The EFF-GO Business Plan 2019

The EFF-GO 2019 Business Plan is written as an accompaniment to the EFF-GO 2019 PGF Expression of Interest submission. It contains a brief history of EFF-GO, the people responsible for EFF-GO's progress to date and a Needs, Approach, Benefits and Consequences assessment of the EFF-GO project.

EFF-GO Ltd – a brief history and the people who make it work

EFF-GO formed in 2017 following the Manawatu AgTech Hackathon which brought Simon Jury, Damian Buckley and Murray Holdaway together. Simon has 58% of the shares, Damian 24% and Murray 18%. The division of the shareholding was agreed to reflect who had conceived the novel mechanism for controlling the supercritical water environment and how much effort, time and resources, had been and were being applied to moving the project forward.

- Simon Jury BSc(Hons) MSc DipOHS has over 10 years of experience as an Analytical Chemist, 6 years as a Waste Contract Manager (managing hazardous and non-hazardous wastes associated with significant UK industrial contracts) and over 5 years as a Health and Safety Advisor in the challenging NZ business sectors that are fishing and quarrying. Throughout his career he has repeatedly demonstrated a penchant for innovation and the successful application of science to solve challenges.
    - In 1998 he gained his Ecological Science with Chemistry BSc(Hons) at the University of North London and completed a research placement with Imperial College to study *Phosphate uptake in mixotrophic algae* – the basis of his BSc(Hons) thesis
    - In 2005 he earned a bursary to study an Environmental Diagnostics MSc with Cranfield University and presented a thesis on the *ElectroChemical Peroxidation of Landfill Leachate*. During his study he also passed the Associate membership exams for the Institute of Environmental Management and Assessment
    - In 2010 he began study with the Open University for a BEng(Hons) which turned into a Certificate of Higher Education in Engineering in 2014, as the cost of maintaining study with the OU, whilst living in NZ, became prohibitively expensive
    - In 2016 he graduated from the Southern Institute of Technology with a Diploma in Occupational Health and Safety
- Damian Buckley BA(Hons) has his roots in the rural sector. He has knowledge and experience of both the operational and management aspects of farming. During his career he has become an experienced Business Development Manager with a demonstrated history of working in the rural software industry and media world. He is skilled in Marketing Management, Negotiation, Business Planning, Advertising, and Sales.
    - In 1991 he graduated from the Harper Adams University with an Agricultural Marketing & Business Administration BA(Hons)
    - In 2015 he entered the Kellogg Rural Leadership Programme from which he successfully graduated in 2106, during this time Damian met and forged links with numerous people of influence within the NZ Primary and Investment Sectors. His ability to maintain and access this network is of continual benefit to the development of the EFF-GO project
    - From 2017 to 2018 he was a Horticultural Advisor with the VSA in Samoa, helping coconut farmers maximise their yield efficiencies – further proof of his business development and growth skills
    - On his return to NZ he joined Ag Challenge Ltd as an Agricultural Tutor and began to share his knowledge and experiences with a range of students (see Englishman Damian Buckley rediscovers his farming roots with Ag Challenge)

    - Recently his knowledge of rural matters, sales skills and interpersonal skills have attracted the attention of Baileys in Cambridge and he has been asked to spearhead their Lifestyle Block Sales Team
- Murray Holdaway is a 5th generation Dairy Farmer and has over the last 45 years doubled the size of his farming business through astute investment and hard work. His astute business acumen is recognised by his peers who have elected him the Chair of the Manawatu/Rangitikei Federated Farmers Dairy Section.

    - Murray has a sound background in engineering, having completed an apprenticeship and gaining a Trade Certificate in Fitting Turning and Machining
    - In 2018 Murray was appointed to the Fonterra Milk Price Working Group
    - Since 2007 he has sat on the Fonterra Directors remuneration Committee
    - He has been and continues to be involved with numerous networking and representation roles for Fonterra, Kiwi Dairy's and Tui Milk Products
    - Since 2015 he has been a co-ordinator of the Lower North Island Farmer of the Year competition
    - He has for numerous years been on the organising committee for the Massey University Dairy Farmers Conference and the Dairy3 Conference
    - He is a current member of the Horizons Dairy Leaders Group

    In short Murray is a successful dairy farmer who has also devoted his time to the support and development of his industry. He has a solution focused approach, yet sees the big picture and has an awareness of NZ Dairy Farming sustainability issues, as evident by his > $300,000 investment in sustainability projects during the growth of his farming operation over the last ten years. He is in it for the long term.

