

# ***The LAX Hydrogen Fueling Station Development: A Historical, Technical, and Economic Overview with a Discussion of the Obstacles Encountered and Lessons Learned***

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March, 2004

## **Introduction**

The SCAQMD has been funding the development of hydrogen fueling stations in the South Coast Air Basin since 2001 for the purpose of creating a refueling infrastructure for hydrogen vehicles. One of the first stations from this effort to begin dispensing hydrogen fuel will be the LAX Hydrogen Station. BP and Praxair are currently leading this project with additional DOE funding.

This report first provides the background and history of the station's development from its inception through December 2003. Next, it presents a technical and economic overview of the station by providing a detailed description of the station's major components and showing the various costs incurred throughout the duration of the project. The report also presents the anticipated timeline of the project at several points in time to show how it changed throughout the duration of the project. The report then discusses the obstacles encountered by the developers that caused both timing delays and cost increases. Finally, through a synthesis of the above information and through interviews with the station's developers, a list of lessons-learned from this project is presented.

The overall purpose of this report will be to serve as a tool for future station developers to learn from the past. This report will provide guidance on what to do and what not to do when building a hydrogen station.

## **Method**

To accomplish this, I have reviewed a collection of documents on this project provided by the SCAQMD. This includes emails, letters, reports, presentations, and other items that reveal information about the project from its inception to the present time. I have also interviewed key personnel from most of the organizations involved in the project to obtain their perspective and any documents they may have regarding the project. Drafts of this report have been reviewed by individuals from some of these organizations for comment and feedback.

## **I. HISTORICAL OVERVIEW**

### **Station Background**

The station, located on LAX Airport property at 7450 World Way West, Los Angeles, will produce hydrogen from water and grid electricity using a Stuart/Hydrogen Systems H<sub>2</sub> IGEN 15 Electrolyzer. The hydrogen will be compressed and stored in ASME steel tanks located on the roof of the unoccupied facility. Praxair will provide a tube trailer to deliver hydrogen to the site if needed (e.g., if the electrolyzer is down or hydrogen demand exceeds supply/on-site

production.) The station will be designed by BP to be compatible with retail facility designs. The station will be accessible to both airport personnel and the general public under certain provisions,<sup>1</sup>.

The station is being developed by Praxair and BP with funding contributions from the SCAQMD, CARB, and the DOE (via the CEC) and real estate contributions from Los Angeles World Airport (LAWA).

**Project Organizations and People**

The following table shows the people and organizations who are or were at one point involved with the project.

*Table 1: Project Human Resources*

<b>Organization</b>	<b>Name</b>	<b>Role</b>	<b>Status</b>
SCAQMD	Gary Dixon	Contract Manager	
SCAQMD	Chung Liu	Director, Technology Advancement Office	
SCAQMD	Ranji George	Former Contract Manager	left project
Praxair	Aaron Rachlin	Project Manager	
Praxair	Jeff Richards	Regional Director of Sales and Business Development	
Praxair	Ed Danieli	Director, Clean Fuels	
Los Angeles World Airport	Roger Johnson	Dep. Exec. Dir. Of Environmental Affairs	left airport
Los Angeles World Airport	Lynn Mayo	LA city attorney	
Los Angeles World Airport	Richard Janisse	Dep. Exec. Dir. of Business Development	left airport
BP	Mike Flaherty	Responsible for permitting & approvals, construction, and site control	
BP	Mike Jones	General Manager, Hydrogen	
BP	Lauren Segal	Director of hydrogen operations	left division
BP	Jim Uihlein		
California Energy Commission	Sandra Fromm/ Karen Shimada	Contract manager/Energy specialist	
City of Los Angeles	David Myers (Fire Marshal)	Permit approval	

<sup>1</sup> The public may use the station provided they are using it to fuel NHTSA certified hydrogen-powered vehicles, they have signed a fueling agreement with Praxair, and have been trained on the safe use of hydrogen at the LAX hydrogen fueling station facility.

Teledyne	Jeff Bortel	Electrolyzer supplier	no longer involved
DCH	Aaron Rachlin		now with Praxair, DCH no longer exists
Ford	Anthony Eggert	CaFCP Representative	no longer involved
State of California	Jane Harman	Congresswoman	No longer within her jurisdiction due to redistricting
State of California	Dan Wasserman	Staff to Jane Harman	Now working with CEC in San Francisco

### **Station History**

The station arose out of a Request for Proposal issued by the SCAQMD on October 20, 2000. The RFP was designed to solicit cost-shared proposals to design, develop, integrate, and install stand-alone hydrogen refueling stations in support of the early introduction of hydrogen fueled vehicles within the AQMD. Two proposals were selected out of the RFP process, one of which was a proposal by DCH to develop a hydrogen station at LAX airport using a Norsk-Hydro electrolyzer. \$351,000 was committed to this project out of SCAQMD's Clean Fuels Fund. Aaron Rachlin of DCH was chosen to be the project manager.

