10.3 Appendix C: Model design assumptions

A Electricity generation – onsite electrolysis – hydrogen transport 160 km

	Sizing	Energy use/efficiency	Capital cost	Cost per unit
Generation	Rated outputs from literature 5-60 MW	Capacity factors from literature	Current capital cost from literature. Future capital cost scaled with future costs / kWh	Costs p/kWh from literature. Low and high values.
Electrolysis	At rated output of generation	now 4.5 kWh/Nm3 (67%) 2020 3.8 kWh/Nm3 (79%) extrapolated	Current and future capital cost / kWout from literature.	Discounted capital cost 20 years, 10% plus 2-3% O&M costs.
Compression	At rated output of generation	Compression to 20 MPa Energy use 2.2 kWh/kg Future energy use considered to be the same	Cost per kW with scale factor and pressure exponent Future capital cost decrease by 5%	Discounted capital cost 22 years, 10%. No O&M or water costs considered
Compressed storage	Intermittency dependent at generation site (0.5-3 days) 0.5 days at refuelling station	20 MPa	Cost per kg with scale factor and pressure exponent Future capital cost decrease by 10%	Discounted capital cost 22 years, 10%. No O&M costs considered
(Liquefaction)	At average output of generation	Energy use 8 kWh/kg Future 4.9 kWh/kg	Cost /kg/hr with sizing exponent Future capital cost decrease by 15%	Discounted capital cost 22 years, 10%. No O&M or water costs considered
(Liquid storage)	0.3-4 days at generating site 5-7.5 days at refuelling station	Boil off rate 0.1% Future boil off rate considered to be the same	Cost per kg with sizing exponent Future capital cost decrease by 10%	Discounted capital cost 22 years, 10%. No O&M costs considered
Compressed transport	160 km To no. of stations possible from generation output	Diesel consumption 6 mpg as in Amos (1998). Emissions estimated per km return.	Using costs from Amos – for 45 kg/hr Here have 25-33 kg/hr per station Future capital cost decrease by 5%	Using costs from Amos Future costs decrease by 5%
(Liquid transport)	160 km To no. of stations possible from generation output	Diesel consumption 6 mpg as in Amos (1998). Emissions estimated per km return.	Using costs from Amos – for 45 kg/hr Here have 25-33 kg/hr per station Future capital cost decrease by 5%	Using costs from Amos Future costs decrease by 5%
(Pipeline)	156 km then 4.5km branches No onsite or forecourt storage	No losses included	Costs extrapolated for pipe throughput needed from literature values. Future capital cost decrease by 5%	Costs extrapolated for pipe throughput from literature values. Future cost decrease 5%
Dispensing	For throughput needed	No losses included No energy use or emissions considered	Capital costs from literature. Future capital cost decrease by 5% for compressed, 15% for liquid dispensing	Discounted capital cost over 20 years, 10%

B Electricity generation – grid – regional electrolysis –storage - hydrogen transport 50km radius