The three current Directors of EFF-GO have between them a functional blend of safety & business risk management, scientific knowledge, research experience, business operational acumen, salesmanship and governance to ensure the EFF-GO project reaches its full waste minimisation and thus commercial potential.

EFF-GO has no paid employees as yet, but has established a network of experts, who understand the potential of the EFF-GO process, have signed NDA's and have given freely of their time to advance the project;

- Peter George, of Sentinel Inspection, is a verifier of design fabrication, an accredited pressure vessel certifier and provider of NDT services.
- Fergus Rhodes, of Rhodes Engineering, is an IPENZ certified pressure vessel design engineer and has provided EFF-GO with concept engineering drawings. Fergus has the contacts to ensure that the reaction chamber is manufactured to certified standards.
- Dr Gaetano Dedual, formerly of Otago University, completed his 2018 Chem Eng PhD in pyrolysis, this required the design, construction and testing of a pyrolysis unit. Gaetano thus brings experience of novel waste treatment project management to the EFF-GO team as a Consulting Chemical Engineer.
- Dr Fabian Dolamore, a postdoctoral Chem Eng research fellow at Otago University, is conducting novel compound separation research. Fabian's CFD modelling expertise has provided EFF-GO with evidence that the proposed supercritical water management system is valid under the modelled conditions. To help ensure an unbiased model Fabian was solely provided with relevant data; the dimensions of the reaction chamber, the flow inputs, temperatures and pressures and asked to create a model. The CFD model doesn't indicate any critical failings of the proposed reaction chamber configuration.
- Campbell Dodds, currently an Agronomist and formerly an operational manager of a municipal wastewater treatment plant. Introduced to EFF-GO by Peter Ellingham (CEDA Manawatu), Campbell has reviewed the potential of supercritical water oxidation and EFF-GO's proposed

management of such conditions and concluded that there is sufficient hard evidence that supercritical water oxidation does work and EFF-GO's proposal is feasible to merit further investigation by constructing a prototype; see Appendix 2.

The EFF-GO Proposal Background – Needs, Approach, Benefits & Consequences

Needs – Why EFF-GO, why now?

The treatment and uptake capacities of New Zealand's nutrient cycles are being exceeded by the volume of organic matter generated by a flourishing human population and their associated activities in the primary, industrial and municipal sectors. This is evident by the now increasingly frequent warnings of our rivers, lakes and coastal waters being un-swimmable and the fact that our native aquatic/marine wildlife is struggling to exist in these same waters.

New Zealand has long cultivated and promoted a "Clean, Green New Zealand" image. An image threatened by an absence of a coherent and sustainable mechanism to treat our increasing volumes of organic waste. Eutrophication and its effects will only expand without a coherent solution.

New Zealand needs a sustainable non-biological solution for its sewage sludges, EFF-GO offers such a solution.

EFF-GO will initially focus on the volumes of municipal sewage sludge created by New Zealand's 323 listed municipal waste water treatment plants, which generate annually between 112,000t and 500,000t of municipal sewage sludge. EFF-GO in its mobile and static configurations, will offer these plants an outlet for their sludges. An outlet that eliminates the deleterious components of municipal sewage sludge, provides a full-stop solution and does so for less cost than the currently favoured and unsustainable composting and landfill options.

Use of the EFF-GO process will also aid those 55 plants, that are currently unconsented, and the 87, that will have expired consents in the next decade, to gain consents without excessive costs.

Approach – how will EFF-GO be delivered, is it feasible?

The commercialisation of the internationally recognised SuperCritical Water Oxidation (SCWO) process is EFF-GO's approach to providing a solution. Supercritical water occurs at temperatures > 374°C and at pressures > 3200psi. Under these conditions organic matter and oxygen approach 100% solubility and thus oxidation reactions occur rapidly and efficiently; process times are measured in seconds and treatment efficiencies > 99.99%.

Why has such a powerful process not already become a standard item for wastewaters containing organic contaminants? The non-polar nature of supercritical water causes the inorganic components of organic matter waste streams to precipitate. This has the potential to cause salt-plugging, erosion and corrosion issues.

EFF-GO has devised an innovative and functional reaction chamber to control its supercritical water environment in a manner that mitigates these confounding factors that have hitherto confined SCWO to niche waste streams and made its wider commercial application financially uncompetitive with established waste treatment processes.

1. Salt-plugging – it is the innovative reaction chamber design that controls and eliminates this confounding factor; EFF-GO will disclose this IP to signatures of an NDA, available upon request
2. Erosion – as above, it is how the EFF-GO reaction chamber handles the supercritical water that allows the elimination of this factor
3. Corrosion – the material from which the reaction chamber is constructed facilitates the control of this confounding factor. The material is readily available and requires no research.

