Lessons Learnt: Global Green Hydrogen Cost Optimization VÖT-BFT Model™

Fadi Maalouf
Dubai 19th Nov 2023
<table>
<thead>
<tr>
<th>Document Title / Number</th>
<th>Rev.</th>
<th>Description Of Change</th>
<th>Effective Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lessons Learnt: Global Green Hydrogen Cost Optimization VOT-BFT Model™</td>
<td>1</td>
<td>Initial Release – For Information</td>
<td>28-Feb-2023</td>
</tr>
<tr>
<td>Lessons-Learnt-GGHCOVOTBFT-Model-R1-fm230228</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lessons Learnt: Global Green Hydrogen Cost Optimization VOT-BFT Model™</td>
<td>2</td>
<td>Update for Webinar</td>
<td>5-Jun-2023</td>
</tr>
<tr>
<td>Lessons-Learnt-GGHCOVOTBFT-Model-R1-fm230228</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lessons Learnt: Global Green Hydrogen Cost Optimization VOT-BFT Model™</td>
<td>3</td>
<td>General Update</td>
<td>19-Nov-2023</td>
</tr>
<tr>
<td>Lessons-Learnt-GGHCOVOTBFT-Model-R3-fm231119</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>Name</th>
<th>Designation</th>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>Fadi Maalouf</td>
<td>CTO - Director IPP &amp; EPC</td>
<td>F2M2</td>
<td>5-Jun-2023</td>
</tr>
</tbody>
</table>
Outline

- Introduction
- Toolkit Versions
- Toolkit Features
- How Does It Work?
- Toolkit Key Objectives
- Toolkit Content
- Toolkit Inputs Form
- Toolkit Pre-COD Finance Cost
- Toolkit Optimization Process & Results
- Takeaways
- Contact
In the Global Energy Transition context and decarbonization, all hands must be on deck!

There is no magic quick fix or silver bullet solution. It is a collaborative effort across all stakeholders and industries.

A double win can be achieved: accelerated energy transition driven by sustainable economic recovery.

An important element of this double win is Green Hydrogen i.e., hydrogen produced from electrolyzers powered by renewable energy resources.

Hydrogen is a versatile energy carrier with a wide range of uses and unique attributes, especially for energy sectors that are hard to electrify with renewable resources but can be made greener through sector coupling.

So, if Green Hydrogen is technically a key enabler of decarbonization, then the next step or barrier to break is economics.

This translates to: how much does Green Hydrogen costs to produce and how to calculate that as well as analyze pathways of cost reduction?

A financial model toolkit for analyzing levelized cost of Green Hydrogen & derivatives becomes necessary.
Toolkits Versions
Levelized Cost of Green Hydrogen LCOH & Ammonia LCOA & e-Methanol LCOM & e-Kerosene LCK

Six Versions:

- LCOH Financial Model Toolkit V5A
  Green H₂ Production

- LCOH Financial Model Toolkit V5.2
  Global Green H₂ Cost Optimization VOT-BFT Model™

- LCOH Financial Model Toolkit V6A
  Green H₂ Production & Delivery Infra Pathways

- LCOA Financial Model Toolkit V7A
  Green NH₃ Production & Storage

- LCOM Financial Model Toolkit V8A
  Green e-Methanol Production & Storage

- LCK Financial Model Toolkit V9A
  Green e-Kerosene Production & Storage

Six versions Modular approach to:

- Verify costs at each stage of the process
- Piecemeal manageable iterative approach
- Identify cost optimization priorities & opportunities

© Dii
Dii Toolkit for RE Grid Integration, Project Development & Industry Localization
General Features:

- Get exclusive market analysis & benchmarking data for Levelized Cost of Green Hydrogen / Green Ammonia / Green e-Methanol / Green e-Kerosene
- Obtain the best of all worlds assembled from over 50 best in class models for LCOH/LCOA/LCOM/LCOK in the market.
- A quick yet very effective holistic approach methodology to determine levelized costs of green molecules.
- Capture all life cycle costs and assess project feasibility.
- A detailed analytical dive into optimizing costs as well as performance parameters.
- Utilize powerful and comprehensive sensitivity analysis scenarios.
- User-friendly design with guideline, rich visuals & charts, printable 17-page report.
- Toolkits are available on a Software as a Service (SaaS) basis.
- Native model toolkits files (.xls) are available as commercial product.
- Download sample pdf reports at: download link provided upon request
Financial Model Toolkit General Features: Zoom In!

