CENTER FOR HOUSTON'S FUTURE

Houston Low-Carbon Energy Summit

Program Summary

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EXECUTIVE SUMMARY

The Center for Houston's Future, in partnership with KPMG, held the Houston Low-Carbon Energy Summit on June 6, 2019, in Houston. An audience of more than 400 leaders from the energy industry heard from 35 national and local panelists and seven moderators.

In sum, we heard that decarbonization work is underway in many corners of the region. But expanding and accelerating that trend is urgent in the face of increased risks from climate change and the need to supply more energy across the globe.

Houston is the world's capital for energy and specifically oil and gas. As the world transforms to a low-carbon/carbon-neutral future, Houston faces a great threat to its position and a great opportunity to lead the world to success.

Houston can create new, high-value energy jobs as the region decarbonizes and we create low-carbon/carbon-neutral markets and products to export across the world.

Our industry has tremendous strengths to bring to bear in the effort to rewire the global energy system. We have technical and engineering wherewithal. We have the ability to execute large-scale projects and efforts. We have a history of innovation. We have a strong wind industry. And critically we have the beginnings of a coalition of the willing.

We must set ambitious goals for regional decarbonization and for creating low-carbon and carbon-neutral hubs. Leaders must step up to help drive the breakthroughs in technology and innovation, and culture shifts are required to take on climate change. The region must foster an innovation ecosystem that draws funding and new talent.

A variety of technologies and solutions are needed. Houston is the logical place to lead in any number of areas: CCUS (carbon capture, storage and utilization), hydrogen, methane leaks, new materials and fuels, trading, the circular economy and electrification. We shouldn't overlook natural solutions, energy efficiency and improved transportation, land-use and green space policies.

We heard repeatedly that collaboration and coordination is necessary among industry, university, community and government leaders. Success also requires the creation of a vision for decarbonizing the region and creating the low-carbon economy of the future. And once the vision is created, we need roadmaps for achieving success.

This is Houston's moment to lead or be left behind. If we aren't afraid to talk about climate change and take concrete actions, we can be viewed as the place to come to be part of the solution.

PANEL SUMMARIES

Energy Scenarios and Implications for the Gulf Coast: How is Houston positioned as a global energy capital in a carbon-constrained world?

Randolph Bell, Director, Atlantic Council · **Andy Steinhubl**, Principal, KPMG

Greater Houston faces substantial risk and opportunity during the energy transition.

Oil demand is expected to fall in the years ahead, though peak oil demand forecasts vary. Uncertainty around the timing can make planning difficult.

In any case, slowing oil industry growth will disproportionately affect Houston's regional economy. The region's super-charged growth — exceeding that of peer cities and the national economy over several decades — has been directly related to high-multiplier oil and gas jobs, and the related service, equipment, engineering and construction sectors.

Aside from the economic fallout of declining oil demand, Houston also faces climate-change induced infrastructure risks, including those from rising sea levels.

Houston must create other high-multiplier jobs to replace those tied to oil and gas. In turn, Houston has significant opportunity to do so across a range of sectors in a low-carbon economy: electrification of transportation, energy efficiency, renewables, data science, low-carbon fuels, new kinds of plastics and chemicals, circular economy and carbon capture. (Houston's health care sector offers the chance to provide non-energy high-multiplier jobs).

Houston as a city is already taking steps for an energy transition by encouraging decarbonization of buildings, encouraging electric vehicle use and adding bike lanes. European oil companies, including those with significant Houston-area operations, are investing in low-carbon options.

Regional decarbonization goals, government policies and industry action are needed. The road ahead will involve trade-offs: If the energy transition moves faster, Houston might face less severe weather risks. But immediate job risks from decarbonization could be greater.

At core, Houston has an opportunity to lead the energy transition. It has a clear need and clear opportunity to diversify from oil and gas and related jobs to other sectors, including those that will be part of a low-carbon future.

Visions of our Energy Future: What are energy companies doing to create a low-carbon economy?

Moderator: Regina Mayor, Global Sector Head, Energy & Natural Resources, KPMG

Jim Ajello, Former CFO, Hawaiian Electric Industries · **Karine Boissy-Rousseau**, President, Air Liquide Hydrogen Energy U.S. · **Mary Anne Brelinsky**, CEO, EDF Energy Services · **Scott Prochazka**, CEO, CenterPoint Energy · **Charlene Olivia Russell**, VP, Low-Carbon Strategies, Occidental Petroleum · **Cindy Yeilding**, Senior Vice President, BP

This panel included high-level energy executives from oil & gas, industrial gas and power companies. Decarbonization activity is underway in these sectors, with expectations that will follow via a variety of technologies. Success also requires cultural shifts inside companies and industry-wide collaboration. In Houston specifically, there is much opportunity to lead, but success will require coalitions, coordination and setting grand goals.