The novelty and IP of the EFF-GO proposal is the management of the supercritical water environment. The safety systems, pumps, heaters, control software, sensors, oxygen concentrators, etc are all tried and tested "off the shelf" items. This approach, blending proven and novel systems, greatly reduces the operational risks associated with the proposal and reduces the lead time to full operational deployment from receipt of adequate finances.

EFF-GO's proposal is to construct a SCWO reaction chamber using its innovative design, a design reviewed by Chemical Engineers and deemed credible by an IPENZ accredited pressure vessel Design Engineer. The design has been validated by a Computational Fluid Dynamic (CFD) Model and the notion to apply SCWO to New Zealand's sewage sludge issues has been warmly received by all audiences engaged under NDA's; specialist engineers, MP's, City Councils, Regional Council employees, etc.

The thought experiments that conceived the EFF-GO reaction chamber design have effectively been substantiated by peer review. At no stage has the response been, "nice idea but can't work because it contravenes a physical or chemical law". The only road block is funding, hence the application to the Waste Minimisation Fund for aid to build the prototype. Once constructed, tested and demonstrated the funding by the private sector will follow, as EFF-GO represents a paradigm changing opportunity. A 21st century solution for a 21st century problem.

Given that the effectiveness of SCWO is a fact and the feedback from specialist engineers, mentioned above, does not identify any physical impossibilities in the EFF-GO reaction chamber design the feasibility study has primarily been focused upon identifying process, operational and financial hazards, risk assessing them and devising mitigation measures to ensure risks are managed as low as is reasonably practicable to do.

Feasibility Study - Scientific

Proposal Facts:

1. SuperCritical Water Oxidation (SCWO) is an established high-performance organic waste treatment process. Water at temperatures > 374°C and pressures > 3200psi becomes supercritical, it becomes a non-polar solvent, organic matter and oxygen approach 100% solubility under these conditions, consequently oxidation reactions occur in seconds and have treatment efficiencies > 99.99%.
2. Any organic matter that can be shredded to a particle size of < 200um and suspended in the aqueous infeed can be completely oxidised by SuperCritical Water.
3. SCWO is autothermic with an in feed of approx. 10% (m/v) organic matter content. The energy released by the oxidation of the 10% (m/v) organic matter solution is sufficient to maintain reaction temperatures. The precise concentration depends upon the calorific value of the organic matter being treated, this will be determined by Bomb Calorimetry and/or Chemical Oxygen Demand analysis, both being established analytical methodologies.
4. SuperCritical Water is immune to toxic shock, being a physiochemical process, the toxicity of the organic matter is irrelevant, save for its handling prior to treatment. PCB's, POP's, etc will effectively be disassembled into their component parts.
5. SuperCritical Water will work come rain or shine, it is immune to the environmental conditions that cause biological processes to fluctuate.
6. SuperCritical Water is a full stop solution, all organic matter is converted to CO_2, N_2 or NH_3 (depending on reaction temps), H_2O and the inorganics, associated with the organic matter being processed, are converted to salts and metal oxides. All pathogens are destroyed. All Persistent Organic Pollutants and plastic particles are disassembled.
7. The CO_2 created by the complete oxidation of organic matter is made recoverable/reusable as it is vented from a point source. Please note that the volume of CO_2 created by the EFF-GO process is no more than that liberated by biological processes. The difference is that the EFF-GO process creates CO_2 faster and from a point source.

A schematic demonstrating how the component parts of the process link together in the mobile treatment plant configuration can be found in Figure 1.

