RENEWABLE HEATING & HOT WATER TECHNOLOGIES

Marcus Baker

www.ecohotwater.co.nz

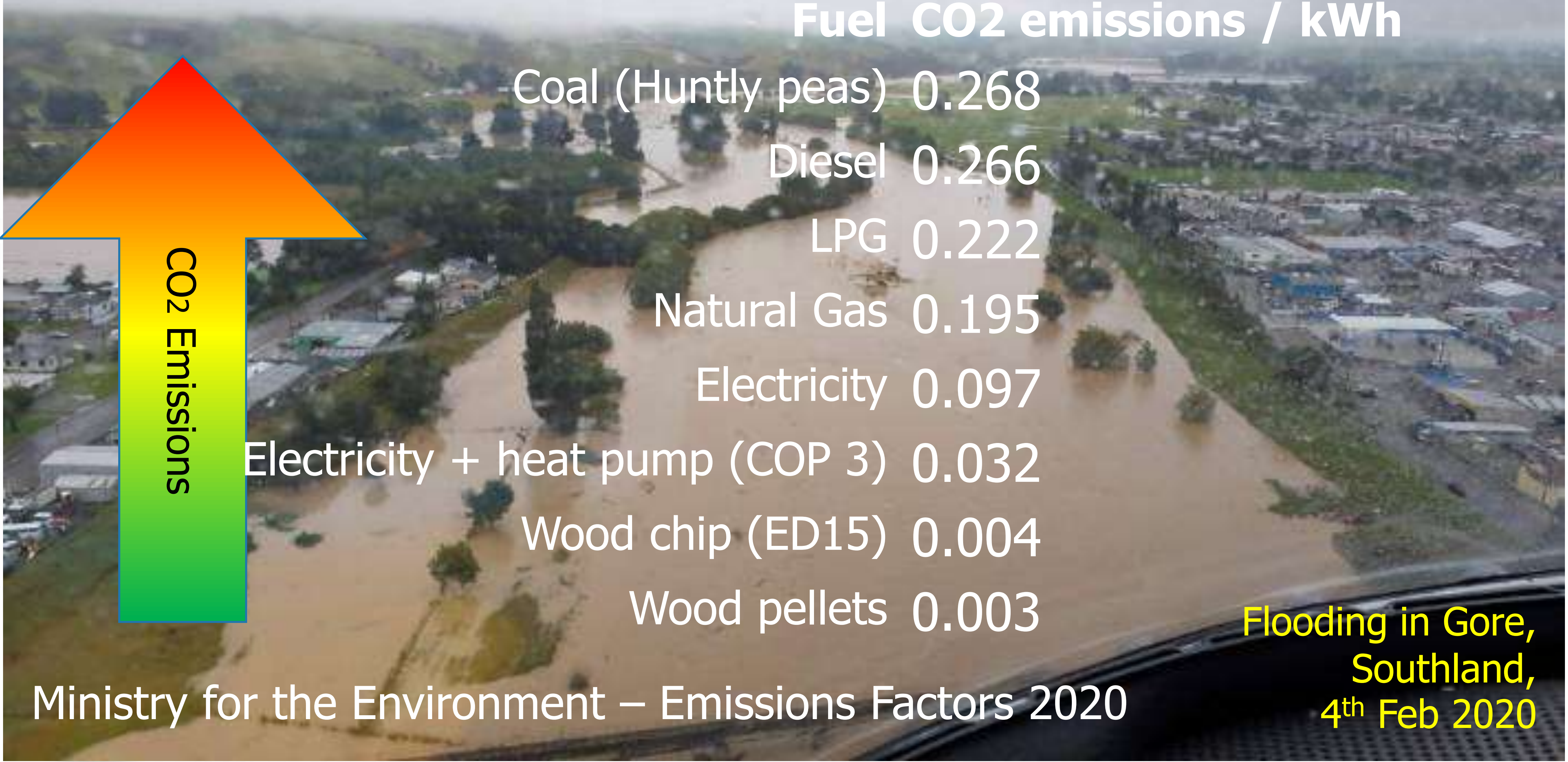
Designers & suppliers of energy efficient, low carbon heating & hot water systems

Authorised system designers and New Zealand distributors for:

- Apricus evacuated tube solar hot water systems
- Reclaim Energy CO_2 hot water heat pumps
- OkoFEN wood pellet boilers
- Easypell wood pellet boilers

WHY ARE FOSSIL FUELS NOT AN IDEAL HEATING FUEL?