By September 2001, however, Norsk-Hydro decided not to participate in the project due to the uncertainty of additional funding sources. In the meantime, DCH had previously purchased (but had never taken delivery on) a Teledyne electrolyzer that was of adequate hydrogen production capacity for the project. During this time, Shell contemplated joining the project, but after one or two months of uncertainty, declined to participate. They felt the project was not in line with their business strategy.

In late 2001, Mr. Rachlin, secured commitments from the U.S. DOE's Hydrogen Program to obtain the necessary additional funding to complete the project using Teledyne's electrolyzer. The U.S.-made Teledyne Electrolyzer made it easier to secure U.S. DOE funding for the project. By February 2002, CARB agreed to contribute \$50,000 towards the station.

In the Spring of 2002, DCH was dropped from the project due to its precarious financial situation. Mr. Rachlin advanced the project on his own, under a newly formed company named H<sub>2</sub>Fuel, but the CEC wanted/required a larger (e.g., Fortune 500) company to be the prime contractor for the project's DOE funding since they were to administer it under the State Special Projects Program. Thus, Mr. Rachlin brought the project (and himself) to Praxair.

While Mr. Rachlin was in the process of bringing the project to Praxair (through Jeff Richards, Praxair's Director of Business Development for the Western Region), BP contacted Praxair to

inquire about partnering with Praxair on the project. BP's goal would be to help Praxair develop a station design that would be compatible with a traditional retail fueling station facility. Teledyne, instead of joining the project, purchased the unit back from DCH, leaving Praxair and BP free to choose the most suitable electrolysis supplier for the project.

Concurrently, Praxair began working with the CaFCP on fueling standards, interface requirements, flow rates, communicating with the CaFCP Vehicle Operations team. In the Fall of 2002, Ford indicated interest in getting involved in the project by meeting with LAWA and other potential fleet vehicle operators in the vicinity of LAX. By the Spring of 03 however, they reduced their involvement in the discussions when they decided to shift their hydrogen vehicle placement efforts in conjunction with the DOE Solicitation of September 2003.

In the Fall of 2002, the first signs of a contract emerged between the SCAQMD and Praxair<sup>2</sup>, though not without a few issues. There was initially some uncertainty in the contract about the BP/Praxair work split. The CEC required clarification on this issue in order to release their funding. Some concerns also arose about acquiring a negative declaration from CEQA (The California Environmental Quality Act), but this process is being completed following the submission of a Risk Assessment for the project to LAWA's Environmental Manager, who is coordinating the project's CEQA compliance efforts.

Praxair met with LAWA executives towards the end of 2002 regarding the lease of the airport's property for the station. There appeared to be no major hurdles or opposition pending a Final Risk Assessment analysis and final approval by BP of the location. The cooperation with LAWA was due in part to Roger Johnson, who was LAWA's champion for the project. Unfortunately for the project, however, Mr. Johnson left LAWA by late May 2003, before the lease agreement was finalized.

In January 03, Praxair and BP met with the LAWA people about siting. They begin discussing the possibility of installing composite storage tanks on the roof of the retail facility). Later that month, Hydrogen Systems (which was, near the same time, purchased by Stuart Energy Systems) was chosen as the electrolyzer provider.

Between February and April, Praxair and BP completed most of the design work for the station. In March, however, problems arose between Praxair and CEC in entering into a contractual relationship over a release of the U.S. DOE funds that were previously committed to the project (which the CEC was administering under the SEP – State Special Projects program). The CEC could not guarantee that Praxair would be reimbursed for hydrogen station building expenses incurred prior to the entering into a contractual relationship between Praxair and the CEC.

The permitting process began in May when the partners held the first Construction Approval Planning Meeting. By September, 95% of the permitting was accomplished by BP<sup>3</sup>. The permits could not be secured, however, until the lease agreement between Praxair and the airport was signed.