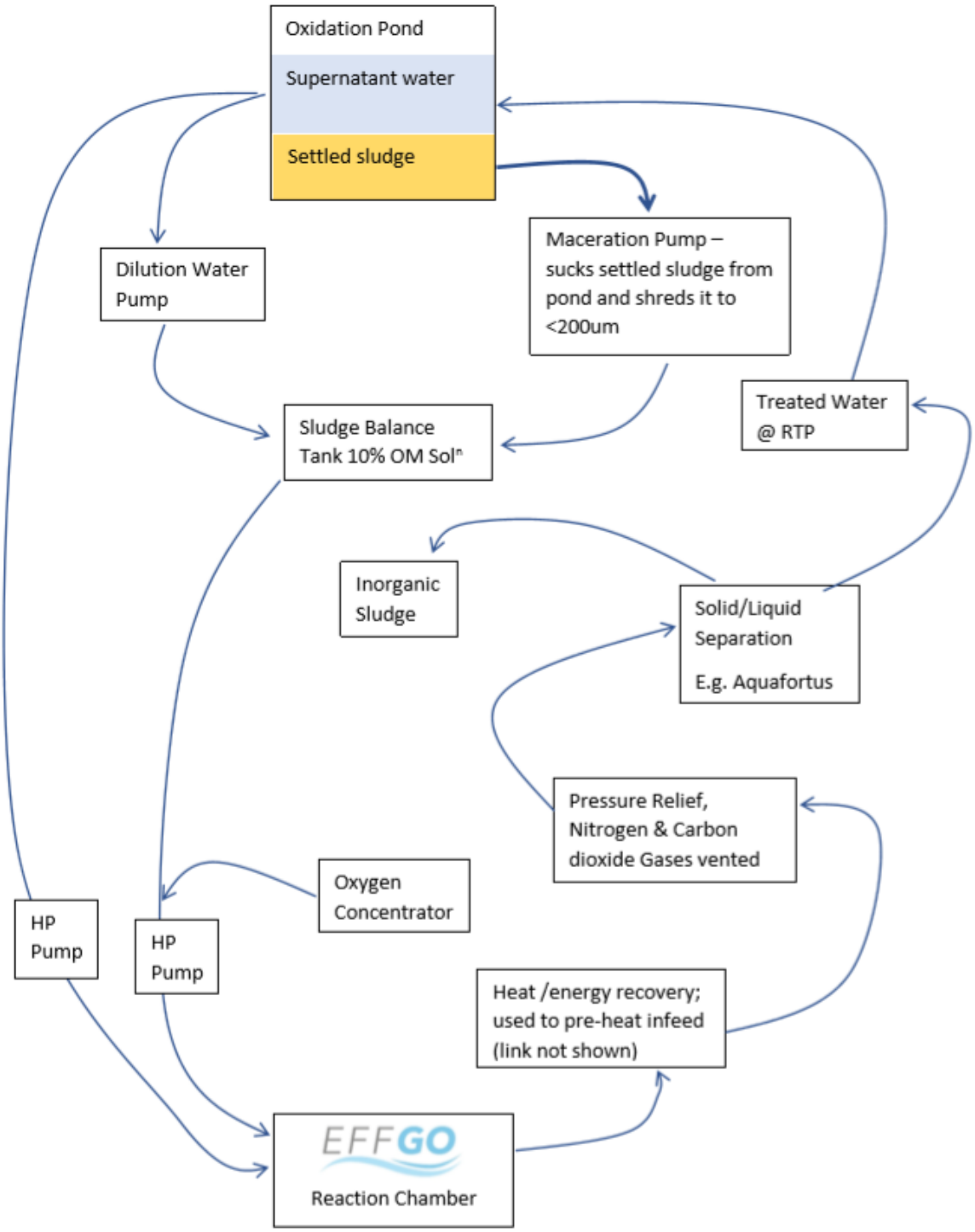

Figure 1 – EFF-GO Mobile Plant Schematic – removing excess sewage sludge from an oxidation pond**.** The outputs from the mobile process are gaseous; carbon dioxide and nitrogen; liquid water (returned to the oxidation pond) and an inorganic sludge. The quantity of inorganic sludge produced obviously depends upon the character of the sludge being treated, but it is typically expected to equate to no more that 1% (m/v) of the organic sludge treated.

Feasibility – Safety

Significant Process Hazards

1. Structural failure risks are controlled by:
    a. Design verification; the reaction chamber and plant design drawings will be peer reviewed by established IPENZ accredited verification processes
    b. Material selection; the reaction chamber is to be constructed from 316 stainless steel and thus has a designed maximum safe operating temperature of 630°C
    c. Monitored manufacturing; the sourcing of materials, fabrication and testing will be overseen by a verification engineer
    d. Reaction chamber inspections; the proscribed inspection regime will be followed, this is determined by the temperature of operation and the number of heating/cooling cycles experienced by the chamber
    e. The pressurised components of the process will be sited within a cargo container, bunded by earth and fitted with a burst valve on the roof. Operatives will not be permitted with the container whilst the process is running, controls will be applied and monitored remotely. An exclusion zone around the bunded container will similarly be applied. The radius of the exclusion chamber to be determined as part of the prototype process. EFF-GO will adopt a layer of protection approach to obviate the failure of any individual safety measure.
2. Reaction management risks:
    a. The energy released from the oxidation reaction causes temperatures to exceed 630°C; this will be prevented by the monitoring of temperature and the use of the following process management controls to keep temperatures within safety limits;
        i. Chemical characterisation of the waste to be treated and determination of calorific content, this will determine the blend required for a sustainable reaction
        ii. Dilution of the feedstock as a feedback loop from the reaction chamber sensors; water can be added to the in feed prior to it reaching the reaction chamber, a diluted feed concentration will equate to a reduced reaction chamber temperature
        iii. Reduction of in-feed flow; less feed = less energy released
        iv. Reduced oxidant addition; reducing the quantity of oxygen added will reduce the reaction and thus the energy released
        v. The ultimate control is to turn it off; shutting the infeed valve will cause the reaction to cease, just as one turns a gas flame off