- Very Well-Structured Content & Workflow
- Project Information Data Capturing Full Scope of Work & Limits
- Detailed Input Parameters Form with Guideline Notes
- Analysis of Pre-COD Finance Cost & Construction Delay Cost
- Tabular LCOH/LCOA/LCOM/LCOK Outputs
- Breakdown CAPEX & OPEX & LCOH/LCOA/LCOM/LCOK Output Charts
- Up to 16 Parameters Sensitivity Tornado Chart
- Up to 8 Two-Dimensional Sensitivity Charts
- Multi-Lifecycle Analysis Chart
- Export Data/Charts Feature
- GIS Interface Feature
Toolkits Versions
Levelized Cost of Green Hydrogen LCOH & Ammonia LCOA & e-Methanol LCOM & e-Kerosene LCOK

Green Hydrogen Toolkit Version 5B
Snapshots

Tornado Chart - LCOH $/Kg H₂

- Total Sp. Energy Consump. (kWh AC/Kg H₂) (-50%, 0%, 50%)
- Energy Cost ($/kWh AC) (-50%, 0%, 50%)
- Capacity Factor (%) (50%, 0%, -50%)
- BoP Pack Cost ($/kWh DC) (-50%, 0%, 50%)
- Stack Pack Cost ($/kWh DC) (-50%, 0%, 50%)
- WACC (%) (-50%, 0%, 50%)
- Fixed O&M Cost (% of EPC Cost) (-50%, 0%, 50%)
- Civil/Infra Pack Cost ($/kWh DC) (-50%, 0%, 50%)

© Dii
Green Ammonia Toolkit Version 7A
Snapshots

Tornado Chart - LCOA $/t NH₃

- Total Sp. Energy Consump. (kWhE AC/Kg H₂)
  -50%, 0%, 50%
- Capacity Factor (%)
  -50%, 0%, 50%
- Energy Cost ($/kWh E AC)
  -50%, 0%, 50%
- NH₃ HB-ASU Pack Cost ($/kWe DC)
  -50%, 0%, 50%
- WACC (%) 
  -50%, 0%, 50%
- Fixed O&M Cost (% of EPC Cost)
  -50%, 0%, 50%
- BoP Pack Cost ($/kWe DC)
  -50%, 0%, 50%
- Stack Pack Cost ($/kWe DC)
  -50%, 0%, 50%

© Dii
Toolkits Versions
Levelized Cost of Green Hydrogen LCOH & Ammonia LCOA & e-Methanol LCOM & e-Kerosene LCOK

Green Methanol Toolkit Version 8A
Snapshots

Tornado Chart - LCOM $/t MeOH

- Total Sp. Energy Consump. (kWhe AC/Kg Hz)
  - (-60%, 0%, 50%)
- Capacity Factor (%)
  - (50%, 0%, -50%)
- Energy Cost ($/Whe AC)
  - (-50%, 0%, 50%)
- CO2 Feedstock Net Cost ($/t CO2)
  - (-50%, 0%, 50%)
- Fixed O&M Cost (% of EPC Cost)
  - (-50%, 0%, 50%)
- WACC (%)
  - (-50%, 0%, 50%)
- MeOH Syn. Pack Cost ($/kWe DC)
  - (-50%, 0%, 50%)
- Stack Pack Cost ($/kWe DC)
  - (-50%, 0%, 50%)
Green Kerosene SAF Toolkit Version 9A
Snapshots

