refining processes have progressed to support the industry with the highest quality supplies for reuse for decades to come. It is a terrific model for sustainable materials in the desirable circular economy.

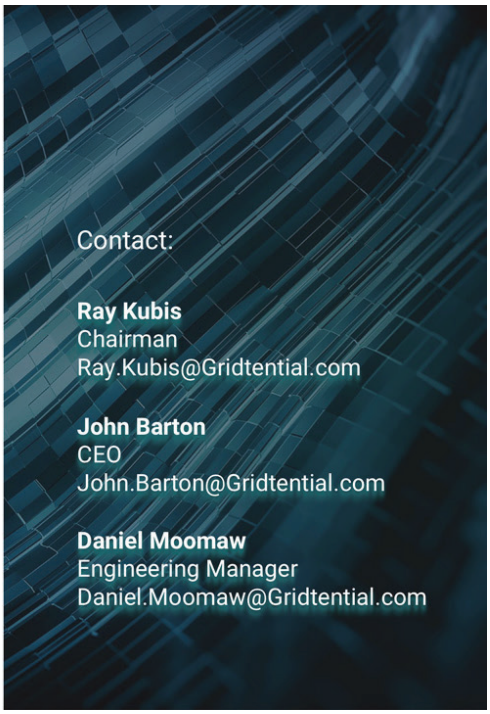
One added point is virtually all credible battery solutions have tricky or dangerous materials contained, no matter the headline “Green” claims. The issue is how well and safely are the products integrated, then recovered and treated this year, and for generations to come.

I believe both lithium and lead battery systems will be further improved by innovative scientists and engineers, and I believe both will contribute to the dynamic growth of 48 volt hybrid systems, reducing emissions and costs, which is so important for our industry.

THANK YOU

Special thanks to EATON Corporation for hosting this workshop

Also, to Roland Berger Consultants who allowed us to integrate their forecast data for vehicle platform evolution.



A special thanks to the folks and Eaton for organizing this event, and also to Roland Berger's consultants who provided the forecast data.

A full copy of these slides and the remarks are also available.

Also, beyond the questions addressed today, we welcome any counsel or questions to us at Gridtential via the contacts noted below.