A Vision for a Houston’s Low Carbon Energy Future
About the Center for Houston’s Future

We bring business, government, and community stakeholders together to engage in fact-based strategic planning and collaboration on issues of great importance to the Houston region.

Our areas of focus:

- Strategic Initiatives
- Community Engagement
- Leadership
Vision for the Houston Energy Transition Initiative

Leverage Houston’s energy leadership to accelerate global solutions for a low-carbon future.

Tenets of the Vision:

Drive sustainable and equitable economic growth in the Greater Houston region through a portfolio of technology, policy, and market initiatives that embrace and create value from the world’s transition to low-carbon energy systems.

Delivering on this vision requires us to build upon our history of leadership in the energy and chemical industries, provide new opportunities to our people, and leverage our assets and existing expertise, while creating conditions to attract new and innovative talent and capital.

A successful effort would result in economic growth and positive impact on the environment, thereby placing Houston as the leading hub of energy and clean tech innovation.
Houston Has Many Distinctive Assets To Capture The Opportunity

Benchmarking Houston with other cities identified 5 core strengths:

- Large **engineering workforce** and vast energy experience
- Existing large scale **energy and industrial infrastructure**
- Significant **renewable generation capacity**
- Business friendly ecosystem that provides the **right environment for startups to scale**
- Largest US **port with global shipping connections**
## Action Is Planned Across Value Chains In Three Domains

1. **Jumpstart emerging sectors where Houston has a distinct advantage**
   - CCUS
     - Hydrogen
     - Circular economy – plastics
     - Battery manufacturing and energy storage solutions
   - **Relevant Industries:**
     - Renewables (Solar and Wind)
     - Renewable natural gas
     - Low-carbon LNG
     - Biofuels

2. **Attract and support companies in established “new energy” industries**
   - **Relevant Industries:**
     - Energy efficiency
     - Natural Gas and Oil
     - Petrochemicals
     - Carbon trading
     - Electric & fuel cell vehicles
     - Nature-based solutions
     - Advanced materials
     - Geothermal, and others

3. **Deploy cross-cutting initiatives to attract and grow companies in all Energy value-chains**
With decisive action to lead in the energy transition, Houston could gain 600k additional jobs.

Houston energy employment across scenarios, Thousand direct and indirect jobs

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Current</th>
<th>Business as Usual</th>
<th>Accelerated Transition</th>
<th>1.5C Pathway</th>
<th>Median wage</th>
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<td>2020</td>
<td>1,284</td>
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Total GDP gains could amount to $70 – 160Bn by 2050 with a concerted effort to attract high-paying new energy jobs with wages that are, on average, 28% higher than Texas median wage.

1. Includes direct and indirect jobs in hydrocarbon (e.g., oil and gas extraction, petroleum refining and petrochemicals) jobs using IMPLAN and EPI multipliers (e.g., supplier jobs, legal and financial service jobs)
4. 2019 median wage, USD/hr
5. 2050 dollars (assumes average inflation of 2%); assumes real GDP per capita remains stable at approximately $72.5k USD (2019 dollars); impact from direct, indirect, and induced new energy jobs
Houston Region: Becoming a Global Hydrogen Hub

Hydrogen industry growth can drive diversification needed to sustain Houston’s economic advantage.

In 2019, the Center for Houston’s Future (CHF) released an economic viability study that assessed Houston’s long-term economic outlook given the close ties between the oil and gas (O&G) sector and the region’s economic success. The study found that Houston had outperformed economically versus peer cities, and that this growth was driven primarily by the O&G sector. Looking at the impact of the 2014 oil price crash, the study found that 80,000 O&G related jobs lost in the fallout of the 2014 oil price decline were:

- high-multiplier jobs, or jobs that spur additional economic activity in the region, resulting in higher economic impact than other jobs.
- not replaced with commensurate jobs once the region’s job growth rebounded. (see Figures 1 and 2 below).