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<sup>2</sup> SCAQMD Statement of Work document

<sup>3</sup> Interview with Michael Flaherty, 12/03

In July 2003, more contract issues arose between several of the partners. Praxair needed to ensure the IP language in the AQMD contract did not conflict with the IP language in the CEC/DOE contract. This issue was resolved between Praxair's legal department and the AQMD's legal department. Furthermore, the CEC required clarification on the funding levels from LAWA and BP regarding in-kind contributions and was unclear about BP's contribution to the project vs. Praxair's contribution. There appeared to be some overlap.<sup>4</sup>

The biggest contract challenges arose in August 2003 between LAWA and Praxair regarding the indemnification clause in their lease agreement. LAWA wanted complete indemnification in case of an accident at the station or with the vehicles that LAWA filled at the station and operated. LAWA's Director of Business Development stated that since that the airport did not have much to gain from the project, while Praxair did, Praxair should carry most of the risk.<sup>5</sup> Praxair, however, was reluctant to accept responsibility for hydrogen fueled vehicles once they left the station primarily because risks such as failure of hydrogen vehicle fueling systems/components and negligent driving by the airport employees were outside of Praxair's control once the vehicles left the station. Progress on the station could not move forward until this issue was settled because the permits required to initiate construction could not be acquired without a signed lease. This resolution was further hampered by the difficulty of arranging an in-person meeting between the two parties.

Between November and April, major obstacles were finally surmounted. Praxair, BP and LAWA were finally able to conduct an in-person meeting, at which they made considerable headway on contract negotiations. On April 5, the lease agreement was approved by the LAWA Board, of Airport Commissioners and signed.<sup>6</sup> As of mid April, Praxair estimates that ground-breaking will commence by late May, and station commissioning will occur in late September.

### **Applications**

The station will initially serve a fleet of FCVs. Hydrogen ICE vehicles placed in the surrounding areas resulting from the recent "5 Cities" RFP will also be expected to fuel here since the site will be accessible to the public.

The station will also serve as a model to show future stakeholders a real commercial hydrogen fueling station. This will be important as more commercial stations are proposed for construction near public places since they will require the approval from the impacted communities.

### **Special Features**

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<sup>4</sup> See letter from Karen Shimada on 7/30/03

<sup>5</sup> Email correspondence, 10/3/03

<sup>6</sup> Press Release, "Los Angeles Airport to Have Nation's First Commercial Compressed Hydrogen Fueling Demonstration Station", April 5, 2004

This project is unique in that it will be one of the first commercial, public-accessible stations, with a station design to reflect this. It will look more like a regular gas station than traditional industrial-looking hydrogen stations (see photos in next section).

The station is also unique in that it is the first station in which the storage system will be placed on the roof of the retail facility. This minimizes the required footprint and eliminates tank visibility.

## II. TECHNICAL OVERVIEW

The following table describes the technical characteristics of the various components within the hydrogen fueling station.

*Table 2: Station Equipment Specifications*

<i>Hydrogen Generation</i>	This Station uses Stuart's IMET 1000/15/10, based on Stuart's recent acquisition of Vandenberg Hydrogen Systems' IMET (Inorganic Membrane Electrolysis Technology) cells. It has a total cell surface area of 1000 cm <sup>2</sup> ; a hydrogen production rate of 15 NCM/hr (1 kg/hr); and an output pressure of 10 bar. It consumes water at a rate of 11 gal/hr. <sup>7</sup>
<i>Electrolyzer auxiliary equipment</i>	The following systems are included with the electrolyzer: reverse osmosis water purification, electric power conditioning, cooling water system, gas electrolyte separator, gas coolers, gas demisters, gas dryer and purifier drier. The drier uses a thermally regenerated molecular sieve; the purifier uses a De-oxo system and filters. This equipment is provided by Stuart.
<i>Hydrogen Purification</i>	Hydrogen exits the electrolyzer and is purified in the integrated De-oxo vessel to remove oxygen. The hydrogen is dried in the regenerative molecular sieve gas drier. Final hydrogen characteristics are: 99.998% final purity <sup>8</sup> , atmospheric dew point : -60 (10.7 ppm), Oxygen: < 10 ppm, Nitrogen: < 12 ppm, Hydro carbons: Trace, CO/CO <sub>2</sub> : Trace, Sulfur: not detected
<i>Integrated unit</i>	The components described above are integrated into a single package. This dimensions of this unit are 6.0 x 2.4 x 2.6 m (L x W x H) The total weight of the system (in operation) is 2200 kg. The integrated unit uses approximately 43-50 kWh per kg of hydrogen produced. It requires 480 VAC, 3 phase electrical connection and 140 kW or power (peak).
<i>Hydrogen compressor</i>	Praxair will provide the station with a Hydro-Pac hydraulically-driven reciprocating compressor with an electric motor drive. The compressor receives hydrogen at 100 psig and raises its pressure to 6,500 psig.
<i>Compressed</i>	The hydrogen is stored in 4-18 ft. <sup>3</sup> /vessel water volume stainless steel

Comment [JW1]: Compressor Power??