Fuel	CO_2 emissions / kWh
Coal (Huntly peas)	0.268
Diesel	0.266
LPG	0.222
Natural Gas	0.195
Electricity	0.097
Electricity + heat pump (COP 3)	0.032
Wood chip (ED15)	0.004
Wood pellets	0.003



Flooding in Gore, Southland, 4th Feb 2020

Ministry for the Environment – Emissions Factors 2020

WHERE ARE FOSSIL FUELS USED IN BUILDINGS?

Primarily heating systems

- Central heating boilers & domestic hot water systems burning natural gas, coal, diesel, LPG
- Diesel generators in buildings but use infrequently unless company is trying to avoid a peak power load for certain plant
- Also refrigerants lost from HVAC heating & cooling systems can have very high Greenhouse Gas Potential

Fires then floods, Australia
February 2020

HOW CAN WE DO THIS?

Measure	What is the demand?
Minimise	How can this be optimised / reduced?
Eliminate	Which renewable energy system / combination best suited to site?

WHAT RENEWABLE HEATING SYSTEMS ARE AVAILABLE FOR COMMERCIAL BUILDINGS?

Apricus NZ eco-energy

Electricity	Domestic hot water (DHW)
Solar thermal	DHW
Heat pump	DHW & central heating
Biomass	DHW & central heating

RECLAIM ENERGY — Apricus SOLAR HOT WATER — ÖkoFEN — EASYPELL CENTRAL HEATING PELLET BOILER

APARTMENTS & COMMERCIAL DHW SYSTEMS

ELECTRICITY
SOLAR THERMAL
HOT WATER HEAT PUMPS

TO CENTRALISE OR DECENTRALISE DHW?

Question applies to all technologies, especially renewables because of high capital cost of implementation & generally requirement for centralisation of plant

- Ownership & management of building = ability to centralise?
  - Multiple owners = apartments in single building
  - Body corporate or management company ability to bill owners individually from centralised system

- Number of apartments in single building = centralise or decentralise?
  - Energy efficiency benefit from centralised DHW system in buildings with 20> apartments
  - Cost benefit to developer with 85> apartments in Auckland

- Forecast daily DHW demand for other building typologies & consider options
  - High DHW use in hotels, sports facilities, medical & accommodation typologies = centralised
  - Offices – relatively low DHW, significantly increasing with end of trip showering & more active commuting = decentralised until demand increases significantly then centralise

LOW CARBON CENTRALISED DHW TECHNOLOGIES

Solar Hot Water

- Hot water storage required varies depending on DHW time of use during day
- Commercial buildings with daytime DHW use (e.g. medical) = less DHW storage
- Accommodation with evening & morning DHW use (e.g. apartments) = more DHW storage

- Heat & store hot water only during daylight hours
- Best performance during summer months
- Always requires boosting to cope with variable weather conditions
- Generally target 50% to 70% reduction in total DHW energy use

- Currently often boosted with gas water heaters
- Can boost with standard efficiency electric elements if DHW load not too large
- Larger loads can be boosted with hot water heat pumps but double capital cost and reduced payback on solar thermal because of higher heat pump COP

HILLS APARTMENTS, HAMILTON

HILLS APARTMENTS, HAMILTON

Apricus solar hot water system with gas boost

- 19 apartments, 51 bedrooms, around 75 residents
- Requires ~4,000L DHW per day = 220kWh / day = 80.5 MWh / year
- Solar thermal modelled for 70% reduction in gas use, running costs & carbon emissions
- 20 x Apricus 30 tube solar collectors (600 tubes) & 3,000L solar hot water storage
- 2 x gas instantaneous water heaters & 1,500L cylinder for boosting (oversized cylinder to absorb additional solar energy)

- Approximately $100,000 cost in addition to gas hot water system
- Apartment building value at first round of sales = $30+ million
- = 0.3% of initial building value for 75% reduction in biggest energy use for coming decades

HILLS APARTMENTS, HAMILTON

How do we continue to implement these systems without fossil fuels?

- Gas boosters are very small, low cost, easy to design and reliable
- Electric elements can be used for boosting but require a lot more storage because slower recovery
- Most feasible renewable alternative is solar thermal plus hot water heat pump boosting
- More expensive & complex to implement HWHP than gas boost
- More space required and potential noise / air movement issues with heat pumps

Should we use modeled and actual carbon emissions of complete systems to inform policy and set incentives for most appropriate and practical outcome for projects?

Will higher carbon reduction options attract greater levels of support / subsidy to match higher implementation costs?