Oil executives stressed the importance of taking an all-of-the above approach on low-carbon and carbon-conversation technologies. Occidental, which leads in using CO2 for enhanced oil recovery, is aggressively focused on CCCUS (carbon capture storage and utilization). It has a unit focused solely on low-carbon strategies, including turning carbon into products such as plastics and fuels. BP, in the renewables sector for years, is reducing carbon associated with its own operations and is sharing its principles on methane reduction.

Air Liquide set significant climate objectives and is working both to decarbonize its operations and on low-carbon products to market. Senior executives set goals and analyzed carbon footprints of current projects. Strategies include renewables and

biogases, but the company believes hydrogen fuel and fuel cells are keys for decarbonization and developing new businesses.

CenterPoint is spending to curb methane emissions from its pipelines and moving to renewables as it seeks to reduce its carbon footprint. It is also offering customers energy-efficiency options and showcases smart meters as a breakthrough for energy efficiency.

EDF offers end-use customers in the U.S. greener energy (wind, solar). It also continues to aggressively decarbonize its footprint, relying on its nuclear portfolio and by increasing the amount of renewable generation it builds, owns and operates.

Hawaii has lessons to share regarding a large-scale conversion to renewable power and carbon-footprint reductions. The state revamped its entire regulatory model and had to solve grid-management problems.

Other catch-all points included: Markets are very different and may require different solutions; nuclear must be part of the conversation; transportation systems must change and EVs and hydrogen should play important parts; and energy supplies must be affordable, reliable and safe.

For Houston to lead in a low-carbon future, panel members agreed, companies - new and established – must work together. A portfolio of solutions, including new technologies and improvements in current technologies, will be required from start-ups and incumbents. The transition is so massive that it requires capital, people and infrastructure across sectors. Incumbents should review existing technology and resources with an eye to the transition, while start-ups should create new technologies and new types of business models. Individual companies and leaders must foster significant cultural changes – from junior engineers to the board rooms –

and create financial incentives. Those who aren't on board, shouldn't be there. Houston specific ideas include:

- Form an overarching coalition and/or specific coalitions (on transportation electrification) to gather individuals who have stakes in issues.
- Create a larger ecosystem that functions together.
- Set a grand challenge and own it: Net-Zero Carbon by 2035 or 2040.
- Link in universities.
- Take advantage of Houston as the natural place for a CCUS hub.

"Houston, it's the energy capital of the world," said Yeilding. "And, we want to stay that way."

Energy Transformations: Do we need an energy transition or transformation to maintain a 2C world?

Moderator: Ted Surrette, Global Head of Power & Utilities, KMPG Australia

Ned Harvey, Director, Rocky Mountain Institute · **Melanie Kenderdine**, Principal, Energy Futures Initiative · **Jason Klein**, U.S. Energy Transition Strategy, Shell

Broadly speaking, climate change is an existential threat and decarbonization requires different technologies, paths, energy mixes and innovations that will vary by country and by regions within countries. Kenderdine and Ernest Moniz are promoting their Green Real Deal, focused on addressing climate change in flexible and innovative ways. China's transition will be different from India's and Ohio's from that of Texas.

The Paris Agreement calls for both decarbonizing and providing energy to a billion people in developing countries. Doubling the amount of energy supplied to the world and reducing emissions to net zero in 50 years is a huge challenge requiring a global rewiring of the energy system and leadership by national and local governments and companies.

Not enough is currently being done to meet decarbonization goals, panelists agreed. The lack of a federal carbon price/tax policy is a huge gap. Technologies don't exist today to get to net-zero by 2050, meaning that technology breakthroughs and innovation are very important.

Consumers still aren't there yet as full-size pickup trucks continue to dominate. But there are positive stories in some states, including wind in Texas and solar in California. Climate, a topic not discussed much by either party in the last presidential

race, is being talked about by Democratic candidates. Tying executive compensation to carbon reduction goals is one way to spur action.

