

Investment Costs (US\$/kW)

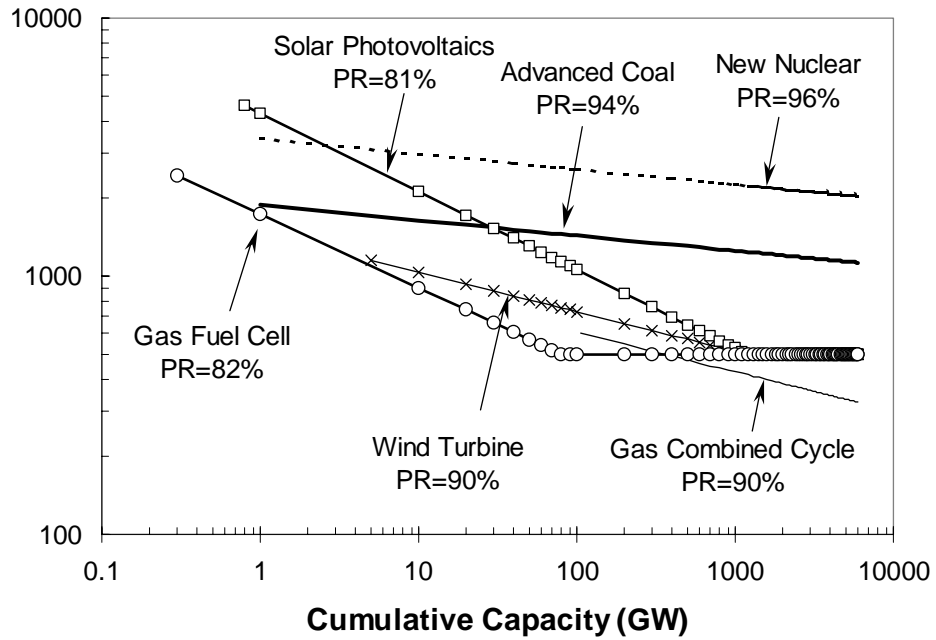


Fig. 1. Learning curves assumed for electricity generation technologies. Markers are used only to distinguish different curves. Progress ratio (PR) gives the reduction in specific investment cost when cumulative installations double. Figure taken from [15].

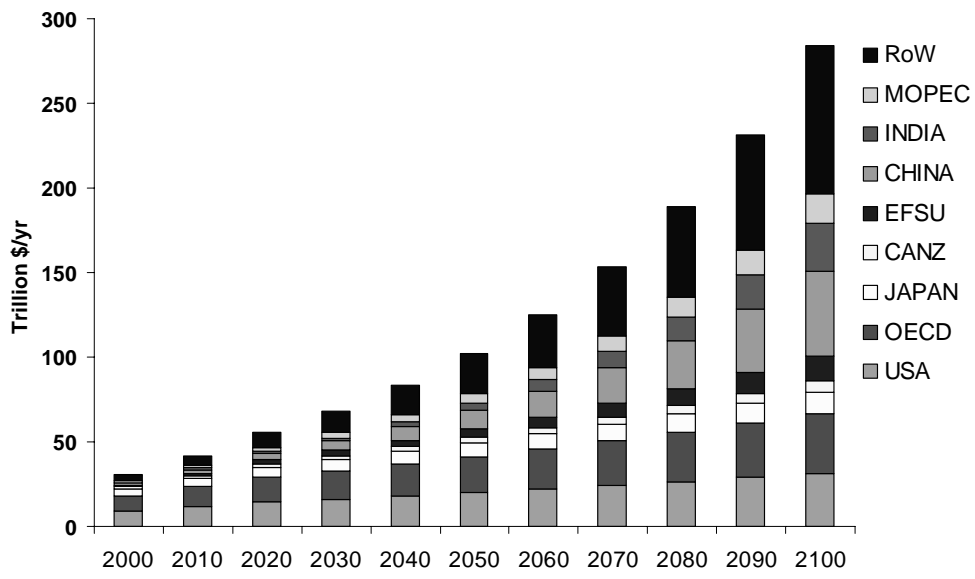


Fig. 2. Regional GDP in the BaUN case; the current developing countries will produce more than 66% of the global economic output late in the century while OECD contributes by only 30%.