	Sizing	Energy use/efficiency	Capital cost	Cost per unit
Generation	Rated outputs from literature 5-60 MW	Capacity factors found from literature	Current capital cost from literature. Future capital cost scaled with future costs / kWh	Costs p/kWh from literature. Low and high values.
Grid		*Loss 7.62 %*	*Not included*	*From literature –0.3 to 0.25p/kWh*
Electrolysis	*To supply total FCV H2 demand of stations in 50 km radius*	now 4.5 kWh/Nm3 (67%) 2020 3.8 kWh/Nm3 (79%) extrapolated	Current and future capital cost / kWout from literature.	*Discounted capital cost 20 years, 10% plus 2-3% O&M costs. Spread over total output*
Compression	*To supply total FCV H2 demand of stations in 50 km radius (regional*)	Compression to 20 MPa Energy use 2.2 kWh/kg Future energy use considered to be the same	*Cost per kW with sizing exponent* *Future capital cost decrease by 5%* *Cost attributed in proportion to output*	*Discounted capital cost 22 years, 10%. Spread over total output* *No O&M or water costs considered*
Compressed storage	*1 hour storage at electrolyser 0.5 days' demand at station*	20 MPa	*Cost per kg with sizing exponent* *Cost attributed in proportion to output* *Future cost capital cost decrease by 10%*	*Discounted capital cost 22 years, 10%. Spread over total storage* *No O&M costs considered*
(Liquefaction)	*To supply total FCV H2 demand of stations in 50 km radius (regional)*	Energy use 8 kWh/kg Future 4.9 kWh/kg	*Cost /kg/hr with sizing exponent* *Cost attributed in proportion to output* *Future capital cost decrease by 15%*	*Discounted capital cost 22 years, 10%. Spread over total output* *No O&M or water costs considered*
(Liquid storage)	*1 hour storage at electrolyser 5-7.5 days' demand at station*	Boil off rate 0.1% Future boil off rate considered to be the same	*Cost per kg with sizing exponent* *Cost attributed in proportion to output* *Future cost capital cost decrease by 10%*	*Discounted capital cost 22 years, 10%. Spread over total output* *No O&M costs considered*
Compressed transport	*33 km* *To no. of stations possible from generation output*	Diesel consumption 6 mpg as in Amos (1998). Emissions estimated per km return.	Using costs from Amos – for 45 kg/hr Here have 25-33 kg/hr per station Future capital cost decrease by 5%	Using costs from Amos Future capital cost decrease by 5%
(Liquid transport)	*33 km* *To no. of stations possible from generation output*	Diesel consumption 6 mpg as in Amos (1998). Emissions estimated per km return.	Using costs from Amos – for 45 kg/hr Here have 25-33 kg/hr per station Future capital cost decrease by 5%	Using costs from Amos Future capital cost decrease by 5%
(Pipeline)	*4.45 km branches only*	No losses included	Costs extrapolated for pipe throughput needed from literature values. Future capital cost decrease by 5%	Costs extrapolated for pipe throughput from literature values. Future cost decrease 5%
Dispensing	For throughput needed	No losses included No energy use or emissions considered	Capital costs from literature. Future capital cost decrease by 5% for compressed, 15% for liquid dispensing	Discounted capital cost over 20 years, 10%

C Electricity generation – grid – forecourt electrolysis

	Sizing	Energy use/efficiency	Capital cost	Cost per unit
Generation	Rated outputs from literature 5-60 MW	Capacity factors found from literature	Current capital cost from literature. Future capital cost scaled with future costs / kWh	Costs p/kWh from literature. Low and high values.
Grid		*Loss 7.62 %*	*Not included*	*From literature –0.3 to 0.25p/kWh*
Electrolysis	*To supply total FCV H2 demand of station*	now 4.5 kWh/Nm3 (67%) 2020 3.8 kWh/Nm3 (79%) extrapolated	*Current and future capital cost / kWout from literature for 1 MW scale. Future cost scaled with projected decrease at >2MW scale*	Discounted capital cost 20 years, 10% plus 2-3% O&M costs
Compression	*At rated output of electrolyser*	Compression to 20 MPa Energy use 2.2 kWh/kg Future energy use considered to be the same	Cost per kW with sizing exponent Future capital cost decrease by 5%	Discounted capital cost 22 years, 10% No O&M or water costs considered
Compressed storage	*At 0.5 days' rated output of electrolyser*	20 MPa	Cost per kg with sizing exponent Future capital cost decrease by 10%	Discounted capital cost 22 years, 10% No O&M costs considered
(Liquefaction)	*At rated output of electrolyser*	Energy use 8 kWh/kg Future 4.9 kWh/kg	Cost /kg/hr with sizing exponent Future capital cost decrease by 15%	Discounted capital cost 22 years, 10% No O&M or water costs considered
(Liquid storage)	*At 0.5 days' rated output of electrolyser*	Boil off rate 0.1% Future boil off rate considered to be the same	Cost per kg with sizing exponent Future cost decrease by 10%	Discounted capital cost 22 years, 10% No O&M costs considered
Dispensing	For throughput needed	No losses included No energy use or emissions considered	Capital costs from literature. Future capital cost decrease by 5% for compressed, 15% for liquid dispensing	Discounted capital cost over 20 years, 10%

