INVEST IN ICELAND
WWW.INVEST.IS

Assessment of Carbon Fiber Manufacturing Cost

Extract from a benchmarking study on Iceland as a location for Carbon Fiber Production

Omnia LLC

October 2012

Please note that the following document is an extract only.
To get further information please contact Invest in Iceland

Assessment of Carbon Fiber Manufacturing Cost for INVEST in Iceland

October 16th 2012

PRODUCT ASSUMPTIONS

The production costs are considered for a polyacrylonitrile (PAN) based carbon fiber. The nominal tow size considered is 12k filaments. The fiber type is a standard modulus.

This fiber and other industrial types would be considered primarily automotive uses. Additional efficiencies are typically gained in production of 24k and 48k fiber. A 12k fiber is a good baseline for a wide range of application use.

SITE NEEDS

In order to establish a reasonable cost absorption for comparison the following sites conditions were assumed:

- Approximately 25 acres. This site provides space for buildings, external facilities, parking, and expansion.
- 4000 mt/a nameplate production. This production capacity is supported by 2 modules of 2000 mt/a each.
- The building(s) encompass a total of approximately 50,000 m^2. The manufacturing area is a 2-3 story steel structure building. Administration is a single story.
- Utilities for the facility require approximately 15MW peak power.

CAPITAL (2000 mt/a LINE)

The capital requirements are broken out by process in the included table. The amounts indicated are for a 2000 mt/a line. When adding a second line a 10% savings is considered based on some shared capital related to facilities.

Process	$1,000
PAN creels	1,500
Oxidation ovens	6,000
LT/HT carbonization	7,000
Abatement	2,000
Wash/size/dry	2,000
Controls	500
Winders	1,500
Cooling water	500
Nitrogen generation	2,000
Drives, rollers	2,500
Platforms, anc.	2,500
Total	28,000

TOTAL CAPITAL AND INSTALLATION

Total capital considered is $53.5 million

Base costs for delivery, installation, and commissioning have been estimated at $22 million for 4,000 mt/a line. Additional premium is considered for Iceland. This includes additional delivery premium for all items shipment by sea as well as additional cost for commissioning team.

Process	$1,000
1st 2000 mt/a line	28,000
2nd 2000 mt/a line	25,500
SUBTOTAL CAPITAL	53,500
Delivery	6,000
Installation	14,000
Commissioning	2,000
SUBTOTAL INSTALL	22,000
Added delivery	1,200
Added commissioning	1,000
TOTAL	77,700

LABOR ASSUMPTIONS

For the direct labor aspect of the facility the job descriptions and quantity are identified in the accompanying table. A 5 shift operation is considered although this varies by region. This can be considered a conservative worst case scenario. The quantities in the table consider all shifts to establish a total operation cost.

Job Title	Qty
Manufacturing Supervisor	**5**
Manufacturing Operator	
Operator, Oxidation	**30**
Operator, Carbonize	**30**
Operator, Packaging	**10**
Operator, Sizing	**1**
Manufacturing Technician	**5**
Maintenance Mechanic	**2**
Maintenance Electrician	**1**
Maintenance Instrumentation	**1**
Environmental Technician	**1**
Laboratory Technician	**2**
Total	**88**

UTILITIES CONSUMPTION BY PROCESS

Utility consumption is provided by process. Peak usage occurs over a 2 hour period during each campaign. The average power consumption for the facility considers 4 hours peak and 20 hours steady power over a 24 hour period.

The utilities provided in the table is based on a 2000 mt/a line.

Source:

Despatch INDUSTRIES

Process	Steady (kWhr)	Peak (kWhr)
Oxidation ovens	2,200	3,600
LT carbonization	250	900
HT carbonization	200	1,250
LT/HT abatement	50	60
Stretching	260	260
Wash/size/dry	90	100
Controls	10	10
Oxidation abatement	120	150
Winders	50	50
Cooling water	40	60
Others	23	70
Total	4,193	7,410

UTILITIES USAGE

The baseline facility considers all electric operation. Gas can be used for the oxidation ovens in regions where gas is economical. Gas fired ovens can reduce the total electrical consumption by 50%. This is offset with approximately 900 Nm^3/hr of natural gas usage.