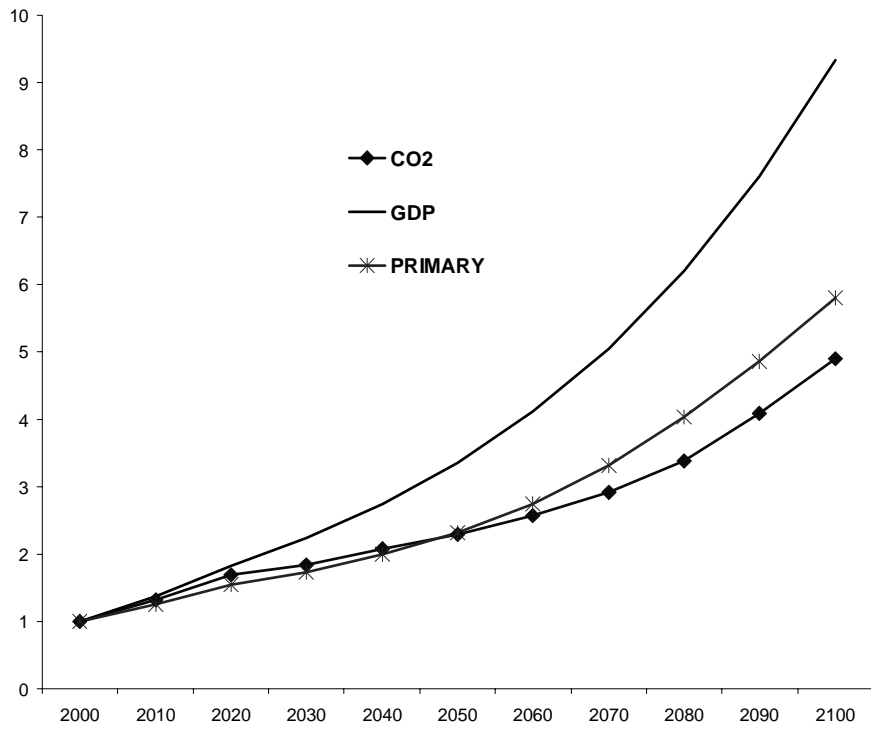


Fig. 3. Energy and Economic Indices for the baseline BaUN case

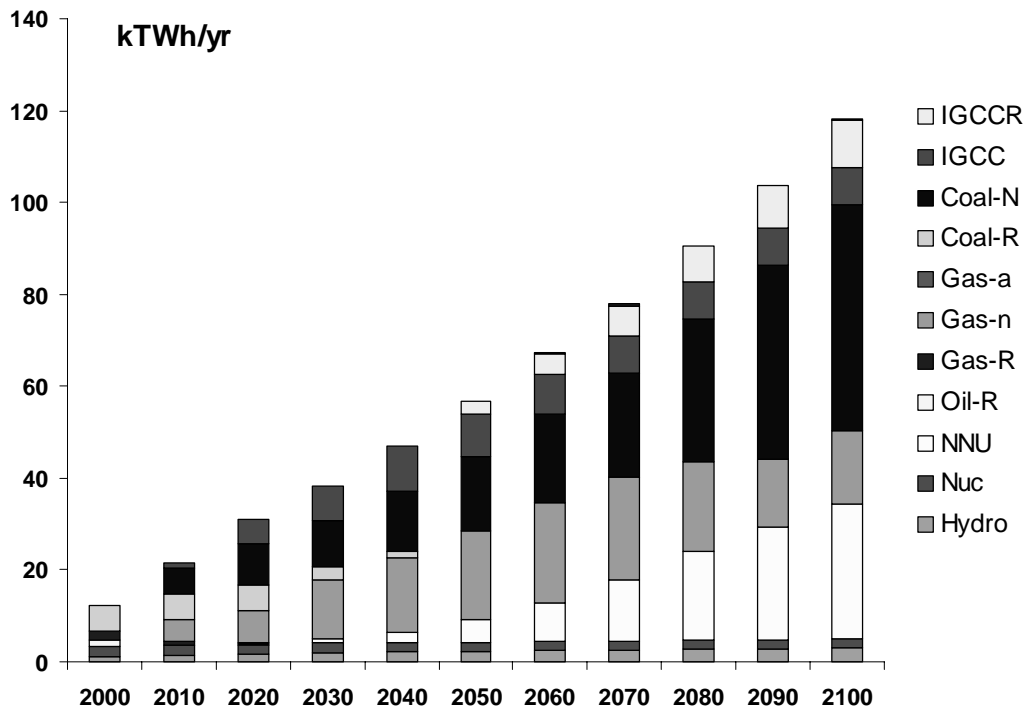


Fig. 4. Electricity Generation in the BauL case

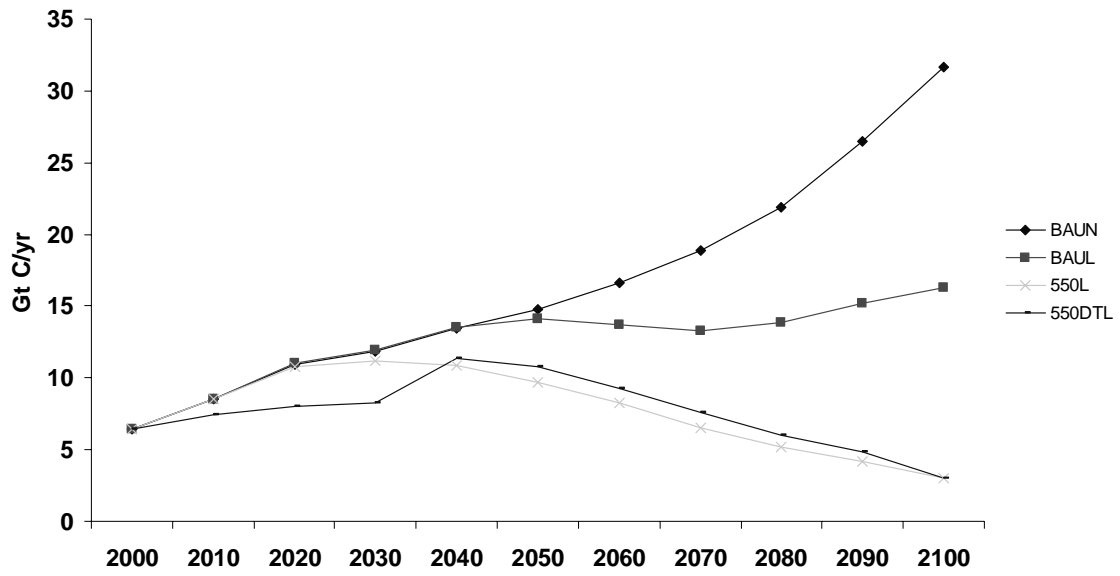