<sup>7</sup> For more information visit the website at [http://www.stuartenergy.com/main\\_our\\_products.html](http://www.stuartenergy.com/main_our_products.html)

<sup>8</sup> Rachlin, 12/03. Stuart's website claims a final purity of 99.997%.

<i>hydrogen storage</i>	pressure vessels, providing a total of approximately 60 kg of storage at 6,600 psi. The tanks are arranged to provide cascade fueling (3 cascades). The total system weighs 20,000 lbs, which includes mounting equipment, valves, and piping. Praxair is supplying this equipment.
<i>Compressed hydrogen dispenser</i>	The station will dispense hydrogen using a FTI dispenser with 1 5,000-psi hose and nozzle at 31.1 slpm. The dispenser includes a card-lock system, data display, control panel, and Sherex nozzles. It is capable of providing CaFCP Type 1, 2, and 3 filling.
<i>Safety equipment and features</i>	The electrolyzer “features electrical connections that automatically ground the unit.” <sup>9</sup> It meets the following international codes and standards: PED, TUV, ASME, and CE.  The station will have active hydrogen leak detection, IR fire detection, various PRVs and fusible links, chain-link fence and barricade protection, hose breakaway connections, and card-lock restricted access. This equipment is provided by Praxair, Stuart, and FTI.
<i>Station Building and Surroundings</i>	The station will be designed as a retail facility design and will thus look similar to modern gas stations, including a canopy over the dispenser island and a mock mini-mart. To minimize footprint, the storage system will be built on the roof of the mini-mart. The total leased area of the facility is 10,500 ft <sup>2</sup> (78 ft N-S, 135 ft E-W)
<i>Hydrogen Distribution</i>	Praxair can provide a tube trailer <sup>10</sup> to deliver hydrogen to the site when needed (e.g., if the electrolyzer is down or hydrogen demand exceeds supply/on-site production.) The tube trailer has a capacity of 300 kg at 2600 psig and has the ability to connect to the station upstream of the compressor, which boosts the pressure up to 6600 psig. These trailers obtain hydrogen at Praxair’s hydrogen production facility in Ontario.

### **Site Design**

The following diagram shows the layout of the station.

*Figure 1: Station Layout<sup>11</sup>*

<sup>9</sup> [www.stuartenergy.com/main\\_our\\_products.html](http://www.stuartenergy.com/main_our_products.html), 12/03

<sup>10</sup> Tube trailer service is contingent on approval by LAWA.

<sup>11</sup> Praxair, 12/03

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(1/31/04)

(will release diagram when  
granted approval)

As depicted in the above diagram, the hydrogen generation and compression modules are housed behind the mini-mart facility though isolated from the customer area. The storage tanks are located on the roof of the facility, and the tube trailer is parked behind it. The dispenser island and canopy (right side of diagram) is located in front of the facility. The following simplified diagram shows the system components of the station and how they fit together.

Figure 2: Station Configuration

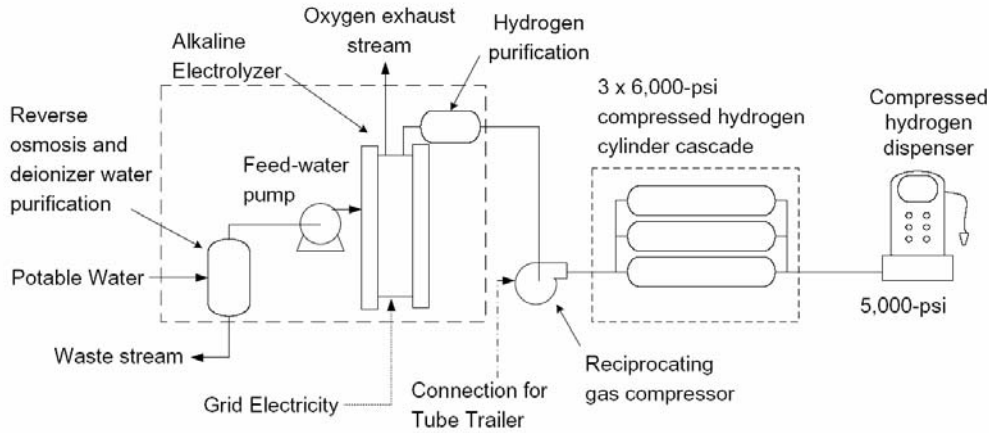
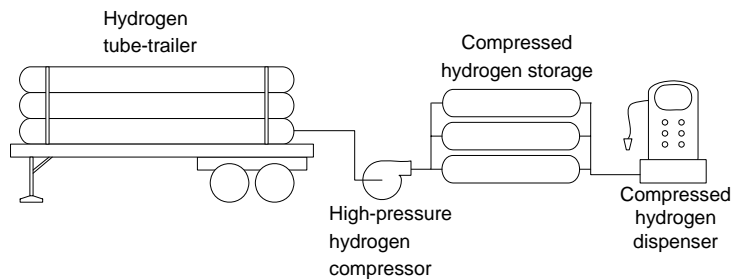