For all electric operation average consumption over is estimated at 13 MWhr for 4,000 mt/a production.

Nitrogen usage is estimated at 7,000 to 9,000 LPM. Since Nitrogen is typically generated on site, only the utility usage is considered in the cost roll up for this study.

TRANSPORTATION SUMMARY

The premise advised is that the PAN precursor would be shipped to Iceland from the carbon fiber manufacturers main PAN precursor production facility. This is a most likely scenario for an initial phase for introduction to Iceland.

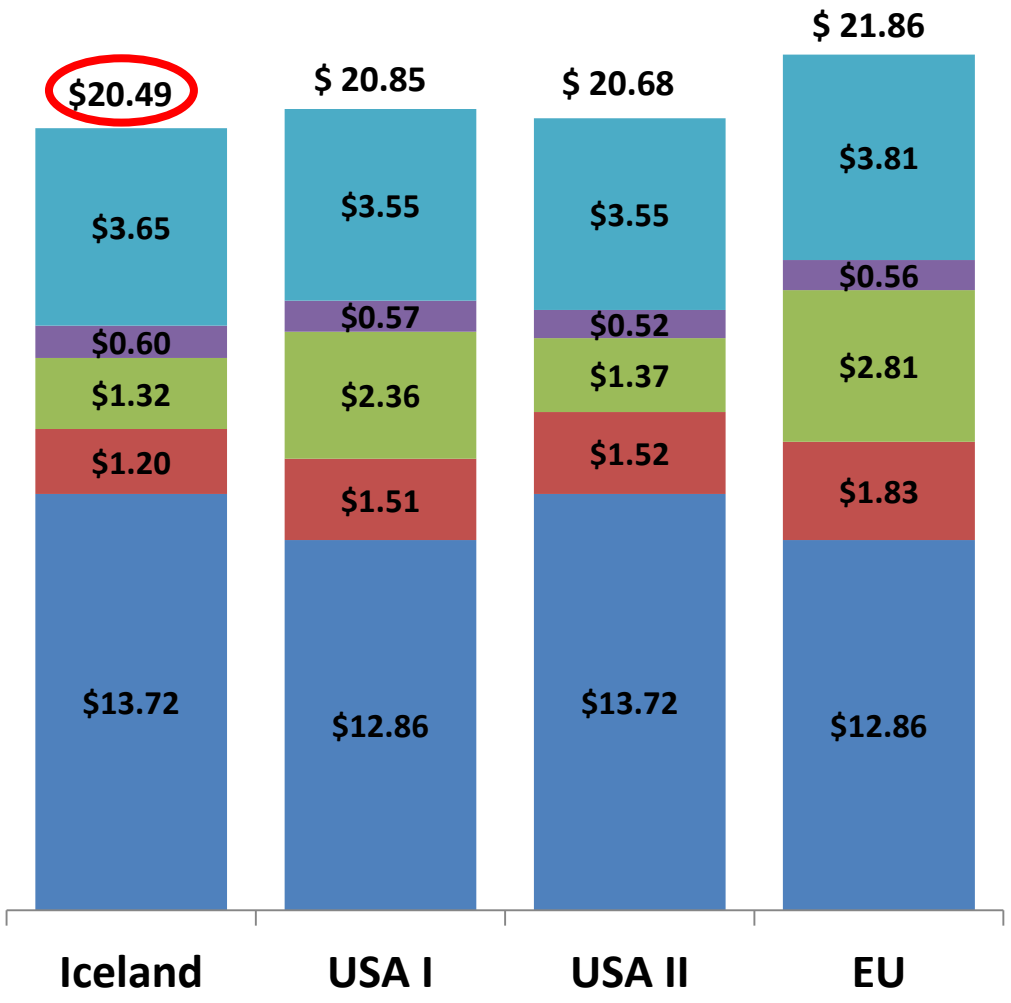
Estimates were collected assuming a maximum load (19,000 kg) for a 40 ft container. 600 kg of precursor per package 45” x 45”. Each row contains skids stacked 2 high side by side (4 skids per 45” row which is equivalent to 2,400 kg). 10 rows possible for maximum of 24,000 kg…meaning a full load can be achieved.