Fig. 5. Carbon emission paths for the reference and the stabilisation cases analysed

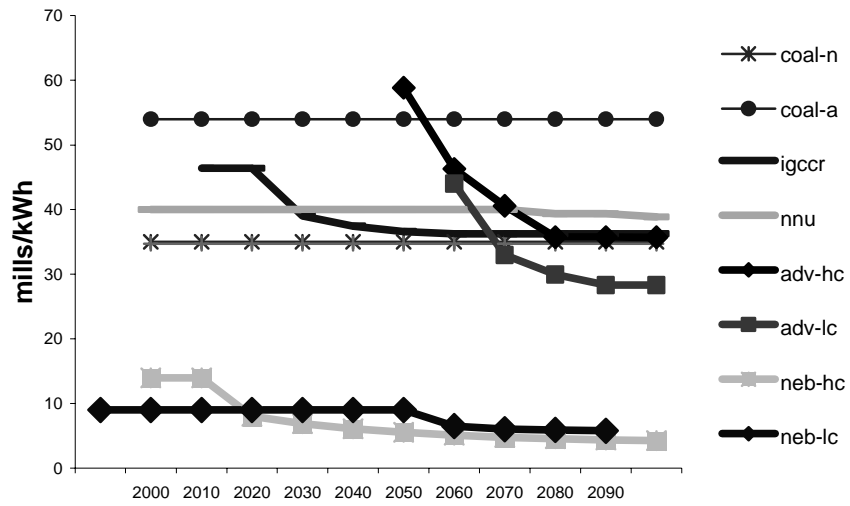


Fig. 6: Electricity generating cost in the 550L case. Here the autonomous cost reduction is not shown; ADV-HC, ADV-LC, IGCCR, NEB-LC, NEB-HC and NNU assume cost reduction due to LBD.