    As you can see there are a variety of reaction control mechanisms, offering the layers of protection risk control favoured by modern chemical engineering process control management theory. The Programable Logic Circuits and sensors required to rapidly coordinate the control of the EFF-GO reaction chamber environment are “off the shelf” items that exist in the petroleum industry (eg. catalytic crackers) and the electrical power sector (eg. gas, coal, wood fired power stations).

Feasibility – Financial

The science stacks up and the layers of safety protection work, but is it commercially viable, is there a market for EFF-GO?

The significant operational costs associated with the EFF-GO process in its 80ltr post-prototype form are:

- Electricity – to power the high-pressure pumps, maceration pump and air compressor will consume approx. 179 kW/hr, so assuming $0.2/kWhr the electrical cost per hour is $35.88

- Labour – initially the process will always be monitored by a two-person team and an hourly rate of $25 per person is proposed; total hourly labour cost = $50

Thus a total hourly treatment cost of $85.88 is projected – not including the recovery of energy from the 300°C high pressure aqueous output of the process.

The projected 10% (m/v) organic matter solution treatment flow rates for the prototype are 5.48m^3/hr; which equates to 0.548m^3/hr of undiluted sewage sludge, which in turn equates to $156.72/$m^3$ of sewage sludge treated. Surveying the current marketplace reveals a cost to compost sewage of $200 to $210/$m^3$ (information sourced during conversations with Composting NZ and the review of literature). The EFF-GO treatment process will be marketed at $185/$m^3$, a saving of at least 7.5% whilst offering a margin of 18%, not including the generation of electrical energy from the residual pressurised hot water.

Not only is EFF-GO cheaper than composting it also totally treats the organic waste. A win-win, rate payers incur a lower charge and the impact of humanity is reduced.

Other benefits of the EFF-GO approach to organic waste treatment are its scalability, if additional processing capacity is required an additional reaction chamber is added, similarly if processing need is reduced the flow rates can be turned down. The EFF-GO process is effectively incineration in the liquid phase, a supercritical water flame, just as a gas flame is reduced by restricting flow, the same is feasible with SuperCritical Water Oxidation. Such responsivity is not feasible in biological processes, they are more suited to steady state.

To build and test the prototype a budget of $384,680 (exc GST) is required.

Please refer to the financial details and project plan within the *EFF-GO 2019 WMF application* and Appendix 1 for more detailed information.

Benefits – what does EFF-GO offer society?

The unique design approach utilised by EFF-GO will facilitate the general application of the internationally recognised treatment process that is SuperCritical Water Oxidation (SCWO) to New Zealand's municipal sewage sludges and other recalcitrant organic matter waste streams. SCWO rapidly converts all organic matter in to benign products:

Organic Matter Solution + O_2 → CO_2* + N_2 or NH_3 *(temp dependent)* + H_2O + Inorganic Salts (SO_4+PO_4, etc)

*Subsequent iterations of the process will seek to sequester the CO_2 generated and create a circular market – see Figure 2 below

EFF-GO is a "Full-Stop" solution, organic matter passing through the EFF-GO reaction chamber is completely oxidised – *it is incineration in the liquid phase*.

- Bacteria and viruses are destroyed
- Persistent Organic Pollutants (POP's) and Endocrine Disruptors are disassembled
- Inorganic components are concentrated and presented in a recoverable format
- The eutrophication potential of the treatment plant output is significantly reduced

