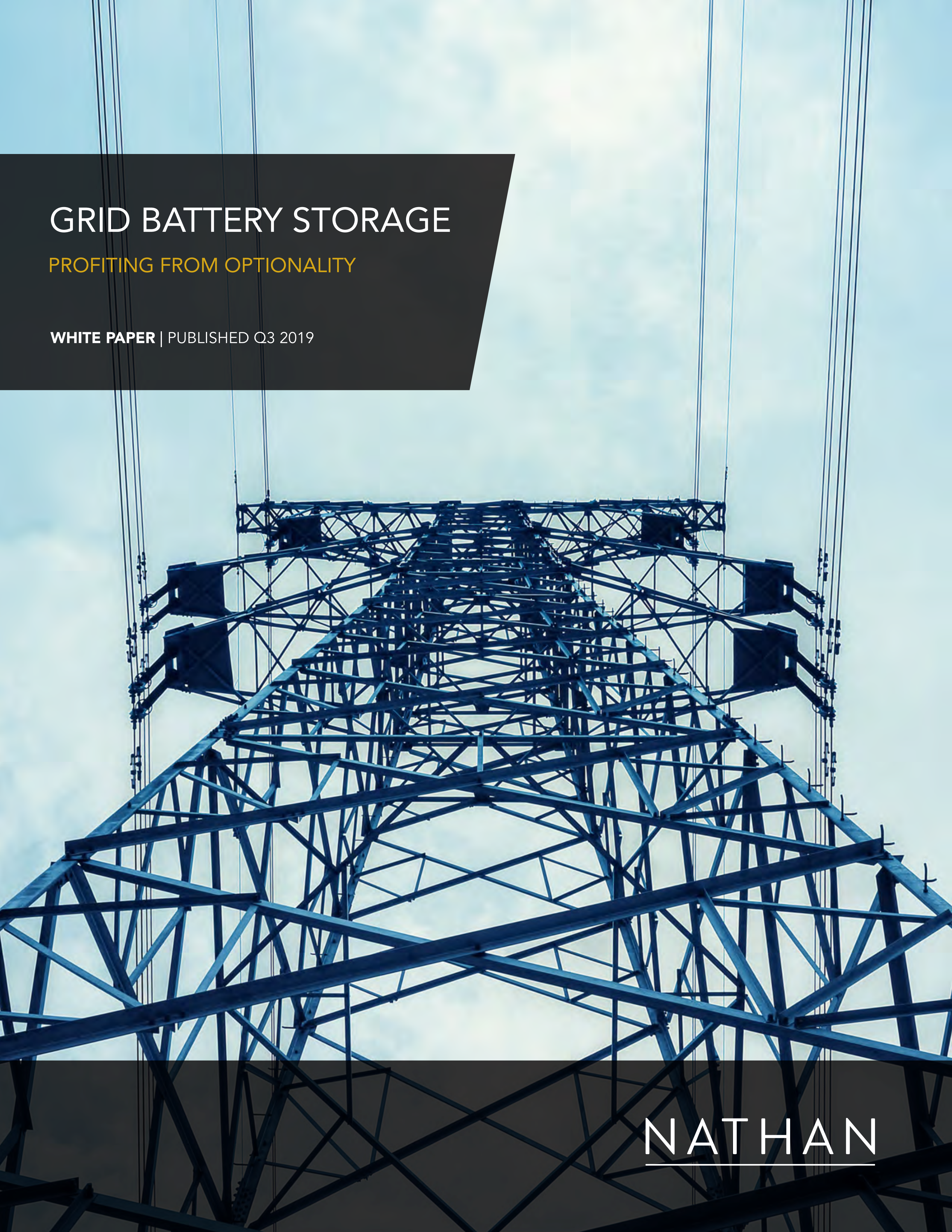

GRID BATTERY STORAGE

PROFITING FROM OPTIONALITY

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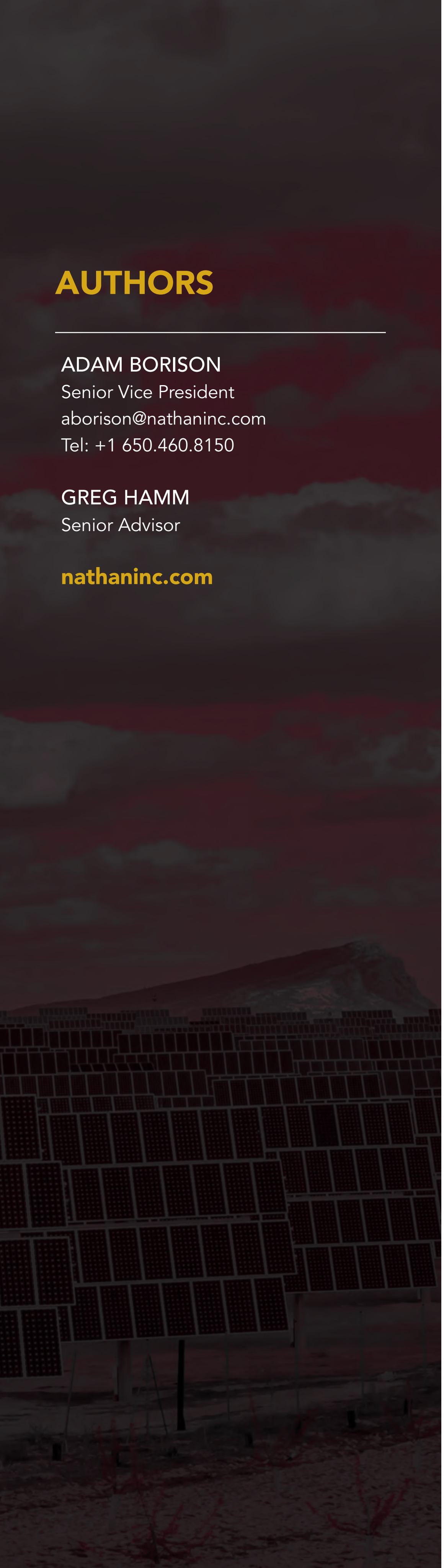

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ENERGY

GRID BATTERY STORAGE: PROFITING FROM OPTIONALITY

INTRODUCTION

Grid battery storage—both utility and commercial/industrial (C&I) scale—is all the rage. It is one of the hottest topics at many power conferences, and hardly a day goes by without an announcement of a new domestic or international project involving battery storage. In many ways, the situation is reminiscent of solar photovoltaics (PV) a decade or more ago.

Listening to this buzz, it is easy to come away with the impression that grid battery storage has proven itself as a fundamental, economic "value add" to the power system. According to a recent PV Magazine article, for example, key industry analysts believe that storage "turned the corner last year" in the competition with fossil for many grid services.[1] In this "half full" view, we have already arrived.

At the same time, there are signs that grid battery storage remains a relatively small niche play. While costs have come down, they are still high. Performance by grid standards is still limited with short charging, discharging cycles. According to a recent Technology Review article on grid storage, for example, "batteries are far too expensive and don't last

1 Max Hall, *Storage set to come of age in the next five years*, PV Magazine, April 29, 2019.

nearly long enough to have a major role."[2] In this "half empty" view, not only have we not arrived but it may be many years—if ever—before we do.