Tornado Chart - LCOK $/t SAF

- Total Sp. Energy Consumpt. (kWhe AC/Kg H2) (-50%, 0%, 50%)
  - 1,078.84
  - 1,625.89
  - 2,172.94

- Capacity Factor (%) (50%, 0%, -50%)
  - 1,445.09
  - 2,249.92

- Energy Cost ($/kWhe AC) (-50%, 0%, 50%)
  - 1,351.57
  - 1,900.20

- CO2 Feedstock Net Cost ($/t CO2) (-50%, 0%, 50%)
  - 1,425.31
  - 1,826.47

- Synthesis Pack Cost ($/kWe DC) (-50%, 0%, 50%)
  - 1,517.25
  - 1,734.53

- Fixed O&M Cost (% of EPC Cost) (-50%, 0%, 50%)
  - 1,524.08
  - 1,727.70

- WACC (%) (-50%, 0%, 50%)
  - 1,540.62
  - 1,720.51

- Stack Pack Cost ($/kWe DC) (-50%, 0%, 50%)
  - 1,564.75
  - 1,687.02

© Dii Dii Toolkit for RE Grid Integration, Project Development & Industry Localization 11
The financial model toolkit is a discounted cashflow model coupled with visual representation in charts and graphs, and analytical features of one- and two-dimensional sensitivity analysis.

Basically, the toolkit is a calculation engine that feeds on user supplied input parameters and provides calculated outputs of LCOH in $/Kg H₂ plus plenty of charts for easier analytical what-if-scenarios representation. The same methodologies is applied for Green Ammonia and Green e-Methanol Toolkits.

To run the model and provide a report, the user (desktop researcher) provides Dii with the required “input parameters”.

This is a two-page Inputs Form that covers the attributes of Green Hydrogen/Ammonia/e-Methanol/e-Kerosene. Dii runs the respective model and provides a report. Service Done!
How Does It Work?
Financial Model Toolkit – Good Practice Principles & Workflow

© 2018 Fadi Maalouf
How Does It Work?

Financial Model Toolkit – Capital Budgeting Process Workflow

Hurdle Case / Go-No-Go

Go

Baseline Case

Additional Cases (Upside/Downside)

Hurdle Case / Go-No-Go

No

Revised Design Iterations

Go

Baseline Case

Additional Cases (Upside/Downside)

Hurdle Case / Go-No-Go

No

Revised Design Iterations

No

© 2018 Fadi Maalouf
Toolkit Key Objectives
Global Green Hydrogen Cost Optimization VOT-BFT Model™ V5.2

- All-in-one model packed with unique advanced flexible features
- Optimum LCOH anywhere globally, based on site coordinates
- 3 Connection Schemes options
  - Standalone PV+Wind w/ hourly temporal correlation
  - Grid connected PV+Wind w/ hourly temporal correlation
  - Grid connected PPA w/o hourly temporal correlation
- 2 Options for PV+Wind hourly generation data profile
  - Model generated PV+Wind hourly profiles via API
  - User imported custom PV+Wind hourly profile
- Model is Excel based, no additional specialty software
- Macro based functions, eliminate manual tasks
- Model run on laptop, no high performance computing servers
Toolkit Key Objectives
Global Green Hydrogen Cost Optimization VOT-BFT Model™ V5.2

- Per Unit (PU) optimization methodology design
- Optimization process workflow is similar to Genetic Algorithm
- Optimum PV+Wind capacity sizing for optimum LCOH case
- Set electrolyzer operating window & track operating & FLEH hours
- 3 User defined alternative constrained optimum cases
- 8 User defined custom cases for comparison & analysis
- Detailed CAPEX/OPEX/System parameters settings
- Extensive Charts & Visuals for Analysis
- Available on SaaS basis for a nominal fee per project report
The model toolkit is an XLS file with 26 sheets.

The integrity of the toolkit structure and calculation engine is secured and protected against unintended formulae edits.

A content sheet provides quick navigation hyperlinks to all sheets.