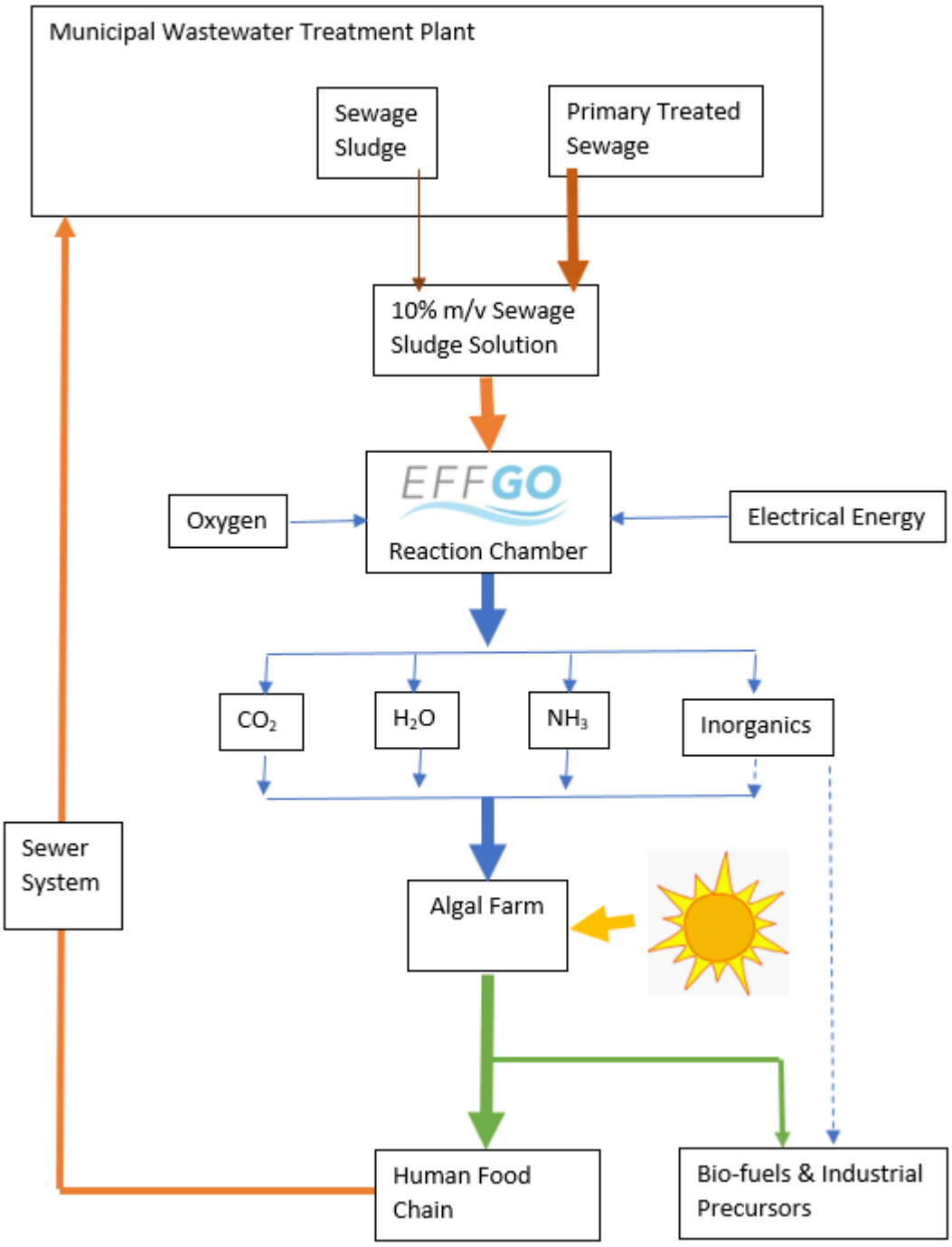

Figure 2 – EFF-GO process facilitating a closed loop incorporating an Algal Farm and a municipal sewage treatment plant; the products of the EFF-GO process (waste heat energy not shown) promote algal growth, which can be fed into the human food chain (directly or indirectly), which feeds the sewage plant, which feeds the EFF-GO process and the cycle continues.

Consequences – what will be the effects of a functional EFF-GO process?

The deleterious effects of Municipal Sewage Sludge are removed from the Green Waste Compost process.

Elimination of organic waste producer liability – your waste is made inert, your liability ends.

A sustainable "Full-Stop" solution applicable to Municipal Sewage Sludge and all other Organic Waste Streams – abattoirs, food & dairy processing, food waste, etc.

The redefinition of New Zealand's Organic Waste Treatment market, a market estimated to be > $6bn; a manmade 21st century solution for the manmade 21st century waste problem.

Globally the wastewater treatment market is estimated to reach >$90bn by 2022, with the help of WMF funding a New Zealand company called EFF-GO could be part of that market.

EFF-GO Ltd is a start-up company that has drawn together Chemical Engineers, an Inspection Engineer and a Certified Pressure Vessel Design Engineer, all without funding, a classic N°8 story if ever there was one, all achieved on the understanding that their efforts will be recognised, professionally and financially, when the EFF-GO process revolutionises the treatment of organic waste effluents. They can obviously recognise the potential of the EFF-GO process, can you?