SOLAR THERMAL CASE STUDY

LAKEVIEW HOLIDAY PARK, WANAKA

Average 7,000L hot water use per day – gas boost

40% reduction in gas use with solar thermal

Apricus NZ eco-energy

LAKEVIEW HOLIDAY PARK, WANAKA

Lakeview campground system reviewed by Robert Tromop, Energy Efficiency International, 2018:

- Apricus solar hot water system contributing 40% of total annual DHW, reducing LPG use
- 12% internal rate of return including depreciation, using discount rate of 6% (2.2% without depreciation)
- DHW continuity despite increasing guest numbers every year since installation
- System lifespan expected at 20 years
- 2020 updated total emissions reduction & cost savings

27,756 kgCO2e

cost savings of $17,660

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COMMERCIAL SOLAR THERMAL SYSTEMS

DENTAL SCHOOL, UNIVERSITY OF OTAGO, AUCKLAND

1,150L of hot water per day – electric boost

72.5% reduction in electricity used for DHW

UNIVERSITY of OTAGO
SAPERE AUDE
Te Whare Wānanga o Otāgo
NEW ZEALAND


COMMERCIAL SOLAR HOT WATER SYSTEMS
SUMMER GARDENS, TAKAPUNA

COMMERCIAL SOLAR HOT WATER SYSTEMS

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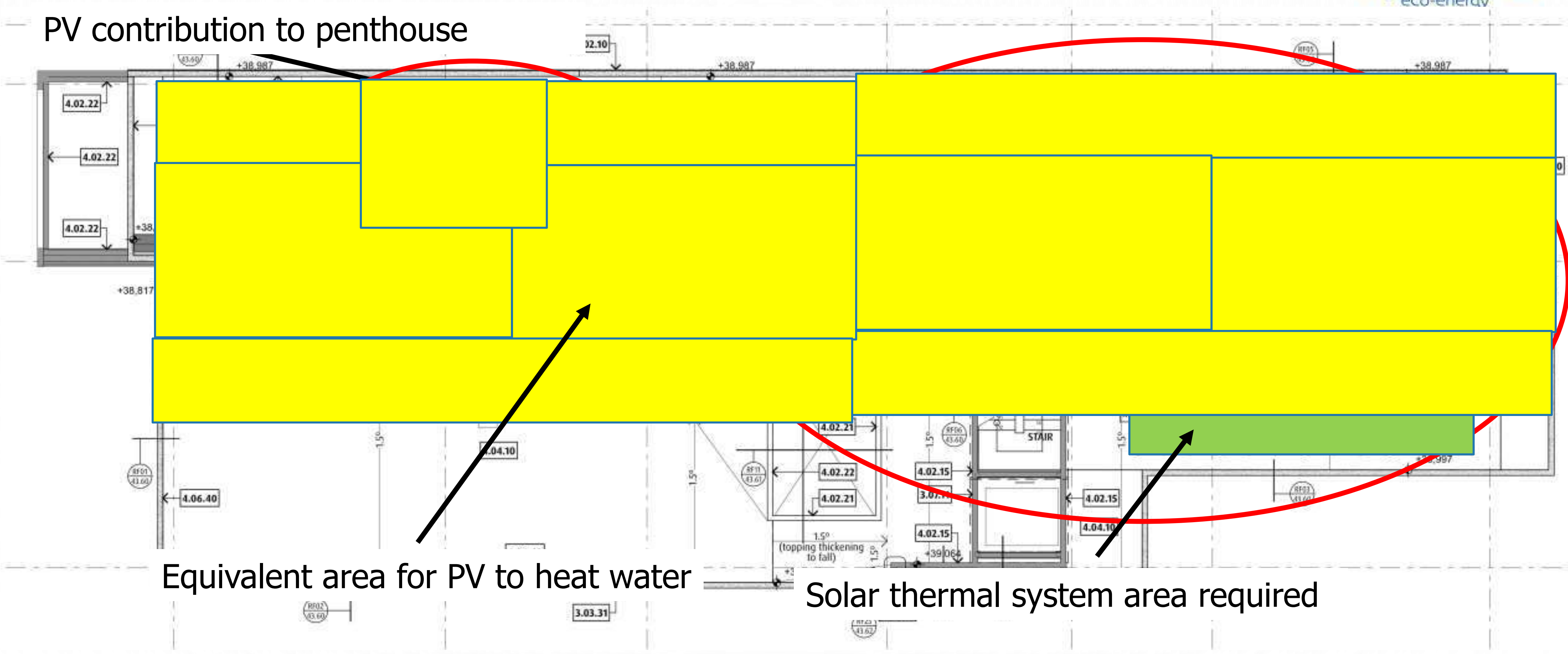