As a result, the study found that Houston’s growth story had shifted: Houston’s economy has since been growing slower than peer cities as new jobs added after the oil price rebound had lower multipliers, whereby resulting in slower GDP growth. Examples included temporary roles and construction jobs driven by Hurricane Harvey recovery, and hotel, restaurant and retail industry expansion resulting from the earlier high economic-growth period. As shown in Figures 1 and 2, the jobs lost during this time period had a 2.9x multiplier (meaning that they created 2.9x additional jobs) and the jobs gained had only a 1.66x multiplier.
Recent Media Coverage of CHF H2 Work

An “Earthshot” that will allow us to conquer climate change and lead the world in creating new markets can also allow us to claim a new title as the “Low-Carbon Energy Capital of the World.”
Reducing GHG emissions resulting from Houston’s vast industrial processes is a vast undertaking.

Notes: (1) Texas Gulf Coast refers to Houston area
Source: EIA, Barclays Research
The Houston area holds an anchor position in a world class H2 system, enabling rapid, scale access to new markets.

Existing hydrogen system in the Gulf Coast area

** TX Gulf Coast H2 system advantages**

- Over 900 miles H2 pipelines (56% of US; 32% of global)
- ~3.4MMt of H2 produced annually largely through steam methane reformation (34% of US; 8.5x Rotterdam)
- 48 H2 production plants
- World’s largest storage caverns for H2; adjacent to H2 network

** Existing H2 system could leverage in-place CCUS assets (e.g., Denbury pipeline) to readily add and scale CCUS to convert grey to blue H2**

Notes:
1. Houston MSA defined Austin, Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery and Waller counties
2. TX Gulf Coast includes a region from Corpus Christi, TX to Lake Charles, LA
3. Number of global H2 plants estimated by dividing global H2 production by US avg. production per H2 plant (52k tons H2 / year)

Source: H2Tools; USDOT PHMSA - National Pipeline Mapping System; Seeking Alpha; Office of US Energy Efficiency & Renewable Energy; Hydrogen Europe
ERCOT Leads in Non-Carbon Electricity Generation

Non-Carbon Electric Power Sector Generation
Billion KWh

Source: EIA, State Energy Data Systems and EIA calculations made for this analysis
Decarbonization is catalyzing rapid H2 market expansion, and strategies are emerging to capture the opportunity.

**Localized Drivers**
- Goals: 2050 net zero or similar
- Funding: Carbon fees or other
- Leverageable assets (blue)
  - H2 system
  - At-scale CCUS hub
- Leverageable assets (green)
  - Geologic storage
  - Low power prices

**Cross cutting Enablers**
- Cost and supply chain improvements
  - Electrolyzers
  - Renewables
- H2 and renewable synergies

Source: Barclays, HSBC, Hydrogen Council
Cost and technology advances expected for blue and green, though greater gains required for green to be competitive

Current Houston blue and green H2 production costs

- **Potential improvements for blue**
  - Continued improvements in CCUS cost and technology
  - Policy instituted to support CCUS adoption
  - Retaining low methane cost

- **Potential improvements for green**
  - Electrolyzer cost and technology materially improve
  - Substantial renewables penetration drives ubiquitous low price power
  - Policy and investor sentiment favor green H2

Notes: (1) Capacity factor of 38% represents extent of 2019 “low price” hours in Houston

Sources: S&P Platts
New markets were prioritized based on relative adoption barriers (or advantages) and emissions impacts.

**Initial prioritization of H2 markets**

- **Adoption barriers**
  - Incremental infrastructure
  - Competitive fuel / solution

- **Emissions impact**

  “We see heavy hauling of freight as kind of like an anchor tenant in the hydrogen shopping mall.”
  - Program Lead, Canadian Energy Systems Initiative

“Notes: (1) Access to CA Transportation / LCFS via addressed in Expand phase; (2) Seasonal / long duration storage addressed as part of green H2 chain
Sources: S&P Platts”
Introducing ... H2Houston Hub – A Global Hydrogen Hub

Vision for a Global H2 Hub

- Anchor local and national heavy transportation markets
- Exporter, market maker
- Decarbonize industrial process heat and power
- Leverage captured CO2 for EOR
- Focuses carbon intensity for all sources of hydrogen
- Seeks to lower H2 production costs and build massive scale at an accelerated pace (2030 time frame)
- Creates opportunities for early deployment for low carbon hydrogen applications through pilot projects
- Integrates the innovation energy ecosystem to create new innovation opportunities and establishes a test bed for new applications
- Develops a new industry base that leverages Houston’s existing assets and skills