Natural gas must play a global role in the transition, but already faces opposition. The U.S., Klein said, isn't doing the industry any favors by deregulating methane emissions, making it easier for operators to be sloppier. The industry must be able to show gas operations are responsible and release few emissions so it can confirm that gas is a clear winner over coal.

Kenderdine presented observations from her work on California, including that the potential for the largest gains in transportation emissions reductions come from café standards and efficiency standards on the road; for industry, it's CCUS and for buildings, efficiency improvements. She noted efficiency improvements resulted in significantly more emissions reductions as electrification of buildings did.

In Houston, we have the capability and resources to come up with solutions and new ideas and must embrace the future – rather than be afraid of it. Panelists suggested a number of actions the region must take if we want to lead the energy transition.

That includes repurposing infrastructure for a low-carbon future and setting policies to enable the move. Infrastructure's current value has contributed to delays in addressing climate change.

Houston is synonymous with oil and gas, rather than energy. An oil and gas-only embrace must be abandoned in favor of energy of all kinds. The change must occur at all organizational levels and across sectors.

The region must attract venture capital and private equity investors. Significant investment in new technology should be a priority for Houston as well as a willingness for energy companies to work with tech and data companies. CEOs must stand up and acknowledge and address climate change. Companies must manage the potential for value destruction in their businesses by finding the potential for value creation.

Opportunity can be found in everything from CCUS to the circular economy to exporting low-carbon technology to growing markets demanding electricity such as India. Harvey also stressed that Houston could have significant opportunities in hydrogen-based or other new fuels for the aviation and marine shipping sectors. New uses for carbon shouldn't just be focused on EOR.

Can Houston think bolder? Instead of continuous highway construction, can Houston do a demonstration project that shows we can lead by embracing hydrogen fleets? Can we curb sprawl?

Critically, according to Klein, Houston must address its reputational problem by fixing the underlying issue. "It's not just a branding challenge. It's an actual challenge that we need to face."

Houston must attract talent, investment and innovation, Klein said. "If the people who want to do those things think that we don't even like to talk about climate change, they're not going to come here. They're going to go to San Francisco."

Keynote: Disruptive Energy Futures

Amory Lovins, Co-Founder and Chief Scientist, Rocky Mountain Institute

The world's energy system is moving from the Age of Carbon to the Age of Silicon, with Houston facing risk and opportunity. Technology is an enabler, but design and efficiency changes, renewables and transportation electrification are significant disruptors.

The oil, power and auto sectors all face fast disturbances. Across all sectors, the pace of innovation is often set by insurgents, instead of incumbents. Insurgents, then, have the opportunity to capture much of the growth. At the same time, today's Information Age informs, enables and organizes customers and consumers to make better and more efficient decisions.

Oil is already becoming uncompetitive, even at low prices. This is before it becomes unavailable at high prices. The power sector faces its own convergence of disruptions, including regulatory shifts, end-use efficiencies, changing customer preferences, distributed renewables, storage advancements and movement away from centralized systems.

Significant design and efficiency changes are required for a successful energy transition and will play key disruptor roles. Integrative design – designing components and systems to work together to reduce energy use – spurs the most efficiencies. (Example: Simple pipe and duct design changes can lead to huge efficiency gains). Since 1975, the most significant contributor to meeting energy demand growth has been efficiency.

Renewables are taking over the world's power markets, and costs keep decreasing. Solar power could, in theory, supply a fifth of the world's total primary energy needs in another eight years. Renewables, efficiency, demand flexibility and

storage combined can offer the equivalent of grid services traditionally provided by gas-fired power plants. At the same time, electric vehicle sales are rapidly rising.

By 2050, as outlined in Lovins' book Reinventing Fire, it's possible to triple U.S. energy efficiency and quintuple renewables. In that case, the U.S. would need no oil, coal or nuclear energy and at least one-third less natural gas. This revolution could be done with state and city policies and led by for-profit businesses.

Houston need not be left behind. It can lead in any number of ways, including by creating the technology and markets to take care of super-polluting methane emissions. This is a critical, immediate problem to solve and an opportunity for profits. The region could also jump into new materials, manufacturing and building efficiency.

Houston can help lead the world to a new energy future, rather than protect the old order. One that moves not at today's pace and expense of infrastructure, but at the speed and cost of design and technology.

Energy Innovation and Decarbonization: Is the pace of energy innovation sufficient to meet our goals for creating a low-carbon energy sector?