A typical example is provided in the following slide. Different ports of export/import were considered from West coast/East coast of US to Europe with results being very similar.

~$0.194 per kg to ship with 2.1 kg of precursor required for 1 kg carbon fiber therefore, **~$0.407** per kg carbon fiber costs related to shipping precursor.

COGS SUMMARY

Iceland should offer competitiveness with established facilities.

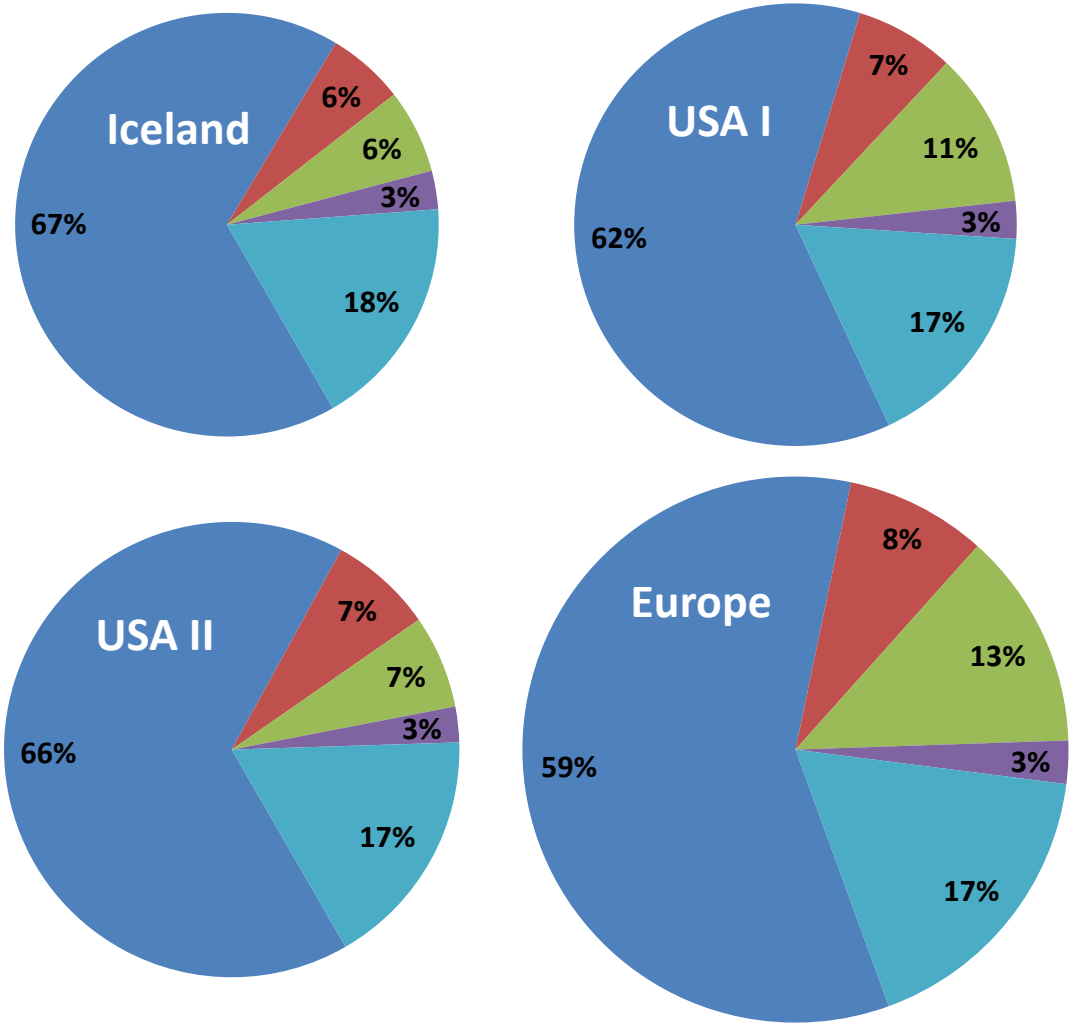


COGS REGIONAL COMPARISON

A graphical depiction of the breakdown of carbon fiber cost

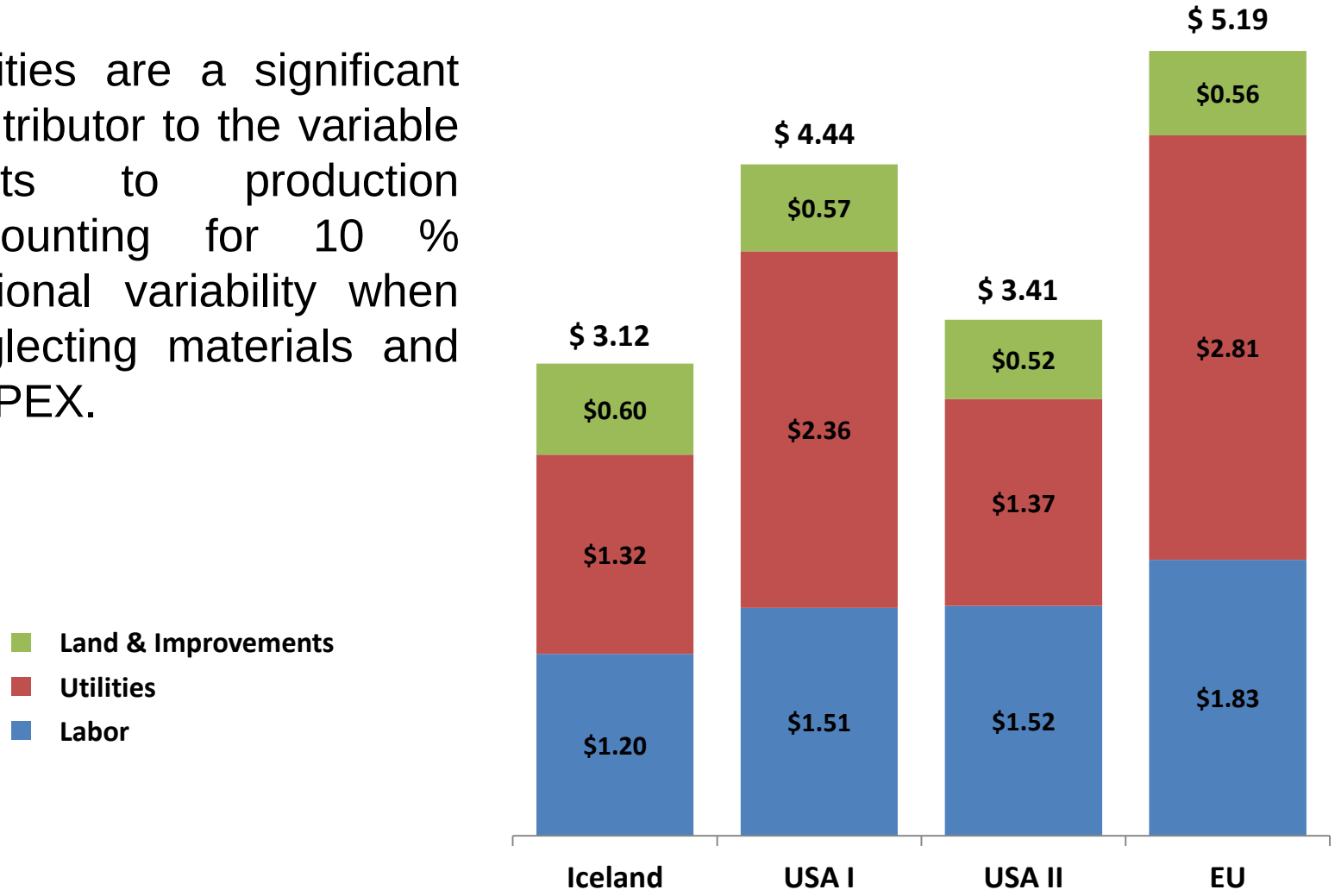
The size of the area is directly proportional to the cost of production

