# APPENDIX 3
# ENERGY SUPPLY ANALYSIS SUMMARY

The following table summarizes the results of the energy supply analysis conducted as part of the development of the CAP (Phase 1).

Analysis drew upon the comprehensive Alternate Energy Feasibility Study done as part of the 2010 CAP, and included an updated review, considering current economic conditions and technology developments.

Each energy supply option was screened against the CAP evaluation criteria, with an initial focus on meeting the financial criterion (potential for positive return) and the potential to reduce GHGs for 2020.

Two options emerged from this analysis as recommended for further investigation:

1. Expand BRDF biomass capacity from 6 MW thermal to 18 MW thermal.
2. Purchase Renewable Natural Gas.

As a third option, based on discussions with potential technology and funding partners, there may be additional energy supply options that integrate new research elements or technology opportunities with biomass and/or RNG supply systems. These opportunities will continue to be explored in parallel with the main two options above. Additional analysis will include:

1. Additional energy supply and financial risk analysis
    a. Future biomass & RNG supply & demand, and future pricing risks
    b. Balancing risks of current & alternative fuel supplies
    c. Risk mitigation strategies
2. A more detailed costing and feasibility study of the potential biomass expansion (option 1).
3. Continue to incorporate information on carbon pricing into options analysis as it becomes available.
4. Continue to explore and evaluate other energy supply research and partnership opportunities (option 3).
5. Based on the outcomes from the above actions, recommend energy supply alternatives for implementation, by early 2017.

| | Supply Side Goals = 10,000 tonnes/yr or 200,000 GJ/yr savings | | | | | | | | | | | | | | | | |
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| | **CAP2020 Action Matrix - Energy Supply** | | | | | | | | **Assessment \| 1=least/worst; 5=most/best** | | | | | | | | |
| **Sub sector** | **ID** | **Idea Source** | **Option** | **Additional descriptive comments** | **Additional resources required:** **i.e. new staff, external consultant, OPEX or CAPEX funding** | **Further Research / Study Needed** | **Assessment Comments** | **Prioritization P=priority F=future R=research N=not recommended** | ***Impact 2020** | **Impact 2050** | ***Political & governance acceptability** | ***Ease of Implementation: within UBC control, lack of barriers** | **Acceptable risks** | **Other opportunities** | **Financial performance** | **Score (full)** | **Potential GHG reduction (tonnes/ year)** |
| ES | ES-1 | Wkshp | Increase BRDF renewable energy supply by 12 MW thermal | | Approx $12M capital | Initial feasibility and costing complete. Detailed design, costing, fuel study, and emissions study needed. | Likely positive NPV after 25 years, some concerns around supply availablility and supply diversidication. Note risk of achieving implementation by 2020. | R | 4.5 | 3.5 | 2.8 | 4.3 | 3.3 | 3.5 | 3.3 | 25.2 | 12,000 |
| ES | ES-2 | Wkshp | Renewable N.G. from Fortis BC | | No capital needed if RNG purchased | Requires further study Also investigate potential for biogas from UBC dairy (off campus) | No capital, low risk, uncertain NPV. NPV may get close to zero if carbon tax increases. | R | 5.0 | 5.0 | 3.3 | 4.0 | 3.7 | 2.5 | 1.7 | 25.1 | Scalable depending on availability |
| ES | ES-3 | Wkshp | Renewable N.G. direct sourcing | | No capital needed if RNG purchased | Requires further study. Need to negociate long tern contract with Vancouver Landfill or other equivalent source. | No capital, low risk, uncertain NPV. NPV may get close to zero if carbon tax increases. | R | 5.0 | 5.0 | 3.0 | 2.8 | 3.0 | 3.0 | 2.3 | 24.1 | Scalable depending on availability |
| ES | ES-6 | Wkshp | Solar Thermal | Could implement a centralized system and/ or distributed systems. Note also potential for integrated therml/ PV systems. Consider a future requirement to make all buildings solar ready as part of green building plan. | | Yes: launch a SEEDS study, perhaps with SBS, to do a cost/feasibility study. | Does not deliever heat when most needed i.e. winter time and early morning, New SUB building (Nest) has Solar Thermal, review performance after some operational experience. | F | 1.5 | 2.5 | 2.8 | 3.8 | 4.0 | 3.0 | 2.3 | 19.8 | <2,000 |

