NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Early Station Costs Questionnaire

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Market Readiness Workshop

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Questionnaire Goals

- The Early Station Costs questionnaire provides an anonymous mechanism for organizations with direct experience with hydrogen station costs to provide feedback on current costs, near-term costs, economies of scale, and R&D priorities.
- This feedback serves the hydrogen community and government agencies by increasing awareness of the status of refueling infrastructure costs

Questions for Market Readiness Workshop Attendees

- Are these questions the right ones to be asking?
- How can we improve this questionnaire to provide more useful information to government agencies, hydrogen supplier/auto companies and potential investors?

Questionnaire Development and Execution

Maintain anonymity

- Questionnaire will be fielded electronically by an independent third party, IDC Energy Insights
- IDC will establish anonymous means of communication and interaction with respondents, similar to “clean room”
- Critical mass of responses required for reporting

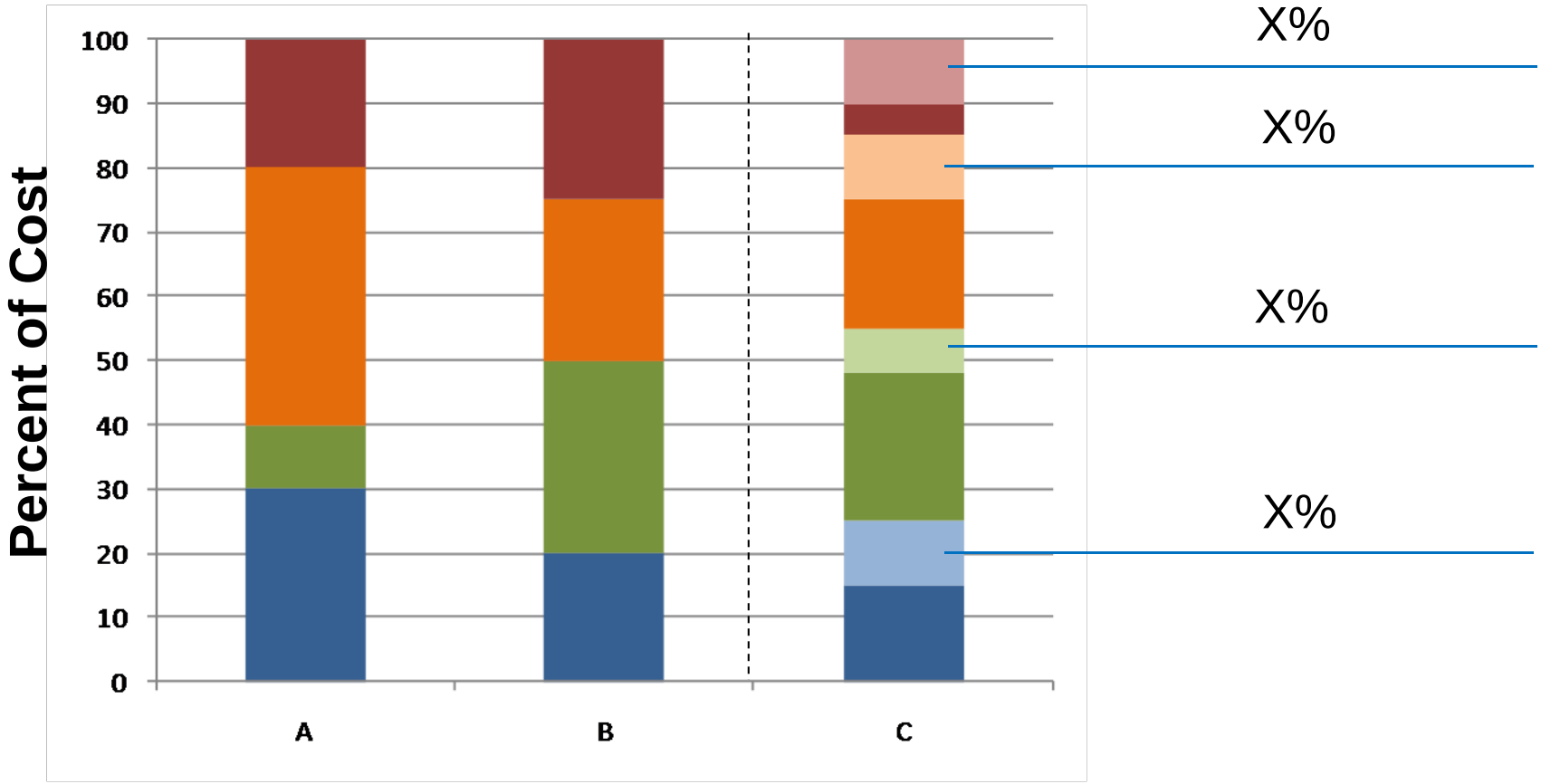
Engage stakeholders in development

- Preliminary discussions with CaFCP working group
- The Beta version in Excel will be available for review by key stakeholders (at DOE discretion)
- Revisions proposed by workshop attendees and Beta version reviewers will be collected and synthesized

Design: Phased Approach

- First round will be for System Integrating stakeholders
- Second round for component suppliers

Cost reductions will be quantified on a cost-component level (examples with 4 components below)

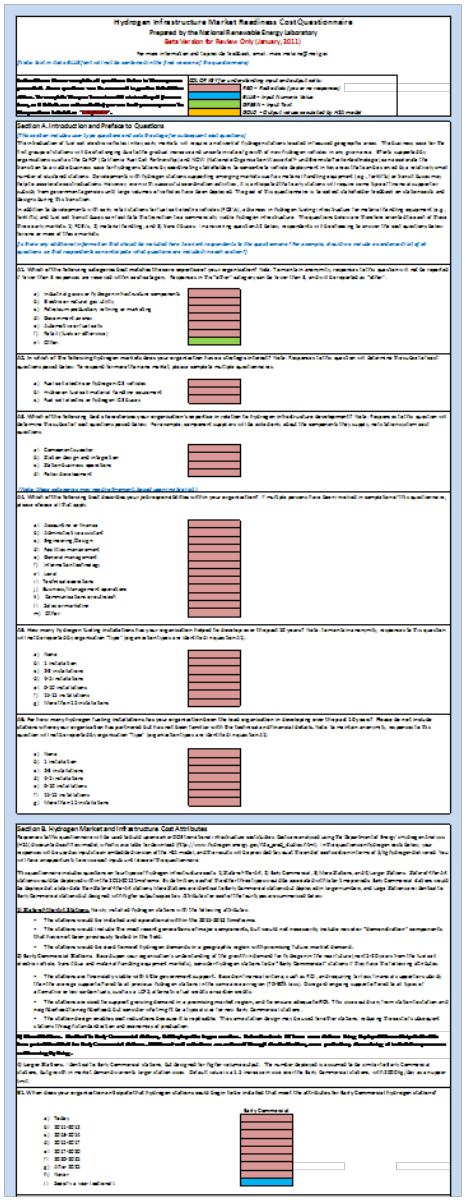


- A and B are distinct stations/pathways, C shows reductions for a particular pathway
- Cost reductions can be due to multiple factors

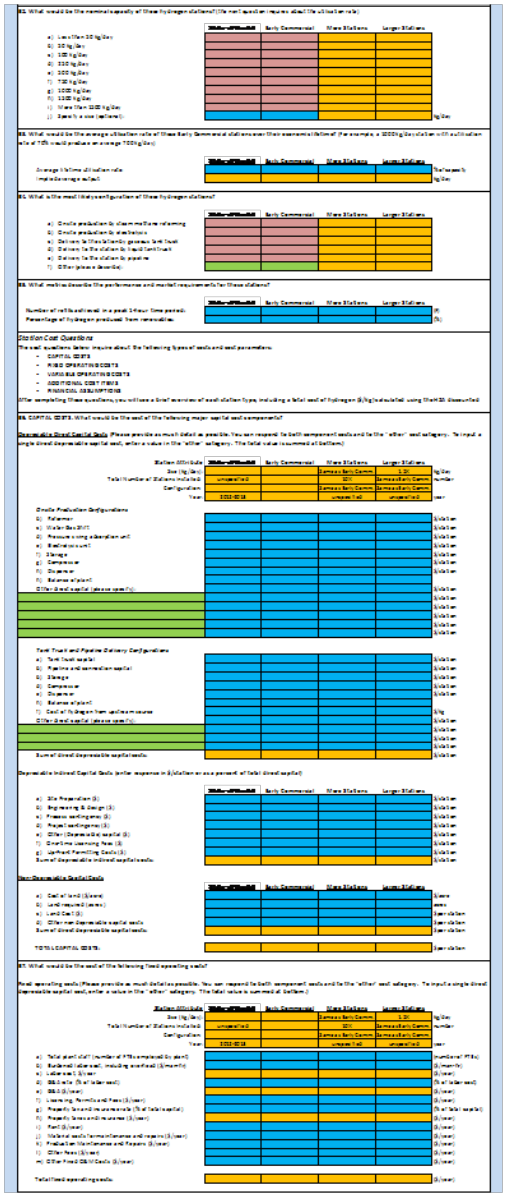
Beta version is in Excel: 3 Sections, 15 questions