For EFF-GO to become a functional commercial entity, able to mitigate societies impact on our environment, financial help from the Waste Minimisation Fund is required.

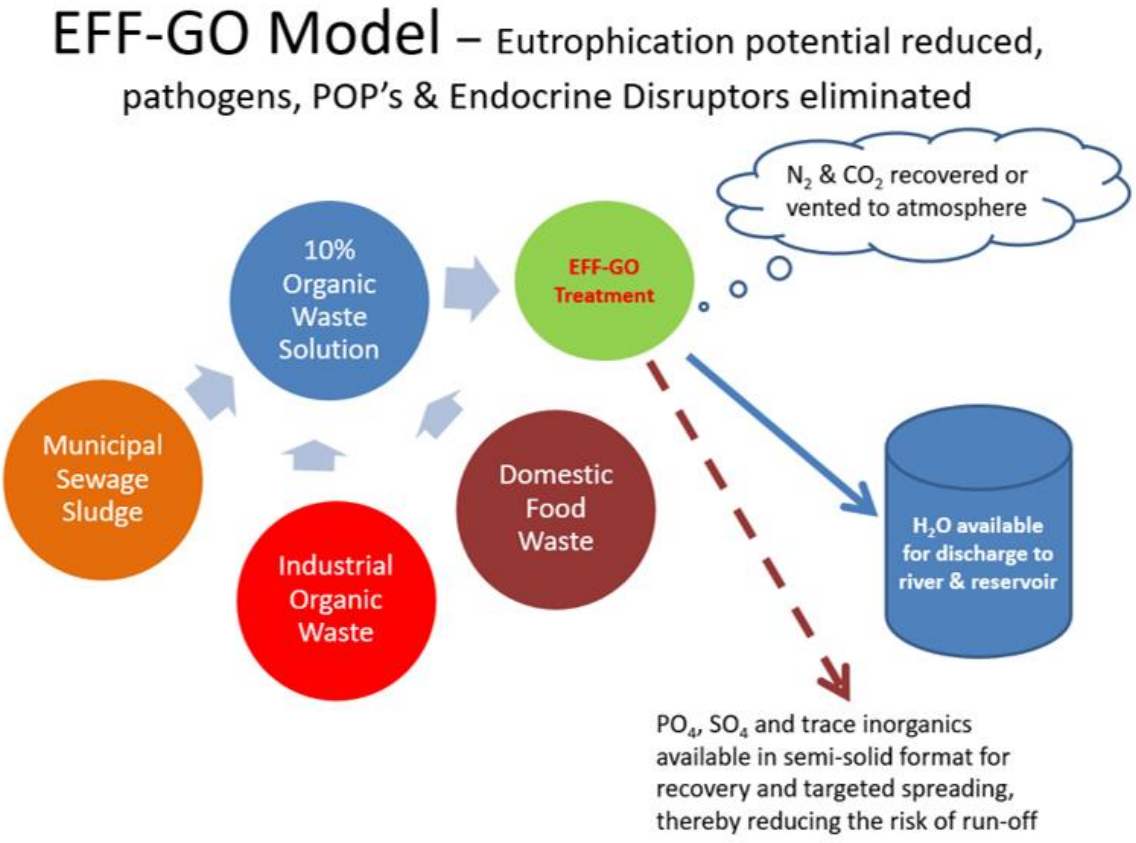

Figure 3 - An overview of the EFF-GO Model, a hub for organic waste treatment the greater the mass of organic matter presented the greater the volume of untreated waste water required as a diluent and thus become treated water as an incidental benefit.