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| ES | ES-10 | Wkshp | Geothermal | | | Study have been completed for both Deep geothermal and geoexchange. | Deep Geothermal has high risks including the possibility of inducing an earthqauke from fracking. Geoexchange does not fair well at UBC due to low K Value (.5 watts/ m^2) Prioritize Waste heat over geothermal. | N | 2.3 | 3.0 | 3.3 | 2.8 | 2.3 | 3.5 | 1.0 | 18.1 | Potentially scalable. |
| ES | ES-5 | Wkshp | Solar PV (electricity) | Consider a future requirement to make all buildings solar ready as part of green building plan. | | | Cost of PV installation ~$4/ Watt still to high for reasonable paybacks. Current scope 2 GHG emission only ~2,000 tonnes/ yr minor impact on 2020 GHG emissions | F | 0.8 | 1.0 | 2.8 | 4.0 | 3.7 | 3.5 | 1.7 | 17.3 | <2000 |
| ES | ES-9 | Wkshp | Waste to Energy | Could be combustion or gasification of solid waste, or biogas production from organics. | | | Potential issues/ concerns with air emissions. Typically need ~100,000 tonne/ yr facility to be economically viable; UBC produces 1,000 tonnes - 5,000 tonnes depending on waste types included. | N | 2.8 | 4.0 | 0.8 | 1.3 | 2.0 | 3.5 | 3.0 | 17.3 | Potentially up to 10,000 if large amounts of waste were brought on campus. |

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| ES | ES-4 | Wkshp | TRIUMF waste heat recovery with energy purchase from Corix | This would include moving implementation earlier, to 2019 instead of the currently anticipated 2024. | | | 4000-8000 tonnes/yr depending on schedule and Neighbourhood District Energy System future growth. Negative NPV (would be positive if implemented at planned timeframe of 2024), low risk, high cost, not in direct UBC control, requires a lot of electrical power. Waste heat availability expected to diminish as south campus neighbourhood is built out. | N | 2.5 | 2.5 | 2.3 | 2.0 | 3.3 | 3.0 | 1.3 | 16.9 | 4000 - 8000 |
| ES | ES-7 | Wkshp | Waste heat recovery (Sewer heat) | | | | Current Sewer water flows ~100 liters per second (70 from north campus 30 from south campus) = ~1-2 MW heat recovery or ~2000 tonnes reduction max Issues with fouling and operational costs a concern TRIUMF heat recovery is preferable due to capacity and water quality. | N | 1.3 | 1.5 | 2.5 | 3.3 | 3.0 | 3.0 | 2.0 | 16.5 | <2000 |
| ES | ES-13 | Wkshp | Thermal Storage | | | | Not currently required 10 year out at least. Expensive. | N | 1.0 | 2.0 | 2.5 | 3.0 | 2.7 | 3.0 | 1.7 | 15.8 | Requires research |

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| ES | ES-18 | Public callout | Implement an Energy Internet including distributed generation such as solar. | | | | Minimal impacts on GHGs. May be more relevant as part of peak electrical demand management.<br>Key enabler is the feed in tariff, in a broader context outside UBC. WE don't have the business case yet, no subsidies.<br>For UBC, this option would probably entail distributed solar generation. | N | 1.0 | 1.0 | 2.5 | 2.0 | 1.5 | 3.5 | 1.5 | 13.0 | <2000 |
| ES | ES-12 | Wkshp | Sewage Sludge/ bio solids / Gasification at UBC | | | More research required. | Potential at UBC is assumed to be less then 1000 tonnes/ yr based on UBC resources. | N | 1.5 | 2.3 | 1.5 | 1.8 | 1.3 | 3.0 | 1.7 | 13.0 | <1000 but could be much larger if large amounts of biosolids were available from off-campus |
| ES | ES-14 | Researcher Callout | Explore carbon capture and utilization or other research opportunities for future implementation. | This action could include carbon capture; carbon utilization for algae/fish production with demonstration "exhibition hall" (researcher callout idea); or other technologies, in collaboration with researchers and potentially as Campus as a Living Lab project. | | Yes, this would initially be a research project or series of projects. Note that there may have been an LCC analysis done. | Longer term option requiring significant R&D. | F | 0.7 | 2.0 | 2.3 | 1.7 | 2.0 | 2.5 | 1.0 | 12.2 | Requires research |

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| ES | ES-16 | Researcher Callout | Invest in a geothermal electricity generation project off-campus to displace natural gas fired electricity generation (possibly for export) and create offsets that UBC could potentially utilize to reduce its emissions. | | | | Challenging in terms of our level of influence and control. An off campus, offsets-based project. Would be subject to Pacific Carbon Trust criteria for offsets. | N | 0.8 | 2.3 | 1.3 | 2.0 | 2.0 | 2.5 | 1.0 | 11.8 | Requires research |
| ES | ES-8 | Wkshp | Wind power | | | Poor location for wind power average wind speed only 4 meters/second also next to YVR flight path | | N | 1.0 | 1.0 | 1.5 | 1.8 | 2.0 | 2.5 | 1.3 | 11.1 | <2000 |
| ES | ES-11 | Wkshp | Wav / Tidal energy | | | UBC is not an ideal location for wave or tidal power | | N | 1.0 | 1.0 | 2.0 | 1.3 | 1.7 | 3.0 | 1.0 | 10.9 | <2000 |