Moderator: Michael Hays, Global Renewables Head, KMPG

Wade Bitaraf, Founder, Sustainability and Energy, Plug and Play · **Charlie Bowser**, President, NetPower · **Mark Coalmer**, CCUS Projects Director, OGCI Climate Investments · **Tim Kopra**, Partner, Blue Bear Capital · **Varun Rai**, Executive Director, UT Energy Institute · **Sadas Shanker**, Professor, Harvard University

Innovation, in general, takes a long time. (Innovation is equal to invention times translation). Given the pressing need to deal with climate change, we don't have the luxury of time. We must find ways to move quickly. Components needed to succeed include: an embrace and commitment by corporate stakeholders, creation of a robust innovation ecosystem, partnerships among Houston, Silicon Valley and East Coast players; and participation by venture capital firms and universities.

Factors unique to Houston include obvious opportunities to focus on CCUS and hydrogen applications, and an energy skillset that can be repurposed for the challenge at hand.

Roadblocks to innovation, in general, include execution and access to capital. Some large failures come despite valid ideas and workable technology. Traditional forms of funding for energy and clean tech innovation are changing. The Department of Energy and foundations used to be the key funders. Now corporations fund innovation because if they don't, they will be shut out from market-changing disruptive technologies.

Innovation work is already happening in our region. Companies are already working on energy efficiency, methane reduction and CCUS, and the investor community is getting stronger.

Panelists highlighted low-carbon work they are doing, including activity underway in Greater Houston:

- Bowser, for example, detailed NetPower's demonstration power plant in LaPorte that captures 100 percent of its carbon emissions. The next phase of the joint venture project, funded by four companies, is commercial sales.
- Coalmer, based in Houston, is with the climate investments arm of the Oil & Gas Climate Initiative's arm and leads a team looking at CCUS projects around the world to invest in. OGCI also works on other areas including methane leak reduction. He also cited NetPower's project as an example of taking advantage of the region's skilled and technical workforce and continuing our history of innovation.
- Kopra is a partner in Blue Bear Capital, which has offices in Houston and Los Angeles. The venture fund focuses on data-driven tech companies in the energy supply chain. That includes data, machine learning, AI and IOT as it applies to oil, gas, wind, solar and energy storage. One advantage Houston has is "connectivity with the customers," or a built-in base of end-users.
- Bitaraf talked about why Plug and Play, a Silicon Valley start-up accelerator that recently opened an outpost in Houston, expanded its energy focus. In short, large corporations shopping for strategic start-up investments say sustainability is a key priority for both cost-allocation and investment decisions. In Houston, he aims both to connect start-ups around the world to local industry, government, nonprofit and academic stakeholders and to help build the local start-up ecosystem.

Much work remains to be done in Houston, starting with building a robust innovation ecosystem. That requires increased attention and buy-in from corporations, partnerships with Silicon Valley, more involvement from universities, and identification and filling of gaps. Slight changes in corporate mindsets can have significant impacts.

Also needed: more VC firms focused on the nexus of energy and new technology, passive investors, a focus on getting solutions and products to market, attention on data analytics and machine learning and more research on advanced materials.

There was also a call to get the word out that Houston is already acting and prepared to do more. We must help sell Houston as a place where people can come to be part of the solution. Success will breed more success.

Grand Challenges:

Roadmap to Zero Carbon in Oil and Gas

Moderator: Richard Stuebi, Future Energy Advisors

Greg Bean, Director, UH Gutierrez Energy Management Institute · **Tracy Hester**, UH Law Center · **Cate Hight**, Principal, Rocky Mountain Institute · **Jeanne-Mey Sun**, Executive, Baker Hughes, a GE Company

There is growing interest and activity in Greater Houston in deep carbonization for internal corporate and government operations and as an external-facing business strategy. Stakeholders interviewed before the summit and panel participants agreed much more must be done. Consensus doesn't yet exist on exactly what should be done, who should do it and who should tie it together. Coordination is needed. Most stakeholders agree CCUS must play a significant role for decarbonization to succeed and that Houston must become a CCUS hub.

Panelists detailed strategies at their organizations. Baker Hughes, Sun explained, has an internal corporate goal of net zero by 2050 with interim goals and is working to reduce scope 1, 2 and 3 emissions. It's also working with oil and gas customers to reduce their carbon footprints as they explore, produce and refine. The efforts include a range of solutions, including internally using more renewable-generated electricity; redesigning tools and equipment sold; and deploying new technology to detect and stop methane emissions. Baker Hughes is also working on carbon-capture and hydrogen technologies.