Not surprisingly, these two very different perspectives lead to very different business models for potential market participants. Following the optimistic view, some are jumping into the grid storage business quickly and fully. There are several small to medium-sized firms with grid battery storage as their primary or only business. Following the pessimistic view, others are remaining on the sidelines. Many independent power producers and utilities have avoided the area almost entirely.

Each of these approaches has its own substantial risk either from over or under investing. Consequently, it is natural to ask if there is an alternative with a better risk-return profile. Fortunately, there is such an alternative. It is driven by the recognition that the future of battery storage is uncertain (the bad news) but that one can adopt a strategy for profiting from this uncertainty by learning and adapting as the future unfolds (the good news). This strategy can be referred to as "an option approach"—because like a financial option, the underlying principle is make a smaller investment that provides the right but not the obligation to make a larger investment…or not…with better information.

2 James Temple, *The $2.5 trillion reason we can't rely on batteries to clean up the grid*, Technology Review, July 27, 2018.

THE ROLE OF OPTIONALITY

One simple way of looking at the uncertainty surrounding the future large-scale economics of grid battery storage—outside of its more modest operational niche—is to consider the cost per kWh for purchasing the battery and a savings per kW-month from avoiding demand charges. The former represents technological uncertainty. The latter represents market uncertainty. Taking this simple view, one can construct a matrix that shows the savings or economic value of storage as a function of battery cost and demand charge.[3] See the figure below. Red indicates unfavorable economics, yellow neutral economics and green favorable economics.