Preface

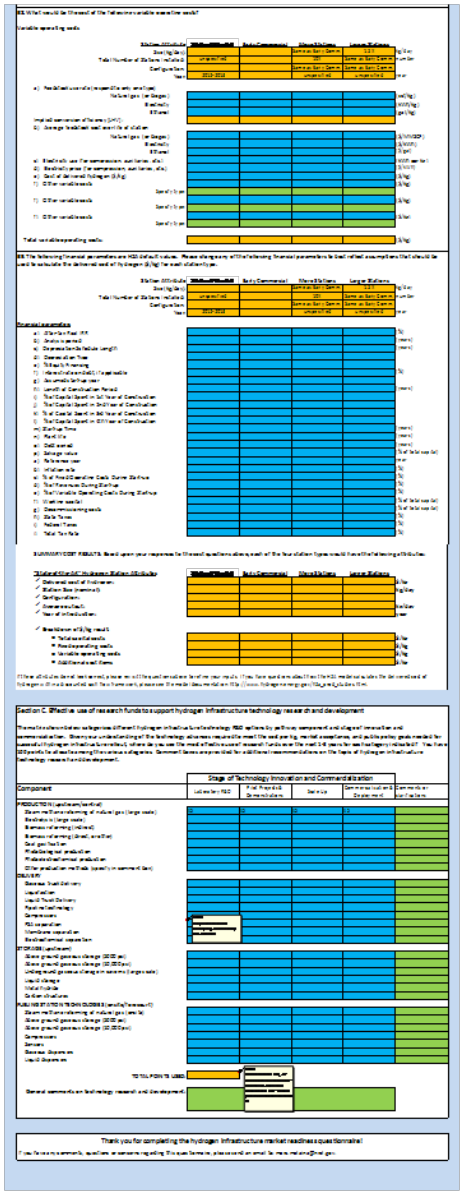
A. Intro Questions



B. Cost Questions



C. R&D



Section A. Introduction and Preface to Questions

A1. Which of the following categories best matches the core expertise of your organization? Note: To maintain anonymity, responses to this question will not be reported if fewer than 3 responses are received within each category. Responses in the "other" category can be fewer than 3, and will be reported as "other".

A2. In which of the following hydrogen markets does your organization have a strategic interest? To respond distinctly for more than one market, please complete multiple questionnaires.

A3. Which of the following best characterizes your organization's expertise in relation to hydrogen infrastructure development?

a) Component supplier

b) Station design and integration

c) Station business operations

d) Policy development

A5. How many hydrogen fueling installations has your organization helped to develop over the past 10 years? Note: to maintain anonymity, responses to this question will not be reported by organization "type" (organization types are identified in question A1).

Section B. Hydrogen Market and Infrastructure Cost Attributes

This questionnaire includes questions on four types of hydrogen infrastructure costs:

1) State-of-the-Art
2) Early Commercial
3) More Stations
4) Larger Stations

State-of-the-Art stations would be deployed within the 2011-2012 timeframe. By definition, each of the other three types would be associated with later time periods:

- Early Commercial stations would be deployed at a later date than State-of-the-Art stations
- More Stations are identical to Early Commercial stations but deployed in larger numbers
- Large Stations are identical to Early Commercial stations but designed with higher output capacities.

State-of-the-Art Stations

1) State-of-the-Art Stations

Newly installed hydrogen stations with the following attributes:

- The stations would be installed and operational within the 2011-2012 timeframe.
- The stations would include the most recent generations of major components, but would not necessarily include novel or “demonstration” components that have not been previously tested in the field.
- The stations would be sized to meet hydrogen demands in a geographic region with promising future market demand.