Hight focused on methane leaks and process emissions, stressing that the only way natural gas succeeds as a bridge fuel is if industry prioritizes fixing those. Addressing emissions is both a challenge and a business opportunity. Data tools exist to identify problem areas by individual operator. RMI is also working on a first-of-its-kind data

platform to track global emissions as well as working to connect producers and end-users to create markets for low-emission natural gas.

UH's Greg Bean turned the conversation to hydrogen, noting that half the world's hydrogen is produced from natural gas and that 90 percent of current hydrogen consumption is in chemical industry refining. That underscores how Houston is well positioned to advance hydrogen's role in a low-carbon future. Hydrogen can serve as a clean-energy storage medium, used as or in new transportation fuels and can potentially replace fossil fuels in industrial processes. It can also play a role in CCUS. Using hydrogen, Houston can decarbonize its industrial sector and export new, lower-carbon fuels elsewhere.

UH's Hester, an environmental attorney, offered cautionary thoughts, noting that CCUS is beset by heavy skepticism from some quarters, especially when it's used for enhanced oil recovery. Data is needed to persuade skeptics that EOR with CCUS results in a net-negative or carbon-neutral footprint over the oil's lifecycle.

CCUS is a critical first step for the energy transition, but the industry isn't even close to developing the technology or scale required to succeed. Any CCUS portfolio must also have a way to safely dispose of or reuse associated methane releases. Federal legislation to make CCUS financially viable, technologically achievable and societally acceptable is also important.

If all CCUS does is minimize the footprint of current emissions, it's a transitional strategy at best. We should think about CCUS with other emissions technologies or direct air capture, aiming to go beyond carbon-neutral to carbon-negative. CCUS should be part of an integrated, systematic approach across the energy value chain, from wellhead to transport and storage to chemical production and consumption.

UH, he noted, is looking at the problem not just as a technology issue but also as a design challenge: Design systems so they don't emit carbon in the first place, instead of sequestering later.

A broad to-do list for Houston to move to a low-carbon future includes setting internal goals and frameworks consistent with Paris; setting city- or region-wide goals; coordinating among stakeholders; integrating separate efforts; and taking a leading role in creating, producing and exporting low-carbon energy products and fuels.

Significant gaps are the lack of a grand vision and a roadmap with pathways to meet the vision. The vision should guide business, government and consumers. Metrics must be created to define and track success, and progress must be communicated to those in and out of Houston.

Grand Challenges:

Electrification as a Climate Mitigation Strategy

Moderator: Suzanne Bertin, Managing Director, Advanced Energy Economy

Elizabeth Brock, Director, CenterPoint Energy · **Dan Gabaldon**, Partner, Enovation artners · **Thomas McAndrews**, Founder, Enchanted Rock · **Matthew Sur**, Director, Calpin

Widespread electrification requires updated rules from the Texas Public Utility Commission.

The story around storage has been changing, but long-term storage issues remain unaddressed. Other power markets – California and PJM – have driven storage and demand response projects on the West and East Coasts via regulatory structures.

Microgrids are an option for combining both resiliency during severe weather events and increasing use of renewables. However, "negative" pricing prevents electrification from taking hold in the Permian.

For electric vehicles to take off in the region, Houston should get the message to automakers to send their EVs here. Giving consumers the chance to drive them could be a game changer. The EVolve Coalition has drafted recommendations and strategies around consumer and commercial use of EVs.

Grand Challenges:

Regional Solutions and Adaption to Climate Change

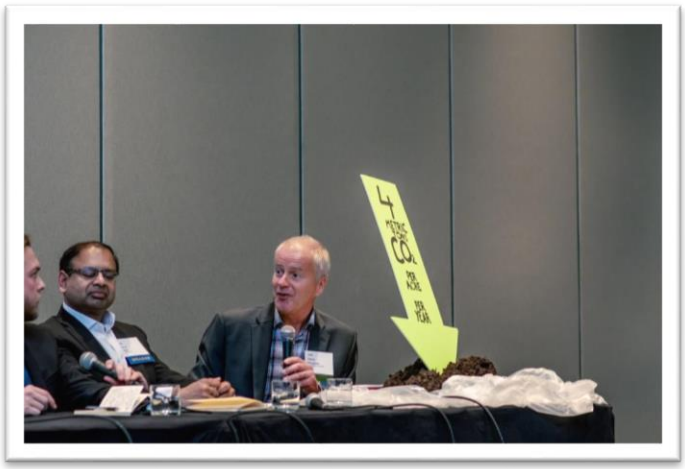
Moderator: Bob Zabors, Chairman, Cleantech Group

Marissa Aho, Chief Resilience Officer, City of Houston · **Josh Brooks**, Associate, Rocky Mountain Institutes · **Arun Mani**, Principal, KPMG · **Henk Mooiweer**, Executive Director, Soil Value Exchange

Aho, in her overview of the City of Houston's in-the-works resiliency strategy, stressed solving more than one problem at once. Resiliency strategies from around the world can be adapted with a "Houston spin."