Battery Cost ($/kWh)

Demand Charge ($/kW-month)	50	100	150	200	250	300	350
5	0	-5	-10	-15	-20	-25	-30
10	5	0	-5	-10	-15	-20	-25
15	10	5	0	-5	-10	-15	-20
20	15	10	5	0	-5	-10	-15
25	20	15	10	5	0	-5	-10
30	25	20	15	10	5	0	-5
35	30	25	20	15	10	5	0

The two blue arrows reflect the sense that the market is moving down and to the left over time. As is widely reported, battery costs have declined significantly and are projected by many to decline further. Bloomberg

3 Other similar matrices could be constructed with somewhat different axes, such as an X-axis with the per kW capital cost of 4-hour storage and a Y-axis with the maximum 4-hour TOU rate differential.

New Energy Finance, for example, shows a decline in 2018$ from over $1000/kWh in 2010 to less than $200/kWh in 2018, and projects a decline to less than $100/kWh within five years.[4] Other observers argue that, while the direction is clear, both the reported historical and projected figures are too low. At the same time, demand charges (or rate structures with similar effects such as time-of-use pricing) are becoming more widespread and more impactful. For example, between 2008 and 2019, PG&E's most common commercial/industrial demand charge more than doubled from less than $9/kW-month to more than $20/kW-month.[5]

Of course, while the historical trends are clear, we can't sure whether these trends will continue and, if so, at what pace. That is a fundamental business challenge.

This matrix provides a compact way of contrasting business strategies. Some, the optimists, appear to be willing to bet that the future is to the lower left—the green zone. Others, the pessimists, appear to be willing to bet that it is to the upper right—the red zone.

The critical question is what to do if we are willing to admit that we really don't know the future. Wouldn't it be best to craft a strategy that recognized that we don't actually know where we will end up in this matrix, and that preserved the flexibility to act appropriately as we learn more about how fast and where we are moving? That is the essence of the option approach. Two examples are described below showing how this option approach to business strategy has been successfully implemented in practice.

4 Logan Goldie-Scot, https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/, March 5, 2019.
5 https://www.pge.com/tariffs/electric.shtml, accessed June 29, 2019.

TECHNOLOGY OPTIONALITY

In the 1970's, offshore oil drilling was still in its infancy. Successful oil drilling had only occurred at modest depths. Some were optimistic about technology that would allow for deeper drilling; others were pessimistic. And still others, specifically Shell, were astute enough to recognize and take advantage of the technological uncertainty. Shell positioned itself for future technology change by acquiring leases in depths that could only be drilled given substantial technology improvement. To quote Shell itself:

> When Shell acquired Cognac in a lease sale, the prospect was far beyond the depths common for the industry at that time. A vessel to drill in more than 1,000 feet of water did not yet exist. Shell translated teamwork and innovation into history-making accomplishments. After Cognac, the American Society of Civil Engineers presented Shell with the Outstanding Civil Engineering Achievement, the first ever awarded to an energy company. By 1982, Cognac was producing 72,000 barrels of oil equivalent (boe) per day.[6]

Shell took advantage of technological uncertainty with an option approach that was appropriate for an uncertain and changing business environment.

While it may seem odd at first, an analogy can be drawn between offshore drilling then and battery storage now. Technology cost and performance are inadequate for the most profitable applications. Yet those limitations appear to be disappearing as the technology marches down the learning curve. Shell took advantage of a similar situation in the 1970's by acquiring prospects in depths that were undrillable. Is there an equivalent to a Shell business strategy for grid battery storage; that is, one that takes advantage of technological uncertainty?

6 Shell Global, *Shell Celebrates 40 Years of Deep-water Innovation*, October 15, 2018.

The answer is yes, particularly for in front of the meter utility-scale storage. The analogy here is clear—anticipating a reduction in cost and improvement in performance that makes grid battery storage economic where it currently is not.

In many jurisdictions in the United States and abroad, queues are already forming for the right to interconnect battery storage with the power grid. In some cases, the conditions are already favorable for battery storage. This is the obvious investment opportunity. In many cases, they are unfavorable. This is the less obvious—but potentially even more promising—investment opportunity. Getting a place in the interconnection queue where conditions are currently unfavorable but still evolving is a classic example of an option approach. It typically requires a moderate but not massive investment, and provides the right but not the obligation to invest further and profit if circumstances change.