By providing a list of input parameters, a model run will generate a 17-page pdf report.
The Inputs Form (xls file) data set is in six categories:

1. General (Lifecycle Selection up to 40 years, economies of scale, technology & costs ref. years, Site Coordinates, Plant Connection Scheme Selection, PV+Wind Hourly Generation Profile Data Source Selection)
2. Finance Structure (gearing, equity & debt rates, construction period finance)
3. CAPEX (breakdown required)
4. OPEX (fixed & variable, energy & water, land lease, escalation rates, stack replacement intervals)
5. System (capacity, efficiency, degradation, capacity factor, system background settings, optimization cases selection)
6. Decommissioning & Residual Value

For each input parameter, notes and remarks are provided. The user can also add his/her special notes as well.
Toolkit Pre-COD Finance Cost

- Pre-COD Finance Analysis:
  1. CAPEX drawdown profile
  2. Construction period finance cost breakdown

Pre-COD Finance Cost Breakdown as % of CAPEX

CAPEX Cashflow
Toolkit Pre-COD Finance Cost

- Pre-COD Finance Analysis:
  1. Construction delay cost analysis
  2. Construction period sensitivity analysis
Optimization Process & Results
Global Green Hydrogen Cost Optimization VOT-BFT Model™ V5.2

Optimization Process Summary - User Defined Alternative Optimum Cases Solver

**Inputs**
- **Site Lat° Lon°**
  - ELZR Site Coordinates: **.****** **.******
  - PV Site Coordinates: **.****** **.******
  - Wind Site Coordinates: **.****** **.******
- **Plant Electricity Connection Type**: Standalone w/ PV+Wind

**Outputs**
- **Step 1**
- **Step 2**
- **Click to Calculate Optimum Case**

**Option 1**
**Alternative Optimum Case Results**
- With Applied Filter - Minimum Required ELZR CF 72%
- ELZRcap (PU) 1
- PVcap (PU) 1.1
- Windcap (PU) 1.1
- Total Gencap (PU) 2.2
- PV+Wind LCOE ($/kWh) 2.746001
- Net Excess Generation % 8.76%
- ELZR CF (%) 72.15%
- ELZR Operating Hours (hr/yr) 8428
- LCOH ($/Kg) 2.098708
- Case No. 79

**Option 2**
**Alternative Optimum Case Results**
- With Applied Filter - Total Gencap Limit 1.60
- ELZRcap (PU) 1
- PVcap (PU) 1.2
- Windcap (PU) 0.4
- Total Gencap (PU) 1.6
- PV+Wind LCOE ($/kWh) 2.316968
- Net Excess Generation % 3.62%
- ELZR CF (%) 49.91%
- ELZR Operating Hours (hr/yr) 7677
- LCOH ($/Kg) 2.106898
- Case No. 3

**Option 3**
**Alternative Custom Case Results**
- With Applied Filter - PVcap Value 1.20
- With Applied Filter - Windcap Value 1.30
- ELZRcap (PU) 1
- PVcap (PU) 1.2
- Windcap (PU) 1.3
- Total Gencap (PU) 2.5
- PV+Wind LCOE ($/kWh) 2.918049
- Net Excess Generation % 14.02%
- ELZR CF (%) 77.88%
- ELZR Operating Hours (hr/yr) 8499
- LCOH ($/Kg) 2.15103
- Case No. 102

**Apply selected case as baseline case via macro**
Optimization Process Summary - User Applied Case

Hourly Energy Balance PV/Wind/ELZR
ELZR Operating Window (min/max/Overload/Cooldown)

Current Status: Plant Electricity Connection Type  Standalone w/ PV+Wind
Current Status: PVcap (PU)  1.10
Current Status: Windcap (PU)  1.10
Optimization Process Summary - User Applied Case
Annual Capacity Factor & H₂ Production
PV & Wind & Electrolyzer Degradation Impact

Current Status: Plant Electricity Connection Type  Standalone w/ PV+Wind
Current Status: PVcap (PU)  1.10
Current Status: Windcap (PU)  1.10