Figure 3: Praxair Tube Trailer configuration



The pictures below show the station site as of March 2004, and a depiction of what the site will look like after construction.

*Figure 4: Pre-Construction Station Picture*



*Figure 5: Post-construction Station Image*

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(will release diagram when  
granted approval)

### **Operation and Maintenance Requirements**

Product information about the electrolyzer states that it is “virtually maintenance free”<sup>12</sup> due to its use of pump-less electrolyte circulation, which minimizes moving parts within the unit. The compressor and dispenser will require regular inspection and maintenance, though the frequency is yet unknown. See Table 4 in the next section for O&M costs.

### **Permits Required for Commissioning**

The following permits are required in order to begin construction at the site:<sup>13</sup>

- LAWA conceptual approval
- CEQA approval
- FAA approval

<sup>12</sup> [www.stuartenergy.com/main\\_our\\_products.html](http://www.stuartenergy.com/main_our_products.html), 12/03

<sup>13</sup> Flaherty, interview, 12/03

- LAWA graphics approval (for lighting and signage)
- Utility approvals (water, electric, telephone)
- Boiler and pressure vessel approval
- City building permits (building, fire, electric, plumbing, and grading permits)
- LAWA construction approval

### III. ECONOMIC OVERVIEW

The following tables show cost estimates of the station equipment, non-capital costs incurred throughout the station’s development, and the costs associated with each major task of this development project.

**Table 3: Capital Costs of Station Equipment** <sup>14</sup>

<b>Item</b>	<b>Cost</b>
<i>Electrolyzer</i>	\$155,000
<i>Storage System</i>	\$70,000
<i>Dispenser</i>	\$70,000
<i>Compressors</i>	\$90,000
<i>Piping, valves, fittings</i>	\$27,500
<i>Controls</i>	\$15,000
<i>Vent stack</i>	\$1,000

**Table 4: Non-Capital Costs** <sup>15</sup>

<b>Item</b>	<b>Cost</b>
<b>Operation and Maintenance:</b>	
<i>Electrolyzer Maintenance</i>	\$ 2,500 /yr
<i>Compressor Maintenance</i>	\$ 2,000 /yr
<i>Dispenser Maintenance</i>	\$ 2,500 /yr
<i>Tube trailer backup</i>	\$ 6,000 /yr
<b>Site Improvements:</b>	
<i>Concrete pads</i>	\$ 20,000
<i>Electrical Modification</i>	\$ 20,000
<i>Lighting</i>	\$ 4,500
<i>Bollards</i>	\$ 5,000
<i>Fencing/Security</i>	\$ 20,000
<i>Env. Enclosure for Compressors</i>	\$ 5,000
<b>Additional Costs</b>	
<i>Permits</i>	\$ 10,000
<i>contractor labor</i>	\$ 50,000
<i>Shipping</i>	\$ 12,000
<i>Safety and Haz-ops Analysis</i>	\$ 30,000

<sup>14</sup> Praxair, Statement of Work with AQMD, 2002. These are estimated costs

<sup>15</sup> Praxair, Statement of Work with AQMD, 2002. These are estimated costs

<i>Training (gaseous)</i>	\$ 4,000
<i>Training (liquid)</i>	\$ 12,000
<i>Program management</i>	\$ 82,111

The SCAQMD funds their hydrogen station projects by dividing each project into a set of tasks, then paying the project manager once the task is complete. The following table shows the set of tasks for this project and the amount of money allocated for the completion of each task. A description of each task is provided to show exactly what sub-tasks are included in these costs.