This approach is not just an intriguing theoretical concept. It is a live practical strategy being adopted by a few forward-looking firms. Invenergy, a U.S. based international power developer, has apparently adopted this approach in Arizona. As Kris Zadlo, leader of Invenergy's storage efforts recently said:

> You want to strategically submit interconnection requests, and sometimes it takes time to go through the queue…When APS actually issued their [request for proposals], we already had an executed interconnection agreement for a storage facility within the Phoenix area, all ready and teed up to go…[7]

Other firms could profit from variations on this technology optionality strategy.

7 Julian Spector, *How Invenergy Quietly Became One of the Biggest Players in Grid Storage*, Greentech Media, April 19, 2019.

MARKET OPTIONALITY

In the 1970's, Southwest Airlines was a very small intrastate airline. By the 1980's, it had become the most profitable U.S. interstate airline while other airlines struggled just to break even. What happened? Through a mixture of luck and skill, Southwest was uniquely positioned to take advantage of market changes—particularly federal deregulation. It had established itself as an intrastate carrier in Texas. It had airplanes, pilots and the necessary infrastructure; it had even cleared substantial legal hurdles. With all this in place, Southwest was able to move with lightning speed when markets changed. To quote Henry Harteveldt, longtime travel industry consultant: "Southwest has succeeded to an enormous degree because they were the first to enter secondary markets and then sprawled like kudzu…"[8]

Again, while it may appear odd at first, there is an analogy between interstate air travel then and grid battery storage now. Market design and government regulation are in flux, and it is difficult to monetize many of the load-shifting and operational benefits of batteries. Is there an equivalent to the Southwest business strategy for batteries; that is, one that takes advantage of market uncertainty? The answer is yes, particularly for behind the meter C&I-scale storage. The analogy here is clear—anticipating a change in regulation and other market conditions that makes battery storage economic where it currently is not.

As in the technology case, the market optionality approach is more than an intriguing theoretical concept. It is a live practical strategy. Ørsted, a Denmark-based global energy developer, has adopted this approach in several countries including the UK, the US and Taiwan. Ørsted anticipates potential market as well as technological change. The market change includes shifts in regulation that better monetize the operational benefits of battery storage and shifts that incorporate large time of use differentials or demand charges that better monetize the load shifting benefits. Speaking of Ørsted's storage efforts, Julian Spector of Greentech Media noted:

> The wind giant's strategic expansion into energy storage is more about the future than the present… Early projects like these could evolve into more ambitious efforts… as battery prices fall or other long-duration storage technologies enter cost-effective commercial service. Market changes will also be crucial.[9]

Other firms could profit from variations on this market optionality strategy.

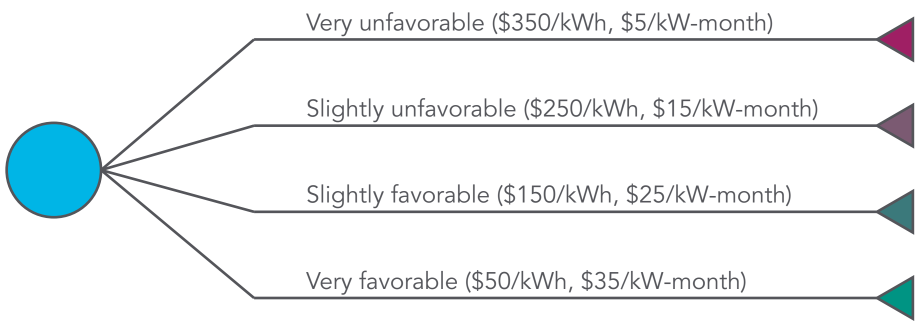
8 P.E. Moskowitz, *Original Disruptor Southwest Airlines Survives on Ruthless Business Savvy*, Skift, September 5, 2018.
9 Julian Spector, *Orsted Diversifies From Offshore Wind With 20MW UK Battery*, Greentech Media, January 10, 2019.

OPTIONALITY BUSINESS CASE

The examples above convey a strong message that the optionality approach to grid battery storage business strategy could have substantial value. But how much value and under precisely what conditions? An example based on real but disguised data may be helpful.

Consider a company looking to enter a power market where conditions are currently very unfavorable for grid battery storage, say at the upper right of our matrix facing a battery cost of $350/kWh and demand charge of $5/kW-month. The company sees signs of improvement both on the technology and market fronts, and wants to take advantage of this emerging opportunity. Unfortunately the rate of improvement is uncertain, so the company is unsure whether the next ten years will see the market roughly where it is now, or with improved conditions—potentially extending all the way to the lower left of our matrix and the $50/kWh, $35/kW-month cell. The figure below shows this uncertainty in the form of a decision tree chance node.