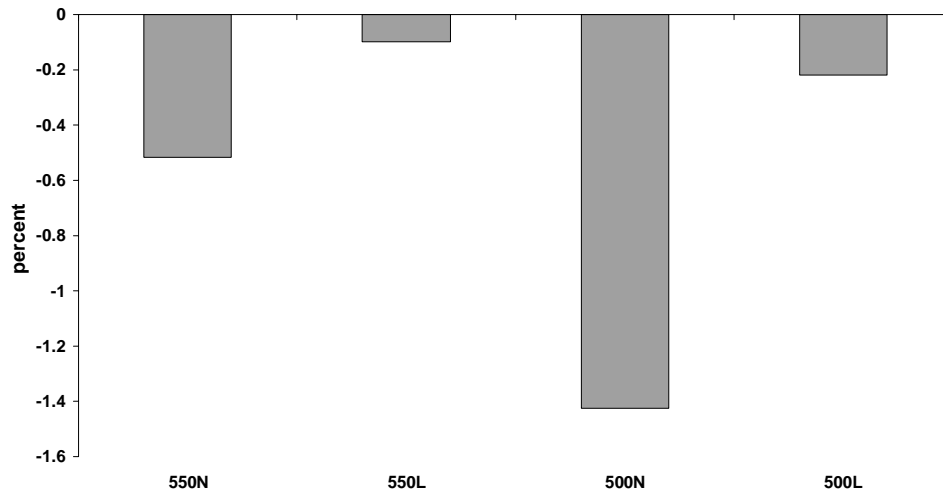


Fig. 7. Cumulative and undiscounted GDP losses for the atmospheric carbon stabilisation cases, relative to the GDP of BaUN, in percent. The cumulative and undiscounted GDP losses are significantly reduced by LBD; thus, in the 550-ppmv-stabilisation case the cumulative losses (0.52%) are reduced to 0.1 % while in the 500-ppmv case losses are reduced from 1.42% to 0.22%.

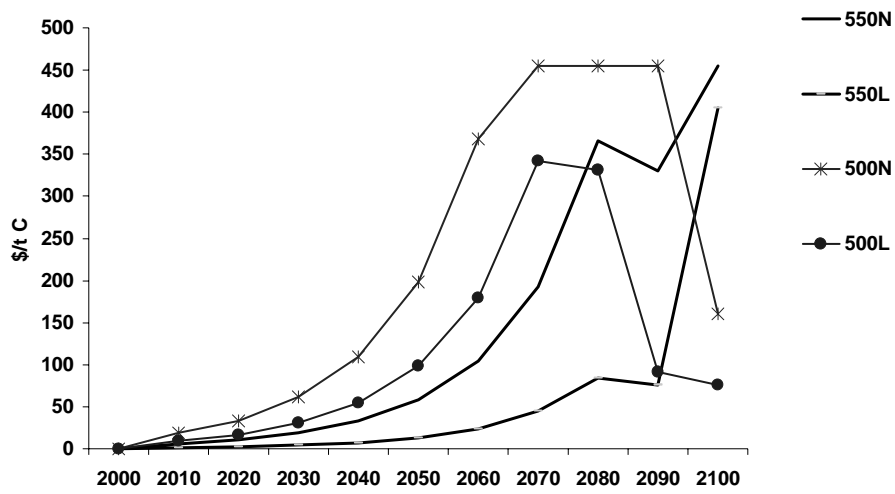


Fig. 8. The marginal costs in the case of LBD are reduced well below \$100 per ton of Carbon by the year 2090 in the 550-ppmv cases due to the introduction of fossil fuel sequestration options and the penetration of renewables in the non-electric markets. The shape of the marginal costs reflects the price of a resource with limited cumulative availability. Only in the last period an extra constraint that is forcing a maximum production of emissions to 3 Gt of carbon, is changing the shape of the marginal cost function. The 500-ppmv stabilisation cases imply higher marginal costs.