Annual Capacity Factor & H₂ Production

Optimization Process & Results
Global Green Hydrogen Cost Optimization VOT-BFT Model™
V5.2
Optimization Process & Results
Global Green Hydrogen Cost Optimization VOT-BFT Model™
V5.2

Optimization Process Summary - User Applied Case
Annual Capacity Factor Energy Balance
PV & Wind & Electrolyzer Degradation Impact

Current Status: Plant Electricity Connection Type  Standalone w/ PV+Wind
Current Status: PVcap (PU)  1.10
Current Status: Windcap (PU)  1.10

Annual Capacity Factor & Energy Balance
## Deep Dive – Advanced Optimization Process Summary

Up to 8 User Defined Custom Cases Analysis

<table>
<thead>
<tr>
<th>Run Custom Case Results</th>
<th>Plant Electricity Connection Type</th>
<th>Standalone w/ PV+Wind</th>
<th>Grid w/ PV+Wind</th>
<th>Standalone w/ PV+Wind</th>
<th>Grid w/ PV+Wind</th>
<th>Standalone w/ PV+Wind</th>
<th>Grid w/ PV+Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ELZRcap (PU)</td>
<td>PVcap (PU)</td>
<td>Windcap (PU)</td>
<td>Total Gencap (PU)</td>
<td>PV+Wind LCOE ($/kWh)</td>
<td>Net Excess Generation %</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>1.20</td>
<td>1.00</td>
<td>2.20</td>
<td>2.710930</td>
<td>9.42%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grid w/ PV+Wind</td>
<td>1.20</td>
<td>1.00</td>
<td>2.20</td>
<td>2.485506</td>
<td>9.42%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standalone w/ PV+Wind</td>
<td>1.30</td>
<td>0.60</td>
<td>1.90</td>
<td>2.482923</td>
<td>7.42%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grid w/ PV+Wind</td>
<td>1.30</td>
<td>0.60</td>
<td>1.90</td>
<td>2.328625</td>
<td>7.42%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standalone w/ PV+Wind</td>
<td>1.50</td>
<td>1.30</td>
<td>1.50</td>
<td>2.710930</td>
<td>5.40%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grid w/ PV+Wind</td>
<td>1.50</td>
<td>1.30</td>
<td>1.50</td>
<td>3.071111</td>
<td>4.39%</td>
</tr>
</tbody>
</table>

Current Status:
- Plant Electricity Connection Type:
  - Standalone w/ PV+Wind

Current Status:
- PVcap (PU):
  - Custom 1: 1.10
  - Custom 2: 1.20
  - Custom 3: 1.30

Current Status:
- Windcap (PU):
  - Custom 1: 1.10
  - Custom 2: 1.20
  - Custom 3: 1.30

Current Status:
- Total Gencap (PU):
  - Custom 1: 2.20
  - Custom 2: 2.20
  - Custom 3: 2.20

Current Status:
- PV+Wind LCOE ($/kWh):
  - Custom 1: 2.710930
  - Custom 2: 2.485506
  - Custom 3: 2.482923
  - Custom 4: 2.328625

Current Status:
- Net Excess Generation %:
  - Custom 1: 9.42%
  - Custom 2: 9.42%
  - Custom 3: 7.42%
  - Custom 4: 7.42%

Current Status:
- ELZR CF (%):
  - Custom 1: 70.33%
  - Custom 2: 70.33%
  - Custom 3: 58.59%
  - Custom 4: 58.59%

Current Status:
- ELZR Operating Hours (hr/yr):
  - Custom 1: 8,380
  - Custom 2: 8,380
  - Custom 3: 8,041

Current Status:
- LCOH ($/Kg):
  - Custom 1: 2.092682
  - Custom 2: 1.967170
  - Custom 3: 2.077212
  - Custom 4: 2.075847