**Table 5: Project Task Costs<sup>16\*</sup>**

<b>Task #</b>	<b>Task</b>	<b>Cost</b>	<b>Description</b>
1&2	<i>Design and permitting &amp; estimation of system performance</i>	\$ 67,600	Approve project design, prepare project design, request input from permitting authority, coordinate project, supervise contractor, submit plan for permit approval, work with permitting agencies to ensure approval, and complete inspections.
3	<i>Site development</i>	\$ 49,900	Dig trenches; prepare site; perform grading; install mini-mart, canopy, fueling island, fencing, underground lines (electrical, water, and hydrogen), cameras, lighting, hydrogen sensors, and support electrical systems; obtain sign-off from permitting authorities.
4	<i>Installation of equipment</i>	\$ 107,200	Install fueler, fueling post/hose, hydrogen storage tanks, and all related interconnecting support equipment; inspect and leak test all equipment.
5	<i>Preparation of tube trailer</i>	\$ 8,600	Prepare for on-site delivery of tube trailer hydrogen; set up trailer on site to allow for on-site filling with hydrogen.
6	<i>Commissioning the hydrogen generation and fueling system</i>	\$ 47,600	Demonstrate on-site hydrogen production from electrolyzer; purge all tanks and lines; show on-site vehicle fueling and tube trailer fill up; verify everything works as it is supposed to; conduct station training; turn over operation to qualified staff.
7	<i>Operation and maintenance</i>	\$ 13,000	Maintain equipment; ensure safe and reliable operation
8	<i>Data acquisition, analysis, and reporting</i>	\$ 22,000	
9	<i>Final report and station transfer</i>	\$ 35,100	

In order to leverage their resources, the SCAQMD will partially fund a project, then look for other government agencies to co-fund and partners willing to contribute their own money or in-kind resources (such as equipment or labor). The following table shows the levels of co-funding by each of the involved partners. The sum of these contributions represents the total station cost.

<sup>16</sup> AQMD contract with Praxair, 2003. Note: these costs may not accurately reflect the true cost of these tasks since partners also contributed to these tasks in-kind)

**Table 6: Funding Levels**<sup>17</sup>

<b>Organization</b>	<b>Funding Level</b>	<b>Description of Contribution</b>
<i>AQMD</i>	\$ 351,000	
<i>DOE</i>	\$ 500,000	
<i>Praxair</i>	\$ In kind (\$+550,000)	Hydrogen equipment, design services, project management
<i>BP</i>	In kind <sup>18</sup> (+180,000)	Design and construction of retail facility, permitting
<i>LAWA</i>	\$ 50,000	Real-estate
<i>Total Budget</i>	\$ <b>+1,580,048</b> <sup>19</sup>	

#### **IV. PROJECT TIMING**

The project, originally approved by the AQMD in October 2000, was scheduled to be commissioned by the Spring of 2003. It is now scheduled to be commissioned in the Fall of 2004. The following table shows how the completion dates were pushed out as time passed.

**Table 7: Changes in Project Timing**

	<b>Tasks</b>	<b>Timing (mid 02)</b> <sup>20</sup>	<b>Timing (late 02)</b>	<b>Timing (5/03)</b>	<b>Timing (12/03)</b>	<b>Timing (04/04)</b>
1	<i>Design and permitting</i>	10/02	1/03	6/03	6/03	6/03
2	<i>Estimation of System Performance</i>	10/02	1/03	6/03	6/03	6/03
3	<i>Site Development</i>	12/02	3/03	8/03	1/04	5/04
4	<i>Installation of equipment</i>	2/03	6/03	10/03	2/04	6/04
5	<i>Preparation of Tube Trailer</i>		6/03	10/03	2/04	6/04
6	<i>Commissioning the Hydrogen Generation and Fueling System</i>	3/03	6/03	11/03	4/04	9/04
7	<i>Operation and Maintenance</i>	5/03-9-04	12/03	3/04	5/04-10/05	10/04-3/06
8	<i>Data Acquisition, Analysis, and Reporting</i>	5/03-9-04	12/03	3/04	5/04-10/05	10/04-3/06
9	<i>Final Report and Station Transfer</i>	5/03-9-04	12/03	3/04	5/04-10/05	10/04-3/06