RECLAIM ENERGY

Apricus SOLAR HOT WATER

ÖkoFEN

EASYPELL CENTRAL HEATING PELLET BOILER

CO2 HOT WATER HEAT PUMPS

- Very high efficiency for domestic hot water (needs high temperature difference)
- 1 x Global Warming Potential of CO_2 as refrigerant
- Output & high COP maintained in colder conditions & higher temperatures required for DHW
- All heat pumps require reasonable amount of buffering, especially CO_2

- Multiple units can be cascaded as loads increase
- Can be economic & provides redundancy to use multiple smaller units

CO2 HOT WATER HEAT PUMPS

CO_2 HWHP Size	Outdoor Air Temp (dry bulb)	Input Cold Water Temp	Output Hot Water Temp	COP
5kW	19°C	15°C	63°C	4.7
	1°C	15°C	63°C	4.3
30kW	16°C	17°C	65°C	4.3
	7°C	5°C	90°C	2.8

SINGLE RESIDENTIAL SOLAR OR HWHP

Why Use Solar or CO_2 HWHP for Individual Homes DHW?

- Newly built homes use an <u>average 46%</u> energy on water heating (WELS Network lines company survey of 600 homes in 2017)

- Solar thermal / CO_2 HWHP provides ~75% energy for hot water used
- Total household energy bills reduced by ~30%
- Huge on-going benefit to all, especially low income households

- Can be installed in parallel with solar PV for very low power use, esp HWHP with timed use for daytime generation

SMALL COMMERCIAL / RESIDENTIAL EXAMPLE

Fire Emergency NZ

- June 2019 to July 2020 monitoring at FENZ Redwood, Christchurch
- 4 occupants 24/7 – sometimes very high DHW use
- Apricus solar thermal provided 75% of energy required across year
- Annual carbon emissions reduction of 418 $kgCO_2e$ vs electricity

- Easy and cost effective implementation in design & build
- All new build permanently occupied fire stations to include Apricus solar thermal

QUICK SOLAR TOOLKIT FOR COMMERCIAL DHW

Net Present Value	
Annual Discount Rate	4.0%
Net Present Value (15 years)	**$90,898**
Net Present Value (10 years)	**$20,037**
Net Present Value (6 years)	[illegible]

Internal Rate of Return	
Year 5 IRR	-20%
Year 10 IRR	1%
Year 15 IRR	8%
Year 20 IRR	[illegible]

Simple Payback in Years	11.7

Financial Constants

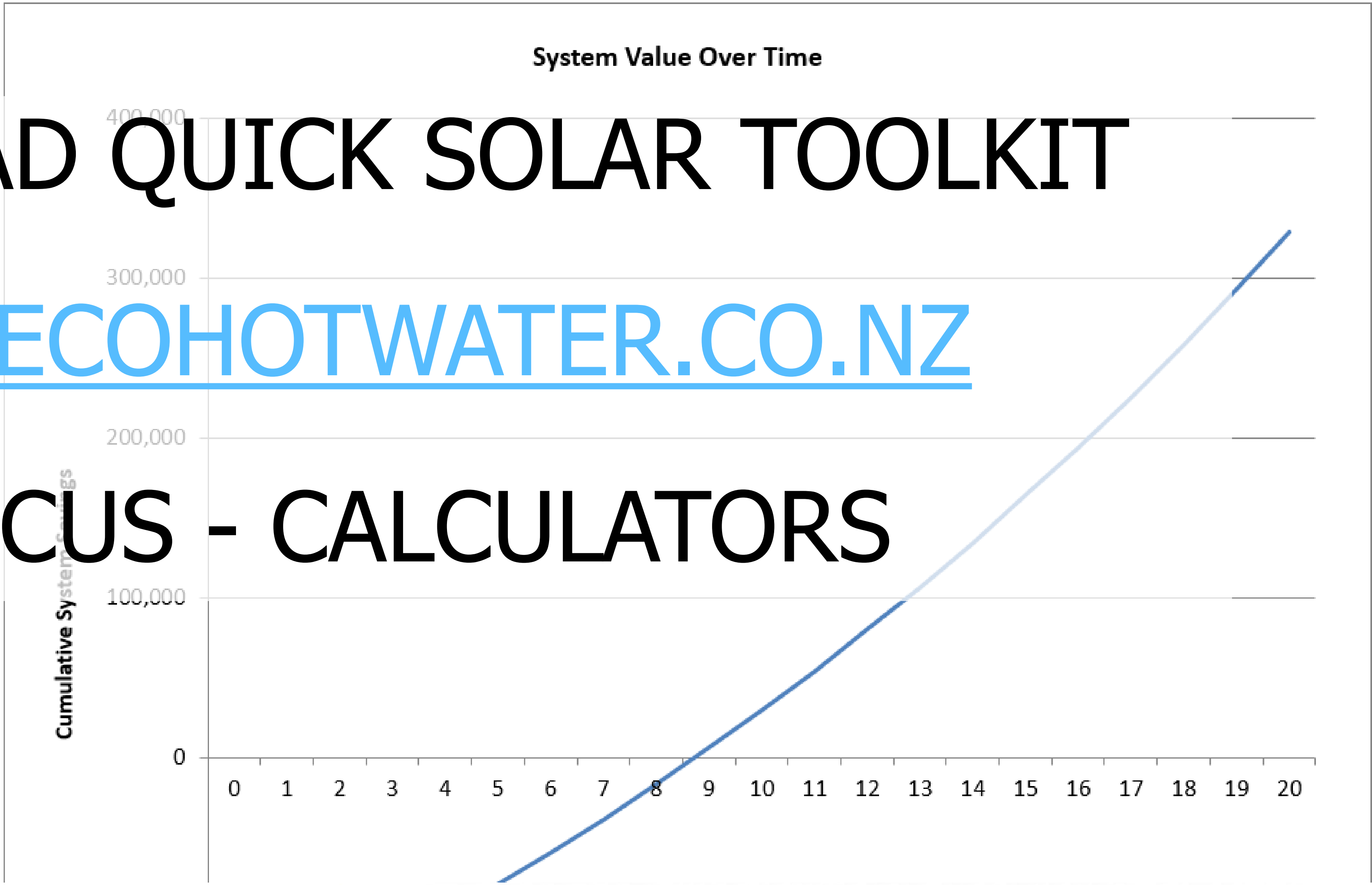
Annual Energy Cost Increase	3%
Inflation	[illegible]
Yearly Maintenance	[illegible]