Current Status:
- Case No.:
  - Custom 1
  - Custom 2
  - Custom 3
  - Custom 4

Current Status:
- Calc Dur:
  - Custom 1: 28.00 sec
  - Custom 2: 30.00 sec
  - Custom 3: 35.00 sec
  - Custom 4: 33.00 sec

Last Run:
- Time Start: 5:25:23 AM
- Time End: 6:33:29 AM
- Calc Dur: 68.10 min

Last Run Status:
- Plant Electricity Connection Type: Standalone w/ PV+Wind
- PVcap (PU): 1.10
- Windcap (PU): 1.10
- Total Gencap (PU): 2.20
- PV+Wind LCOE ($/kWh): 2.710930
- Net Excess Generation %: 9.42%
- ELZR CF (%): 70.33%
- ELZR Operating Hours (hr/yr): 8,380
- LCOH ($/Kg): 2.092682

Click to Calculate Optimum Case
Click to Calculate PV Only Optimum Case
Click to Calculate Wind Only Optimum Case
Click to Backup Last Run
Click to Backup Last Run in PR2

Task automation via macros
Optimization Process & Results

Global Green Hydrogen Cost Optimization VOT-BFT Model™ V5.2

Optimization Process Final Step
- Apply a user selected case as baseline case (dropdown list)
- Print the complete 17-page report with all data and cases

### PV+Wind Sizing Summary

<table>
<thead>
<tr>
<th>Plant Electricity Connection Type (Grid Connected or Standalone)</th>
<th>Standalone w/ PV+Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV+Wind+BESS Optimization Case Selection (Optimum, Options 1/2/3, Custom 1/2/3/4)</td>
<td>Option 1</td>
</tr>
<tr>
<td>PV Plant Capacity (kW)</td>
<td>1,100,000</td>
</tr>
<tr>
<td>Wind Plant Capacity (kW)</td>
<td>1,100,000</td>
</tr>
<tr>
<td>Total Generation Capacity (kW)</td>
<td>2,200,000</td>
</tr>
<tr>
<td>BESS Power Capacity (kW)</td>
<td>NA</td>
</tr>
<tr>
<td>BESS Energy Capacity (kWh)</td>
<td>NA</td>
</tr>
<tr>
<td>PV LCOE $/kWh</td>
<td>0.01888427</td>
</tr>
<tr>
<td>PV Plant Annual Capacity Factor (%)</td>
<td>28.78%</td>
</tr>
<tr>
<td>Wind LCOE $/kWh</td>
<td>0.02959250</td>
</tr>
<tr>
<td>Wind Plant Annual Capacity Factor (%)</td>
<td>43.11%</td>
</tr>
<tr>
<td>PV+Wind LCOE $/kWh</td>
<td>0.02746001</td>
</tr>
<tr>
<td>Plant Annual Capacity Factor (%)</td>
<td>72.15%</td>
</tr>
<tr>
<td>Plant Annual Operating Hours (hr/yr)</td>
<td>8,428</td>
</tr>
</tbody>
</table>
Optimization Process & Results
Global Green Hydrogen Cost Optimization VOT-BFT Model™
V5.2

Optimization Process Results - CAPEX & OPEX Breakdown

- Total CAPEX $556,972,936
  - Electrolyzer Stack Package Cost ($/kWe DC) $14.00
  - Electrical & Mechanical BOP Packages Cost ($/kWe DC) $11.76
  - Overall Civil & Infrastructure Package Cost ($/kWe DC) $35.00
  - Plant Start-up Package Cost ($/kWe DC) $40.00
  - Project Development Contingencies Allocation Cost ($/kWe DC) $0.00
  - Taxes GST/VAT ($/kWe DC) $0.00
  - Finance Cost During Construction ($/kWe DC) $275.00

- Total OPEX $200,362,436
  - Energy Consumption Net Cost ($/yr) $10,263,773.87
  - General Fixed O&M Cost Yr1 w/ Taxes GST/VAT ($/yr) $3,631,889.23
  - Water Consumption Net Cost ($/yr) $12,829,717.33
  - MMRA - Electrolyzer Stack Replacement Cost Allocation Yr1 to YrN-1, multi-interval ($/yr) $200,000.00
  - H2 Electrolyzer Plant Leased Land Cost ($/yr) $173,567,056.75