Decision Tree Chance Node: Long-Term Market



Suppose further that the company is considering three strategies—stay out, jump in, or an option approach.

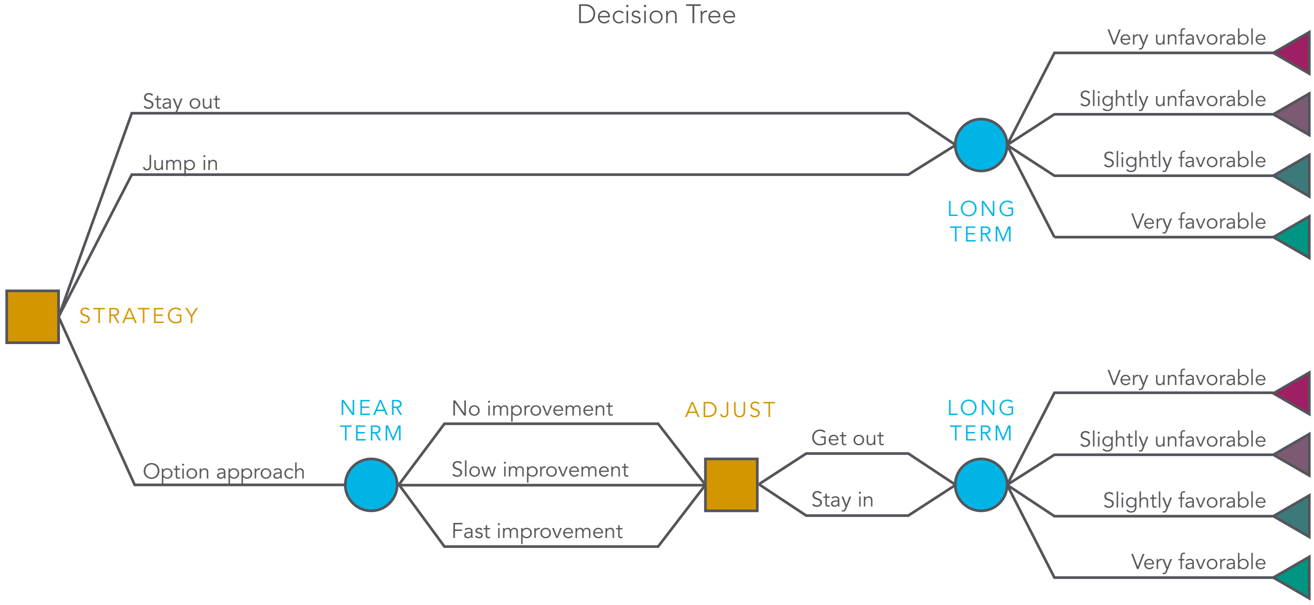
Assuming the company stays out, nothing is gained or lost. There is no up-front investment, and no risk and no return. If the market remains unfavorable, the company will be grateful it did not act. If the market turns favorable, it is too late to act and the company will regret losing an opportunity.

Assuming the company jumps in, there is a sizable up-front investment and a good chance of both substantial gain and loss. If the market turns favorable, the company is positioned to earn a good return. On the other hand, if the market remains unfavorable, it is too late to turn back and the company faces considerable losses.

Assuming the company takes the option approach and makes a smaller upfront investment, it has the flexibility to adjust based on better information and "tune" its larger investment to actual market conditions. If the market remains unfavorable, the company can exit with only a moderate loss. It can let the option expire. If the market turns favorable, the company is positioned to double down. It can exercise the option and act aggressively under the right conditions.

These strategic choices are shown below in the form of a decision tree.