The city looks at resiliency by scale: individual, neighborhood, bayou, city and regional. The strategy is organized around five key areas: equity and inclusion; building forward (around infrastructure and the economy); improving health and safety; housing and mobility; and living with and without water (planning for climate extremes.)

Houston should be open to unusual solutions that make economic sense. Mooiweer talked about his Soil Value Exchange company that works with ranchers to use soil and ranch grasslands to store carbon. A rancher can improve soil health, raise healthier cattle and store massive amounts of carbon. There is tremendous opportunity to work with nature rather than against nature and make money.



Other discussion threads included the need to acknowledge and manage financial risks tied to climate change; looking for natural solutions such as reclaiming land previously used for coal mining; and the importance of public-private partnerships, collaboration and leadership. Resilience is a collective problem that requires collective solutions.

Houston's Competitive Advantages in Creating a Low-Carbon Energy Sector

Moderator: Andy Steinhubl, Principal, KMPG

Lara Cottingham, Chief Sustainability Office, City of Houston · **Bob Harvey**, CEO, Greater Houston Partnership · **Chuck McConnell**, Executive Director, UH Center for Carbon Management, · **Mike Skelly**, Senior Advisor, Lazard · **Patrick Wood, III**, Wood3 Resources and Former FERC Chair

Houston has any number of strengths it can use to its advantage. We have talent, resources, experience and scale all concentrated in one place. We are good at big projects and have expertise in financing, engineering, construction and law. We are experienced at producing the world's energy and can use that template to incorporate different forms of energy into the mix.

We have deep experience leading significant change. The state, with many of Greater Houston companies taking the lead, restructured its power market. We have a strong, successful wind industry.

We also boast: a nascent electric-vehicle culture and significant green and park space with room for more. The city of Houston, which has a Climate Action Plan, is also the largest municipal user of renewable energy. The region is no longer afraid to talk about climate change and Hurricane Harvey gave some the impetus to talk about it even more.

We have a trading infrastructure that can easily expand to include low-carbon markets and products. The unique ecosystem of people started as oil and liquids traders, became natural gas traders and then added power and even sulfur dioxide credits.

Being the oil and gas capital – though it may sound contradictory – makes us a natural to lead the charge on climate change. As earlier panelists said, significant low-carbon work is already underway at energy companies across the region.

On the flip side, we don't have much of a solar industry and we do have "deeply unsustainable land-use policies," Skelly noted, adding that our region is defined by highways funded with public debt even as we barely fund other types of transportation. We essentially codify sprawl.

So, where do go from here? We need an overarching vision and we should be seen on the world stage as leading actors in the transition to a low-carbon/zero-carbon future. We must organize ourselves first in a visible, coordinated and committed way. In short, we must lead and be seen as leading, Harvey stressed.

Companies across the energy value chain must be involved. Universities must also play a big role. As we think about education, we should consider teaching consistent messages in elementary and high schools. Those students will play a role in shaping the future they want.

We should explore other "regional models of excellence" such as Singapore's port electrification or Los Angeles' public transportation investments. Overall, we must be more expansive in our thinking. It's not just an issue of cost for companies, but also an opportunity to make differentiated low-carbon products that fetch higher prices and generate profits.

This summit is a great jumping off point for needed regional activity. Perhaps years later it will be regarded as the catalyst for Houston to take charge of the issue, build coalitions and make it all happen.

Next Steps

Building on what we heard at the Summit, Center for Houston's Future will work with industry, community and government stakeholders to ensure the Houston region is set to lead the transition to a low-carbon world. The Center will harness the momentum clearly in evidence at the Summit as we help to crystalize regional goals for decarbonization and for building a low-carbon economy. We will work to create roadmaps that set out pathways for success.

Photos by Gavin Wegener for Center for Houston's Future

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