(the higher the cost - the bigger the cake)



COGS (MATERIAL, CAPEX) REMOVED

Utilities are a significant contributor to the variable costs to production accounting for 10 % regional variability when neglecting materials and CAPEX.

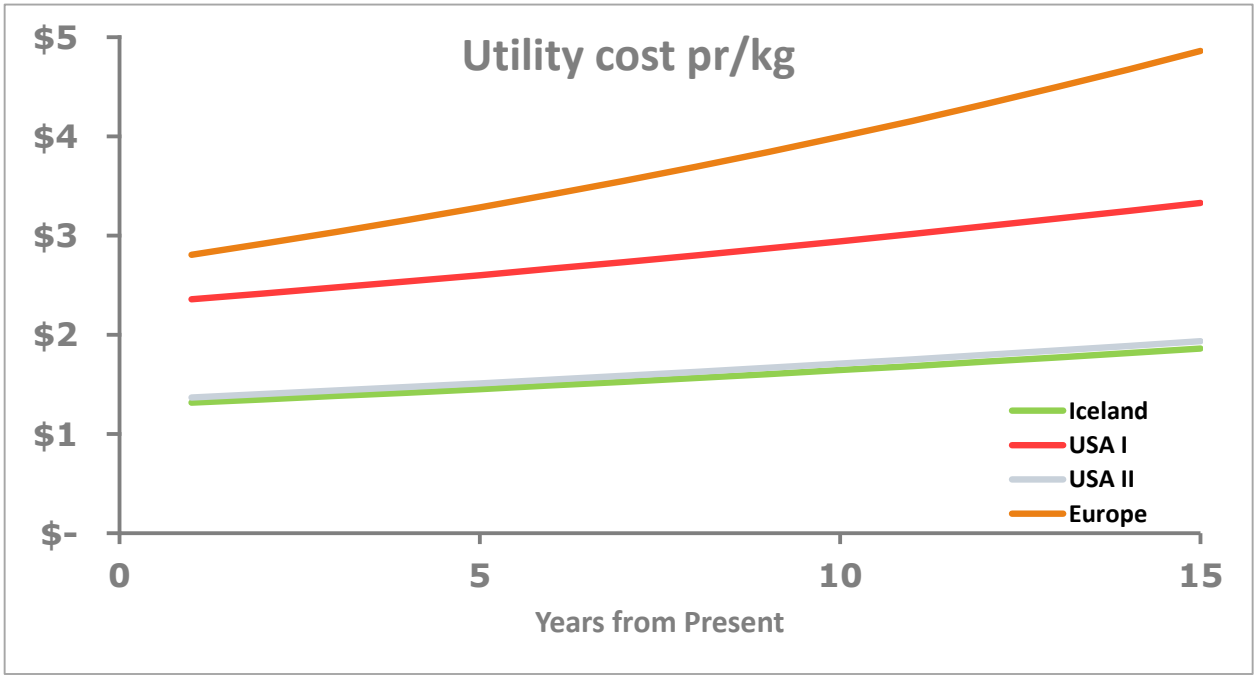


PROJECTED UTILITY COST IMPACT ON PRODUCTION

The projected utility costs per kg of carbon fiber assumes an average annual inflation rate of energy of the following:

Iceland and USA	**2.5 %**
EU	**4.0 %**

It assumes no improvements in electric consumption per kg of carbon fiber produced.



These figures are theoretical to give guidance on the significant impact utility rates could have on the production cost of carbon fiber.