Appendix 1 – detailed project budget

Personnel – breakdown of cash costs *Wages, salaries, recruitment, training, etc (eg, Joe Brown's salary at $25 per hour for period of 20 hours)*	**Year One**
Project Management - Dr G Dedual is the preferred candidate	$75,000.00
Total estimated cash costs for personnel (exclusive of GST)	$75,000.00
Administration – breakdown of cash costs *Stationery, insurance, postage, phone calls, courier, etc*	**Year One**
Insurance - Public Liability Insurance	$5,000.00
Stationery, pens and note pads	$200.00
Total estimated cash costs for administration (exclusive of GST)	$5,200.00
Consultants and contractors – breakdown of cash costs *Environmental consultancies, Crown research institutes, etc*	**Year One**
Electrician - installation & certification of electrical services	$10,000.00
Pipework installation - connecting pumps to the reaction chamber	$10,000.00
Independent sampling and analysis - eg NIWA	$10,000.00
Rhodes Engineering - engineering drawings	$30,000.00
Sentinel Inspection - verification of manufacture and installation	$15,000.00
Engineering Design Validation	$6,000.00
Massey University - specialist research advisors	$10,000.00
Total estimated cash costs for consultants and contractors (exclusive of GST)	$91,000.00
Purchase of capital assets and other capital costs – breakdown of cash costs *Includes the cost of bringing the new asset to working order*	**Year One**
80 ltr reaction chamber	$12,500.00
2 x BB/SS-3560 CAT Pump; 54.8kW each	$22,000.00
Oxygen Concentrator and air compressor	$30,000.00
Inlet submersible heater	$7,000.00
Pipework, connectors, gaskets, etc	$10,000.00
20 foot Cargo Container - to house and isolate the pressurised process elements	$4,000.00
Earth bunding of cargo container - to further isolate the pressurised elements	$2,000.00
Pressure & Temp sensors to monitor the process	$10,000.00
20 foot Cargo Container - to house control systems	$4,000.00
Process control system	$10,000.00
8 IBC's for storage of input/output solutions	$480.00
Total estimated cash costs for the purchase of capital assets and other capital costs (exclusive of GST)	$111,980.00

Venue and equipment – breakdown of cash costs *Venue (hire or rent), equipment (rental or leasing), etc*	**Year One**
Diesel Electric Generator & connecting cables	$6,000.00
Lease of test site - Awapuni Quarry (disused)	$5,000.00
Total estimated cash costs for venue and equipment (exclusive of GST)	$11,000.00
Travel and accommodation – breakdown of cash costs *Domestic travel and accommodation expenses incurred solely in relation to the project*	**Year One**
Travel & accommodation for Project Manager	$12,000.00
Total estimated cash costs for travel and accommodation (exclusive of GST)	$12,000.00
Promotion and dissemination of information – breakdown of cash costs *Publication of brochures, advertising costs, seminars, etc*	**Year One**
Analysis of data and creation of a report - Massey University to provide input	$10,000.00
Total estimated cash costs for promotion and dissemination of information (exclusive of GST)	$10,000.00
Financial, legal and information technology (IT) expenses – breakdown of cash costs *Financial, legal and IT expenses incurred solely in relation to the project*	**Year One**
Monthly Financial Management Meetings with Naylor Lawrence & Associates	$6,000.00
Total estimated cash costs for financial, legal and IT expenses (exclusive of GST)	$0.00
Health and Safety – breakdown of cash costs *Specify the costs associated with managing health and safety during the project (e.g. First Aid kits, training, hi-visibility vests)*	**Year One**
HAZOP Assessment and monitoring of project health & safety systems	$12,500.00
Health and Safety Management - development of SOP's and monitoring of same	$50,000.00
Total estimated cash costs for health and safety (exclusive of GST)	$62,500.00
Other miscellaneous costs – breakdown of cash costs *Specify the expenses in detail, excluding the purchase of capital assets (or other capital costs) and contingencies*	**Year One**
Unexpected costs will be dealt with by EFF-GO	$0.00
Total estimated cash costs for other miscellaneous costs (exclusive of GST)	$0.00

Total project budget (exclusive of GST)	**$384,680.00**

Appendix 2 – Letter of recommendation from Campbell Dodds

Comment on EFF-GO Supercritical Water Oxidation Process Concept

4 October 2018

I have been asked to provide a brief comment on the validity of EFF-GO's SCWO treatment concept model.

I am an industry professional with over 18 years experience in the waste treatment industry covering municipal, trade, industrial and agricultural sectors.

The Supercritical Water Oxidation process has been proven scientifically to achieve sufficient treatment of organic waste material. There are numerous scientific research reports available including a number of reports published in the International Water Association (IWA) Journal.

Historically the SCWO process has not been given great consideration due to several factors such as:

1) High costs associated with construction
2) Design flaws causing fouling, limiting plant process run time
3) Limited to processing small flows
4) Labour units required to keep the process running.

The design concept that EFF-GO has developed is appealing, due to its potential ability to overcome these issues.

The EFF-GO process could provide existing infrastructure with a robust physiochemical treatment option to support temperamental biological processes and their increasing inability to effectively treat wastewater to the level required for "eco-system protection" and to meet the conditions of the Resource Management Act.

In my opinion this design concept deserves serious consideration to enable the next steps to be taken towards building a prototype.

Yours Sincerely

Campbell J Dodds