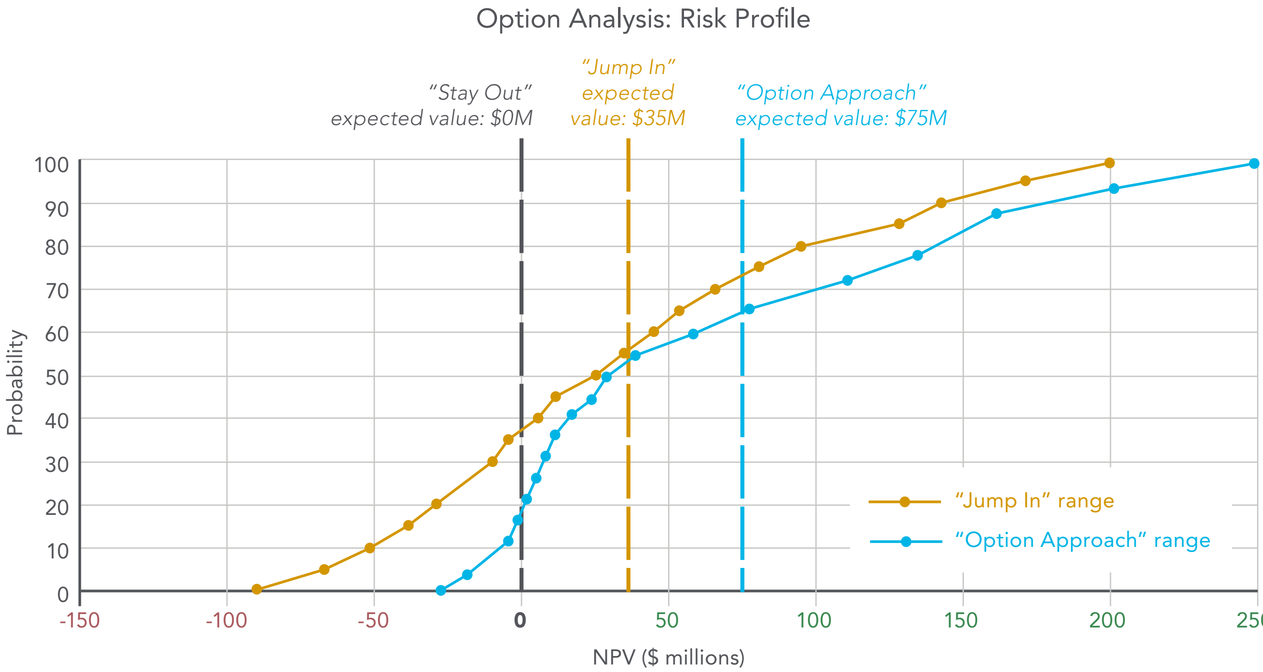
Decision Tree



The tree shows that—if the company chooses to stay out or jump in—it is committed and will face the risk of the long-term market. If the company chooses the option approach, it can learn in the near term about the rate of improvement and then adjust (Get out, Stay in) with better information.

Formalizing this situation in a decision tree enables us to evaluate the alternatives rigorously and make a quantitative business case for the right strategy.

The figure below shows the net present value (NPV) associated with each strategy, both the range and expected value.



"Stay out" is the base case. It requires no investment and has a zero NPV.

"Jump in" requires a $50 million upfront investment in hard assets—physical facilities. Given the substantial technology and market uncertainty, the outcome extends from a loss of $85 million to a gain of $200 million. The expected value if $35 million, and there is almost a 40% chance of a loss.

"The option approach" requires a $10 million upfront investment in soft assets—permits and agreements. Compared to "stay in," the potential loss has been reduced to $25 million and the potential gain has been increased to $250 million. The expected value has increased to $75 million, and there is now only a 15% chance of a loss.

The choice among these strategies depends heavily on decision-maker's risk attitude. If the company is extremely risk averse, it may just have to go with the "stay out" alternative. That is the only way to avoid the possibility of loss. If the company is willing to accept some risk, the "option approach" alternative is clearly preferred to "jump in." Technically-speaking, the "option approach" alternative stochastically dominates the "jump in" alternative, meaning that its risk profile is entirely to the right and its outcomes are better. This alternative produces $75 million more in value than staying out and $40 million more than jumping in.

This example illustrates that, correctly implemented, an option approach can create substantial value. In this case, the expected NPV is tens of millions higher than the two other alternatives.

CONCLUSION

It's an exciting and uncertain time for grid battery storage. The potential both for substantial success and substantial failure makes choosing the right business strategy difficult. Historical evidence and economic analysis both demonstrate that an option approach can provide market participants with the ideal balance of higher return and lower risk.

GRID BATTERY STORAGE AT NATHAN

Nathan Associates is a trusted advisor for both public and private organizations seeking to understand and shape the grid battery storage revolution.

We have unmatched experience across the globe facilitating market reforms and improving performance, guiding infrastructure investment and operation, and providing technical, economic and financial project support. In this work, Nathan combines deep technical knowledge of the power industry, broad qualifications across a range of key analytical and organizational disciplines, and a commitment to helping our clients affect meaningful positive change.

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ABOUT NATHAN

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