Dii Toolkit for RE Grid Integration, Project Development & Industry Localization
Optimization Process & Results
Global Green Hydrogen Cost Optimization VOT-BFT Model™ V5.2

Optimization Process Results
LCOH Breakdown
### Project Location

- **Electrolyzer Capacity (MW AC):** 1,000
- **CAPEX ($):** 559,973,936
- **LCOE ($/MWh):** 27.460009
- **Required Total Generation Capacity (MW):** 2,200

### Project Dashboard

#### Global Green Hydrogen Cost Optimization VOT-BFT Model™

<table>
<thead>
<tr>
<th>Electrolyzer Capacity (MW AC)</th>
<th>1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCOE ($/MWh)</td>
<td>27.460009</td>
</tr>
<tr>
<td><strong>Electrolyzer Plant Net Annual Production</strong> (ton H₂)</td>
<td>117,730</td>
</tr>
</tbody>
</table>

#### Site Coordinates (Lat°/Lon°)

- **Site Coordinates (Lat°/Lon°):** **.****** / **.******

#### Plant Electricity Connection Type

- **Type:** Standalone w/ PV/Wind

#### Plant Annual Capacity Factor (%/yr1)

- **Value:** 72.15%

#### Electricity Consumption (MWh/yr1)

- **Value:** 6,320,721

### Water Consumption (m³/yr1)

- **Value:** 1,177,296

### LCOH ($/Kg H₂)

- **Value:** 2.098708

### Plant Annual Capacity Factor (%/yr1)

- **Value:** 72.15%

### H₂ Production (ton/yr1)

- **Value:** 117,730

### Electricity Consumption (MWh/yr1)

- **Value:** 6,320,721

### Water Consumption (m³/yr1)

- **Value:** 1,177,296

### LCOE ($/MWh)

- **Value:** 27.460009

### Required PV Plant Capacity (MW)

- **Value:** 1,100

### Required Wind Plant Capacity (MW)

- **Value:** 1,100

### Required Total Generation Capacity (MW)

- **Value:** 2,200

### Annual Production (ton H₂)

- **Value:** 117,730

### LCOH Breakdown $/Kg H₂

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capex Component</td>
<td>56.2%</td>
</tr>
<tr>
<td>Opex Component - Energy Cost</td>
<td>17.6%</td>
</tr>
<tr>
<td>Opex Component - General Fixed O&amp;M</td>
<td>16.2%</td>
</tr>
<tr>
<td>Opex Component - Water Cost</td>
<td>8.8%</td>
</tr>
<tr>
<td>Opex Component - Stack Replacement Cost</td>
<td>4.7%</td>
</tr>
<tr>
<td>Opex Component - Leased Land Cost</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

### Graphs

- **Graph 1:** Annual Production (ton H₂)
- **Graph 2:** Water Consumption (m³/yr1)
Global Green Hydrogen Cost Optimization VOT-BFT Model™

Download Sample Project Report
Lessons Learnt: Global Green Hydrogen Cost Optimization VOT-BFT Model™

Download This Presentation
Takeaways

➤ The green molecules era has arrived.
➤ Their contribution to the energy transition will rise and accelerate.
➤ Balancing technical solutions with sound economics will be critical to the success.
➤ Challenges ahead that are vital for bankable projects development:
  ➤ Clear long-term guarantees of origin / standards / policy / regulatory environments
  ➤ Risk-balanced long-term offtake agreements
  ➤ Overall plant performance guarantees
➤ Again, all hands must be on deck!
Thank You For Your Attention!

Contact:
Fadi Maalouf
CTO - Director IPP & EPC
+971 50 624 6126
fadi@dii-desertenergy.org
www.dii-desertenergy.org
@SolarUAE
linkedin.com/in/FadiMaalouf