Early Commercial

2) Early Commercial Stations. Based upon your organization's understanding of the growth in demand for hydrogen in the near future (next 5-20 years from the fuel cell electric vehicle, transit bus and material handling equipment markets), consider hydrogen stations to be **"Early Commercial"** stations if they have the following attributes:

- **The stations are financially viable with little government support.** Based on financial criteria, such as ROI, and requiring far less financial support or subsidy than the average support offered to all previous hydrogen stations in the same area or region (70-90% less). Disregard ongoing support offered to all types of alternative or low carbon fuels, such as a LCFS, alternative fuel credits or carbon credits.
- **The stations are sized to support growing demand in a promising market region, and to ensure adequate ROI.** This size could vary from station to station and neighborhood to neighborhood, but consider what might be a typical size for new Early Commercial stations. ·
- **The station design enables cost reductions because it is replicable.** The same station design may be used for other stations, reducing the cost of subsequent stations through standardization and economies of production.

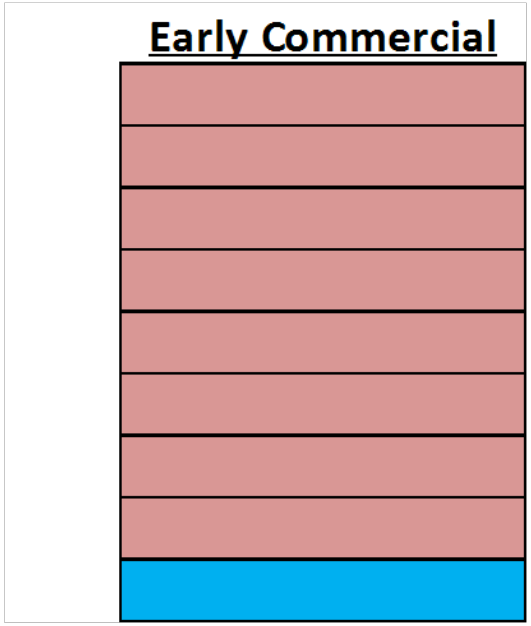
More and Larger

3) More Stations. Identical to Early Commercial stations, but deployed in larger numbers. Default value is 10 times more stations being deployed than anticipated in the time period identified for Early Commercial stations. Additional cost reductions are achieved through standardization, mass production, streamlining of installation processes and learning by doing.

4) Larger Stations. Identical to Early Commercial stations, but designed for higher volume output. The number deployed is assumed to be similar to Early Commercial stations, but growth in market demand warrants larger station sizes. Default value is a 1.5 increase in size over the Early Commercial stations, with 2000 kg/day as an upper limit.

B1. When does your organization anticipate that hydrogen stations could begin to be installed that meet the attributes for Early Commercial hydrogen stations?

a) Today
b) 2011-2012
c) 2013-2014
d) 2015-2017
e) 2017-2020
f) 2020-2025
g) After 2025
h) Never
i) Specify a year (optional):



COLOR KEY for understanding input and output cells:

RED = Radio dials (yes or no responses)
BLUE = Input Numeric Value
GREEN = Input Text
GOLD = Output values caculated by H2A

B2. What would be the nominal capacity of these hydrogen stations? (the next question inquires about the utilization rate)

	State-of-the-Art	Early Commercial	More Stations	Larger Stations
a) Less than 50 kg/day				
b) 50 kg/day				
c) 100 kg/day				
d) 250 kg/day				
e) 500 kg/day				
f) 750 kg/day				
g) 1000 kg/day				
h) 1500 kg/day				
i) More than 1500 kg/day				
j) Specify a size (optional):				

B3. What would be the average utilization rate of these Early Commercial stations over their economic lifetime? (For example, a 1000 kg/day station with a utilization rate of 70% would produce on average 700 kg/day)

	State-of-the-Art	Early Commercial	More Stations	Larger Stations	
Average lifetime utilization rate:					% of capacity
Implied average output:					kg/day

B4. What is the most likely configuration of these hydrogen stations?