<sup>17</sup> AQMD presentation to Board of Directors, 9/13/02

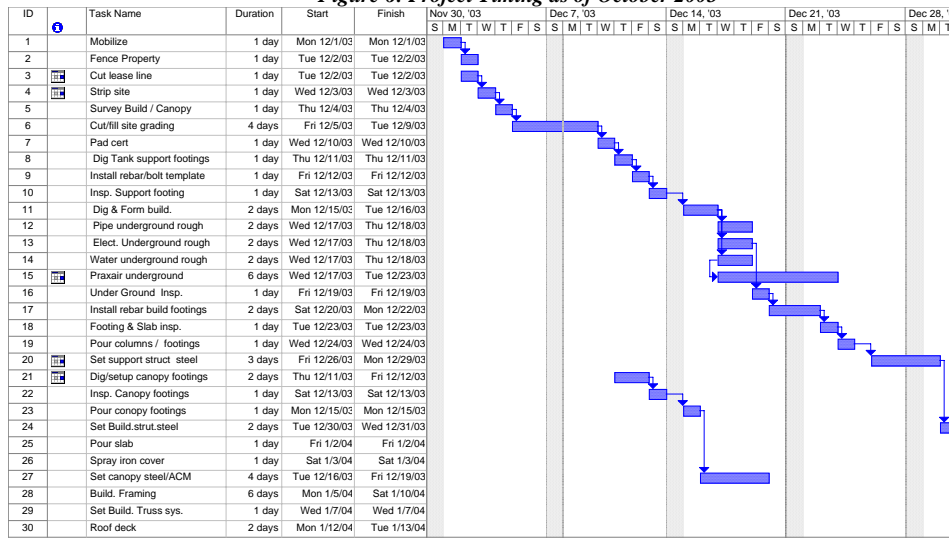
<sup>18</sup> "In kind" in this case refers to construction of the retail facility.

<sup>19</sup> Press Release, "Los Angeles Airport to Have Nation's First Commercial Compressed Hydrogen Fueling Demonstration Station", April 5, 2004

<sup>20</sup> Statement of Work, Praxair, 2002

The figure below shows a recent snapshot of the timing for the initial construction phase of the project.

**Figure 6: Project Timing as of October 2003**



These activities have been delayed approximately from their original schedule.

## V. OBSTACLES

The following section describes the obstacles and challenges that have confronted the station partners since the project's inception. These obstacles have caused both increases in cost, and delays in task completion.

*1. Indemnification:* The indemnification issue (see description from the History section) was a major obstacle in the station's development. Progress on the station could not move forward until this issue was settled since permits required to initiate construction require a signed lease. LAWA preferred to wait until the two parties were in closer agreement on the issues to hold an in-person meeting, which delayed the opportunity to work through issues face to face .

*2. Public Perception:* LAWA is taking a more cautious stance on hydrogen than with CNG because they are not as comfortable with the safety of hydrogen. This is the main cause for the lease agreement problem mentioned above. Praxair noted that their indemnification language for their CNG station is less stringent on the fuel provider than what they are proposing for the H2 station contract. LAWA justification for this is the lack of field experience with hydrogen fuel.<sup>21</sup> More interaction and education with the lawyers may mitigate this problem in the future.

<sup>21</sup> Email from Richard to Aaron, 10/3/03

3. *Wavering Commitment:* Throughout the course of this project, several potential partners dropped out after expressed initial interest. For example, Shell decided not to participate on 10/13/01 after a few months of negotiations on technical specifications and intended financial contribution, stating their goals were not in line with the station plans and the project was duplicative of other Shell Hydrogen projects. This created a funding gap of 400,000 that needed to be filled. It also caused the project to abandon Norsk Hydro and instead select the American-based Teledyne for the electrolyzer in order to cut costs and encourage DOE funding. Ford provided initial interest in using the station for fuel cell vehicles located in the Los Angeles area but this never translated into a definite commitment.

4. *Financing:* Problems between Praxair and the CEC arose regarding the release of funds for costs incurred on the project, nearly creating a lengthy delay in project completion. Praxair applied for DOE funding in January 02 and was awarded \$500,000 of FY 2002 2003 funding through the DOE's State Energy Program (SEP), which would be administered by the CEC. In the Fall of 2002, before entering into a contractual relationship with the CEC, the CEC advised Praxair to go forward with the engineering and design work on the project stating they would be reimbursed for their work once the contract was finalized. In January of 2003, they instructed Praxair to "stop all work" on the project pending entrance into a contractual relationship, under penalty of forfeiting reimbursement of already incurred expenses. This would have delayed the station considerably due to long lead times relating to equipment ordering. CEC felt they needed more complete oversight over project expenditures. To help resolve this problem, Praxair, through Woody Clark, drafted a letter to Commissioner James Boyd of the CEC.<sup>22</sup> This issue was partially resolved by the CEC's formal recognition of the project at its late May 2003 Board Meeting. A CEC funding contract with Praxair is still not in place, but recent emails indicate that it could be finalized before the end of December 2003.

The timing of when the DOE's funding became available created minor project delays since it created reimbursement doubts within Praxair. They ultimately decided to go forward with the project using its own funding, part of which will hopefully be reimbursed with DOE funds once all issues with the CEC are resolved.