D Forecourt generation – forecourt electrolysis

	Sizing	Energy use/efficiency	Capital cost	Cost per unit
Generation	*Rated outputs from literature*	*Capacity factors from literature for wind. Future factor scaled with efficiency increase from 15 to 20% for PV*	Current capital cost found from literature. Future capital cost scaled with future costs / kWh	Costs p/kWh from literature. Low and high values.
Electrolysis	*At rated output of generation*	*now 3.9 kWh/Nm3 (77%)* *2020 3.8 kWh/Nm3(79%)*	*Current and future capital cost / kWout from literature for 0.25 MW scale. Future cost scaled with projected decrease at >2MW scale*	Discounted capital cost 20 years, 10% plus 2-3% O&M costs.
Compression	*At rated output of generation*	Compression to 20 MPa Energy use 2.2 kWh/kg Future energy use considered to be the same	Cost per kW with sizing exponent Future capital cost decrease by 5%	Discounted capital cost 22 years, 10%. No O&M or water costs considered
Compressed storage	*3 days average output of generation*	20 MPa	Cost per kg with sizing exponent Future capital cost decrease by 10%	Discounted capital cost 22 years, 10%. No O&M costs considered
(Liquefaction)	*At average output of generation*	Energy use 8 kWh/kg Future 4.9 kWh/kg	Cost /kg/hr with sizing exponent Future capital cost decrease by 15%	Discounted capital cost 22 years, 10%. No O&M or water costs considered
(Liquid storage)	*At 0.5 days' rated output of electrolyser*	Boil off rate 0.1% Future boil off rate considered to be the same	Cost per kg with sizing exponent Future cost decrease by 10%	Discounted capital cost 22 years, 10%. Actual output considered No O&M costs considered
Dispensing	*For throughput needed for wind, minimum scale (one dispenser) considered for PV*	No losses included No energy use or emissions considered	Capital costs from literature. Future capital cost decrease by 5% for compressed, 15% for liquid dispensing. Minimum cost for PV	Discounted capital cost over 20 years, 10%

E Biomass production – biomass transport - gasification – hydrogen transport 50km radius

	Sizing	Energy use/efficiency	Capital cost	Cost per unit
Production	To supply 30 MWe BIGCC plant equivalent. Yields from literature	Energy ratios from literature. CO2 emissions from literature	Current capital cost from literature. Future capital cost assumed to be the same.	Costs p/GJ from literature Future costs same
Transport	Transported average distance of point in circle of biomass production (5% land use, tortuosity 1.5) – about 30 km	Energy use and emissions factors from literature	Not included	Cost / tkm from literature Future costs same
Gasification	At 70 MW biomass in - about 43MW out	55% efficiency including electricity use. Future 63%	From literature Future capital cost decrease by 15%	Discounted capital cost 25 years, 10%, no O&M
Compression	At rated output of generation	Compression to 20 MPa Energy use 2.2 kWh/kg Future energy use the same	Cost per kW with sizing exponent Future capital cost decrease by 5%	Discounted capital cost 22 years, 10%. No O&M or water costs
Compressed storage	1 hour storage at electrolyser 0.5 days' demand at station	20 MPa	Cost per kg with sizing exponent Future cost decrease by 10%	Discounted capital cost 22 years, 10%. No O&M costs
(Liquefaction)	At rated output of generation	Energy use 8 kWh/kg Future 4.9 kWh/kg	Cost /kg/hr with sizing exponent Future capital cost decrease by 15%	Discounted capital cost 22 years, 10%. No O&M or water costs
(Liquid storage)	At 1 days' rated output of generation at generation site 3 days' demand at station	Boil off rate 0.1% Future boil off rate the same	Cost per kg with sizing exponent Future capital cost decrease by 10%	Discounted capital cost 22 years, 10%. No O&M costs considered
Compressed transport	*32 km* *To no. of stations possible from generation output*	Diesel consumption 6 mpg as in Amos (1998). Emissions estimated per km return.	Using costs from Amos – for 45 kg/hr Here have 25-33 kg/hr per station Future capital cost decrease by 5%	Using costs from Amos Future capital cost decrease by 5%
(Liquid transport)	*32 km* *To no. of stations possible from generation output*	Diesel consumption 6 mpg as in Amos (1998). Emissions estimated per km return.	Using costs from Amos – for 45 kg/hr Here have 25-33 kg/hr per station Future capital cost decrease by 5%	Using costs from Amos Future capital cost decrease by 5%
(Pipeline)	*4.45 km branches only*	No losses included	Costs extrapolated for pipe throughput needed from literature values. Future capital cost decrease by 5%	Costs extrapolated for pipe throughput from literature values. Future cost decrease 5%
Dispensing	For throughput needed	No losses included No energy use or emissions	Capital costs from literature. Future capital cost decrease by 5% for compressed, 15% for liquid	Discounted capital cost over 20 years, 10%