	State-of-the-Art	Early Commercial	More Stations	Larger Stations
a) Onsite production by steam methane reforming				
b) Onsite production by electrolysis				
c) Delivery to the station by gaseous tank truck				
d) Delivery to the station by liquid tank truck				
e) Delivery to the station by pipeline				
f) Other (please describe):				

B5. What metrics describe the performance and market requirements for these stations?

Number of refills achieved in a peak 1-hour time period:

Percentage of hydrogen produced from renewables:

State-of-the-Art	Early Commercial	More Stations	Larger Stations	
				(#)
				(%)

Station Cost Questions

The cost questions below inquire about the following types of costs and cost parameters:

CAPITAL COSTS
FIXED OPERATING COSTS
VARIABLE OPERATING COSTS
ADDITIONAL COST ITEMS
FINANCIAL ASSUMPTIONS

Station Attribute	State-of-the-Art	Early Commercial	More Stations	Larger Stations	
Size (kg/day):			Same as Early Comm.	1.5X	kg/day
Total Number of Stations Installed:	unspecified		10X	Same as Early Comm.	number
Configuration:			Same as Early Comm.	Same as Early Comm.	
Year:	2012-2013		unspecified	unspecified	year

Example of detailed H2A cost tables

Depreciable Indirect Capital Costs (enter response in $/station)

	State-of-the-Art	Early Commercial	More Stations	Larger Stations	
a) Site Preparation ($)					$/station
b) Engineering & design ($)					$/station
c) Process contingency ($)					$/station
d) Project contingency ($)					$/station
e) Other (Depreciable) capital ($)					$/station
f) One-time Licensing Fees ($)					$/station
g) Up-Front Permitting Costs ($)					$/station
Sum of depreciable indirect capital costs:					$/station

SUMMARY COST RESULTS: Based upon your responses to the cost questions above, each of the four station types would have the following attributes:

"State-of-the-Art" Hydrogen Station Attributes

- ✓ Delivered cost of hydrogen:
- ✓ Station Size (nominal):
- ✓ Configuration:
- ✓ Average output:
- ✓ Year of introduction:

- ✓ Breakdown of $/kg result:
  - ○ Total capital costs
  - ○ Fixed operating costs
  - ○ Variable operating costs
  - ○ Additional cost items

State-of-the-Art	Early Commercial	More Stations	Larger Stations	
				$/kg
				kg/day
				kg/day
				year
				$/kg
				$/kg
				$/kg
				$/kg

Respondents can see how revisions influence $/kg results

Section C. Effective use of research funds to support hydrogen infrastructure technology research and development

The matrix shown below categorizes different hydrogen infrastructure technology R&D options by pathway component and stage of innovation and commercialization. Given your understanding of the technology advances required to meet the cost per kg, market acceptance, and public policy goals needed for successful hydrogen infrastructure rollout, where do you see the most effective use of research funds over the next 1-3 years for each category indicated? You have 100 points to allocate among the various categories. Comment boxes are provided for additional recommendations on the topic of hydrogen infrastructure technology research and development.

Component	Stage of Technology Innovation and Commercialization				
	Laboratory R&D	Pilot Projects & Demonstrations	Scale Up	Commercialization & Deployment	Comments or clarifications
PRODUCTION (upstream/central)					
Steam methane reforming of natural gas (large scale)	45	45	45	45	
Electrolysis (large scale)					
Biomass reforming (indirect)					
Biomass reforming (direct, or other)					
Coal gasification					
Photobiological production					
Photoelectrochemical production					
Other production methods (specify in comment box)					
DELIVERY					
Gaseous truck delivery					
Liquefaction					
Liquid Truck Delivery					
Pipeline technology					
Compressors					
PSA separation					
Membrane separation					
Electrochemical separation					
STORAGE (upstream)					
Above ground gaseous storage (5000 psi)					
Above ground gaseous storage (10,000 psi)					
Underground gaseous storage in caverns (large scale)					
Liquid storage					
Metal hydride					
Carbon structures					
FUELING STATION TECHNOLOGIES (onsite/forecourt)					
Steam methane reforming of natural gas (onsite)					
Above ground gaseous storage (5000 psi)					
Above ground gaseous storage (10,000 psi)					
Compressors					
Sensors					
Gaseous dispensers					
Liquid dispensers					
TOTAL POINTS USED:					
General comments on technology research and development:					

Questions?

Comments can be send to: marc.melaina@nrel.gov