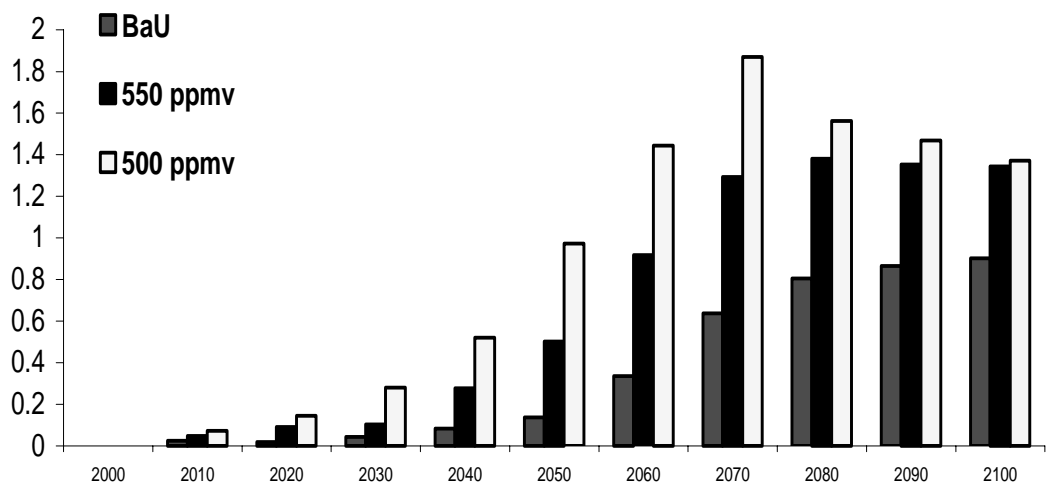


Fig. 9. “GDP gains” from “learning-by-doing” expressed as percentage change relative to the baseline case without LBD, (e.g., $100 (BaUL - BaUN) / BaUN$); gains increase at lower CO₂ stabilisation targets.

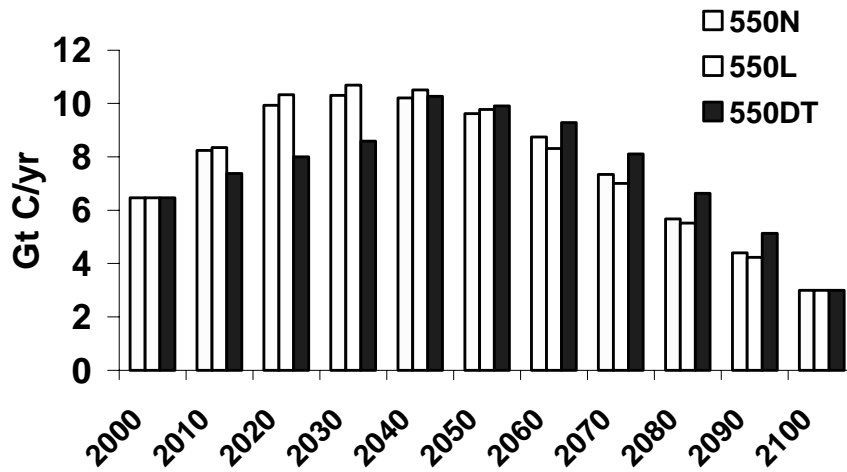


Fig. 10: LBD (second column) is postponing actions to reduce carbon emissions by a few decades while annual emissions remain almost as in the BaUL case. Results are quite different if another constraint is imposed concerning the rate of temperature change (e.g., by applying a maximum temperature increase of 0.21 degree Celsius per decade) as shown for the 550DT case.

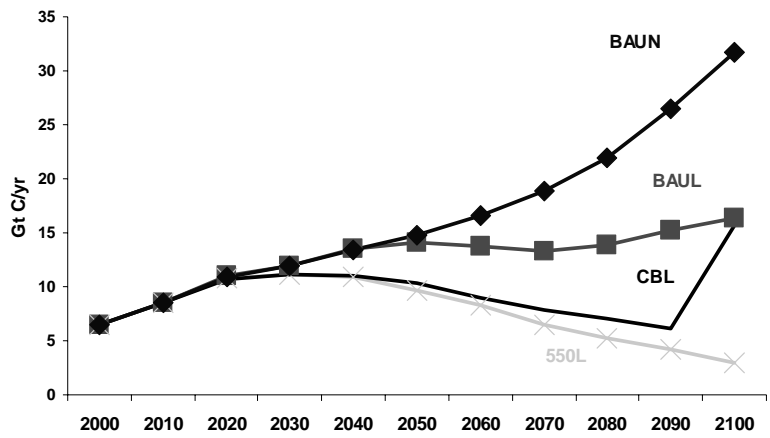


Fig. 11. Emissions in the C/B case with ETL are quite similar to the emission levels of the 550-ppmv case while the corresponding concentrations remain around 590-ppmv.