5. *Codes and Standards:* Since composite storage tanks are still awaiting ASME approval for stationary hydrogen storage and there is risk that OSHA may not certify the tanks without that approval, Praxair and BP chose to abandon their original plans for composite tanks and instead use steel tanks. These tanks are so heavy, however, that the facility has to add structural reinforcements to its roof.

## **VI. LESSONS LEARNED**

1. *Lease Agreement:* Get the lease agreement signed before anything else. See Obstacle 1 for reason. Contractual agreements need to be clear.

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<sup>22</sup> Letter from Aaron to James Boyd, 3/5/03

*2. Multi-organization Contract Management:* The more organizations involved, the more complex the contract resolution process becomes. For example, Praxair had difficulty establishing consistent IP language between the CEC contract and AQMD contract. Government agencies typically use standard, approved language for contracts of this type. Changing this language to be consistent with the partnering agency while maintaining approval within their own agency creates time delays.

Another example of how the number of parties involved created contract delays was with the issue of partner contributions (or “who’s paying for what”). CEC needed to know the specific contributions of each partner to process their contract. Sometime these lines were blurred, however, since both BP and Praxair are involved in station design and implementation.

*3. Streamline Government Funding:* Streamline the funding process between government agencies and industry. The release of funds from the SCAQMD and DOE to Praxair proved difficult, creating delays in project timing (see obstacle 4). Government agencies should explore more efficient, expedient procedures to transfer money to avoid wasting the time and resources of private companies.

*4. Ensure OEM commitment:* Commitment early on that vehicles will be ready to fuel when the station opens creates an incentive to open the station on time. The project originally had some level of interest from Ford but they reduced their involvement as the project continued and focused their efforts elsewhere.

*5. Owner/Operator Involvement:* Earlier and more inclusive involvement from the station’s owner/operator (in this case LAWA). Discussions with the LAWA airport staff first began in late Spring 2001, and discussions with the LAWA’s real property division personnel began in earnest in starting in late 2002 (after the project was moved to Praxair). Once these discussions take place, be sure to include the legal staff, real estate staff, and safety officials from the operator organization. Get them educated early on about hydrogen, safety, make sure their concerns are addressed.

*6. Site Location: City-owned land vs. private-owned land:* Siting a hydrogen station on city-owned property can be difficult from a permitting perspective because of long delays associated with the bureaucratic nature of a city agency, such as LAWA, that has a lot of other competing issues on its plate.<sup>23</sup> It is much easier (more smooth permitting process) if installed on private property.

On the other hand, getting approval for a project on city-owned land is in some respects easier than obtaining approval on a private piece of property because it doesn’t have to go before the city planning commission or city council.<sup>24</sup> It usually takes around 12-14 months to get approval for a conventional fueling station in most cities. The planning commission process takes 3-4 months, the city council process takes 3-4 months, and the construction approval process takes 3-4 months. In the case of the LAWA station permitting process, no public hearings were required, which expedited the process.

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<sup>23</sup> Conversation with Aaron Rachlin, October 2003

<sup>24</sup> Conversation with Mike Flaherty, December 2003

7. *Project Champion*: High-level champions are critical to a station's success. Roger Johnson, the champion from LAWA, was very enthusiastic about the project and helped convince other airport personnel to support it. This single point of commitment/enthusiasm at LAWA helped advance the project in the early stages before he left. If the project champion from one of the key partner organizations leaves, ensure that contracts are signed indicating what each organization has committed to contribute.

8. *Multi-organization Project Management*: The complexity of a multi-organization project such as this requires clear leadership, strong project management, and clearly defined roles, responsibilities, and accountability.<sup>25</sup> To achieve these goals, establish an effective communication strategy at the inception of the project.

9. *Engage Fire Marshals*: Meet early and meet often.<sup>26</sup> BP and Praxair had a good experience with the Fire Marshall David Myers because they met with him before submitting their design to find out what his questions and concerns were. The design they presented to him later on addressed most of these concerns, so there were only minor issues to work out.

10. *Engage Lawyers*: Involve the lawyers from each organization as early as possible. Get them educated about hydrogen so they more familiar with the kinds of issues they will confront.

12. *Engage Local Congressmen*: Get local congressmen involved with the project. Jane Harman (Rep from the station's district) and staff were involved in this project from early 02, which made the permitting and approval process easier.

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<sup>25</sup> Mike Jones, Personal communication, 2/04

<sup>26</sup> Conversation with Mike Flaherty, December 2003