Table 1: Technologies used in MERGE-ETL and naming conventions

| <i>Technology name</i> | | <i>Identification/Examples</i> | <i>Introduction date</i> |
|---------------------------|---|--------------------------------|--------------------------|
| Electric Technologies | | | Introduction date |
| HYDRO | Hydroelectric, geothermal and other renewables | | Existing |
| NUC | Remaining initial nuclear | | Existing |
| GAS-R | Remaining initial gas fired | | Existing |
| OIL-R | Remaining initial oil fired | | Existing |
| COAL-R | Remaining initial coal fired | | Existing |
| GAS-N | Advanced combined cycle | | 2000 |
| GAS-A | Advanced combined cycle with sequestration and LBD | | 2020 |
| COAL-N | Pulverized coal without CO2 recovery; | | 2000 |
| COAL-A | Pulverized coal with CO2 recovery and LBD | | 2020 |
| IGCC | Integrated gasification and combined cycle without CO2 removal | | 2010 |
| IGCCR | Integrated gasification and combined cycle with CO2 removal and LBD | | 2020 |
| ADV-HC | Carbon-free technologies (e.g., SPV); costs decline with LBD (high cost) | | 2000 |
| ADV-LC | Carbon-free technologies (e.g., WND); costs decline with LBD (low cost) | | 2000 |
| NNU | Carbon-free technologies (e.g., New nuclear); costs decline with LBD (low cost) | | 2010 |
| Non-Electric Technologies | | | |
| CLDU | Coal Direct use | | Existing |
| OIL1-OIL10 | Oil categories | | Existing |
| GAS1-GAS10 | Gas categories | | Existing |
| SYNF | Synthetic fuels w/o Learning | | Existing |
| RNEW | Renewables w/o Learning | | Existing |
| NEB -HC | Renewables Back-stop High cost with LBD e.g., Hydrogen from SPV, nuclear, etc. | | 2010 |
| NEB -LC | Renewables Back-stop Low cost with LBD | | 2010 |

Table 2: Technical data for systems used in MERGE-ETL

| | <i>Gen. Costs mills/kWh</i> | <i>Carbon Emissions Kg C/kWh</i> | <i>specific cost \$/kW</i> | <i>load factor</i> | <i>life years</i> | <i>Learning rate (-)</i> | <i>floor cost \$/kW</i> |
|--|---------------------------------|--------------------------------------|--------------------------------|------------------------|-----------------------|------------------------------|-----------------------------|
| Electric Technologies | | | | | | | |
| HYDRO | 40 | 0 | | | | | |
| NUC | 37 | 0 | | | | | |
| GAS-R* | 6.3 | 0.1443 | | | | | |
| OIL-R* | 6.3 | 0.2094 | | | | | |
| COAL-R | 20.3 | 0.2533 | | | | | |
| GAS-N* | 9.1 | 0.087 | | | | | |
| GAS-A* | 18.4 | 0.01 | 1010 | 0.7 | 25 | 0.11 | 550 |
| COAL-N* | 35 | 0.209 | 1300 | | | | |
| COAL-A | 54 | 0.0068 | 2090 | 0.7 | 25 | 0.05 | 800 |
| IGCC | 34.7 | 0.193 | 1400 | | | | |
| IGCCR | 46.4 | 0.026 | 1910 | 0.7 | 25 | 0.05 | 1000 |
| ADV-HC | 220 | 0 | 5000 | 0.25 | 25 | 0.2 | 1000 |
| ADV-LC (Wind) | 44 | 0 | 1000 | 0.25 | 25 | 0.11 | 400 |
| NNU | 40 | 0 | 2500 | 0.7 | 25 | 0.04 | 1000 |
| Non-Electric Technologies | | | | | | | |
| | <i>\$/GJ</i> | <i>t C/GJ</i> | <i>\$/GJ</i> | | | | <i>\$/GJ</i> |
| CLDU | 2.5 | 0.0241 | | | | | |
| OIL1-OIL10 | 3.00-5.25 | 0.0199 | | | | | |
| GAS1-GAS10 | 2.00-4.25 | 0.0137 | | | | | |
| SYNF | 8.33 | 0.4 | | | | | |
| RNEW | 6 | 0 | | | | | |
| NEB -HC | 14 | 0 | 13.3 | 1 | 20 | 0.15 | 4 |
| NEB -LC | 9 | 0 | 10 | 1 | 20 | 0.1 | 4 |
| * Gas and oil systems do not include fuel cost | | | | | | | |