Carbon Cost inclusion

Include cost of CO_2?		Yes
Cost CO_2 emissions / tonne	$	50.00

System Information

Number of Collectors	45	ETC-30
Annual Efficiency Decrease	0.5%	
Annual Energy Savings	161,923	kWh/year
Annual CO2 Savings	31,575	kgCO2e/year



DOWNLOAD QUICK SOLAR TOOLKIT

WWW.ECOHOTWATER.CO.NZ

APRICUS - CALCULATORS


BIOMASS FOR COMMERCIAL BUILDINGS

- Building heating almost all from two biomass fuels in NZ
  - wood pellets
  - wood chip

- Wood chip needs to be used close to production site otherwise uneconomic & high transport carbon emissions
- Wood chip better fit for larger loads & locations with dedicated on-site energy services personnel – e.g. hospitals, food processors
- Energy density and fuel performance varies depending on fuel contract

- Wood pellets have more easily defined fuel performance, easier handling attributes, more appropriate for sites without skilled personnel for energy needs – e.g. commercial & apartment buildings, aged care homes, schools
- Wood pellets have energy density close to coal = 19 GJ/tonne or 3.3 MWh/m^3

PELLETS – LOW CARBON, AFFORDABLE, CONVENIENT

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Heating technology	Fuel	Reduction in CO2 emissions if replaced with pellets	Real world example for building with DHW use of 10,000L per day (204MWh/yr)	
			Annual CO2 emissions	Calculated annual running cost
Pellet boiler	Wood pellets	Base case	599	$16,320
Heat pump	Electricity (COP 3)	-91%	6,693	$11,560
Gas boiler	Natural gas	-98%	39,726	$22,440
Gas boiler	LPG	-99%	45,240	$36,720
Diesel boiler	Diesel	-99%	54,190	$20,400

Costs / kWh - pellets $0.08, electricity $0.17, NG $0.11, LPG $0.18, diesel $0.10

PELLET BOILERS FOR COMMERCIAL BUILDINGS

- Direct replacement for fossil fuel boilers
- All building heating loads & DHW demand levels
- Individual residential up to commercial buildings of any size
- Primary heating system – full peak load – doesn't require additional backup
- High temperatures for use on any heating system – radiators, air handlers, underfloor
- Multiple heat loads & temperatures easily managed:

space heating
+ DHW
+ swimming pool
+ spa

COMMERCIAL PELLET BOILERS

- Fully automated operation
- No manual handling of fuel
- Flexible fuel storage options
- Automatic fuel delivery to boiler & ash removal
- Highly reliable operation with decades of experience overseas
- BMS integration, remote connection for programming & fault finding – online & via smartphone app
- Deashing & fuel reordering reminders

CASE STUDY - RETIREMENT VILLAGE

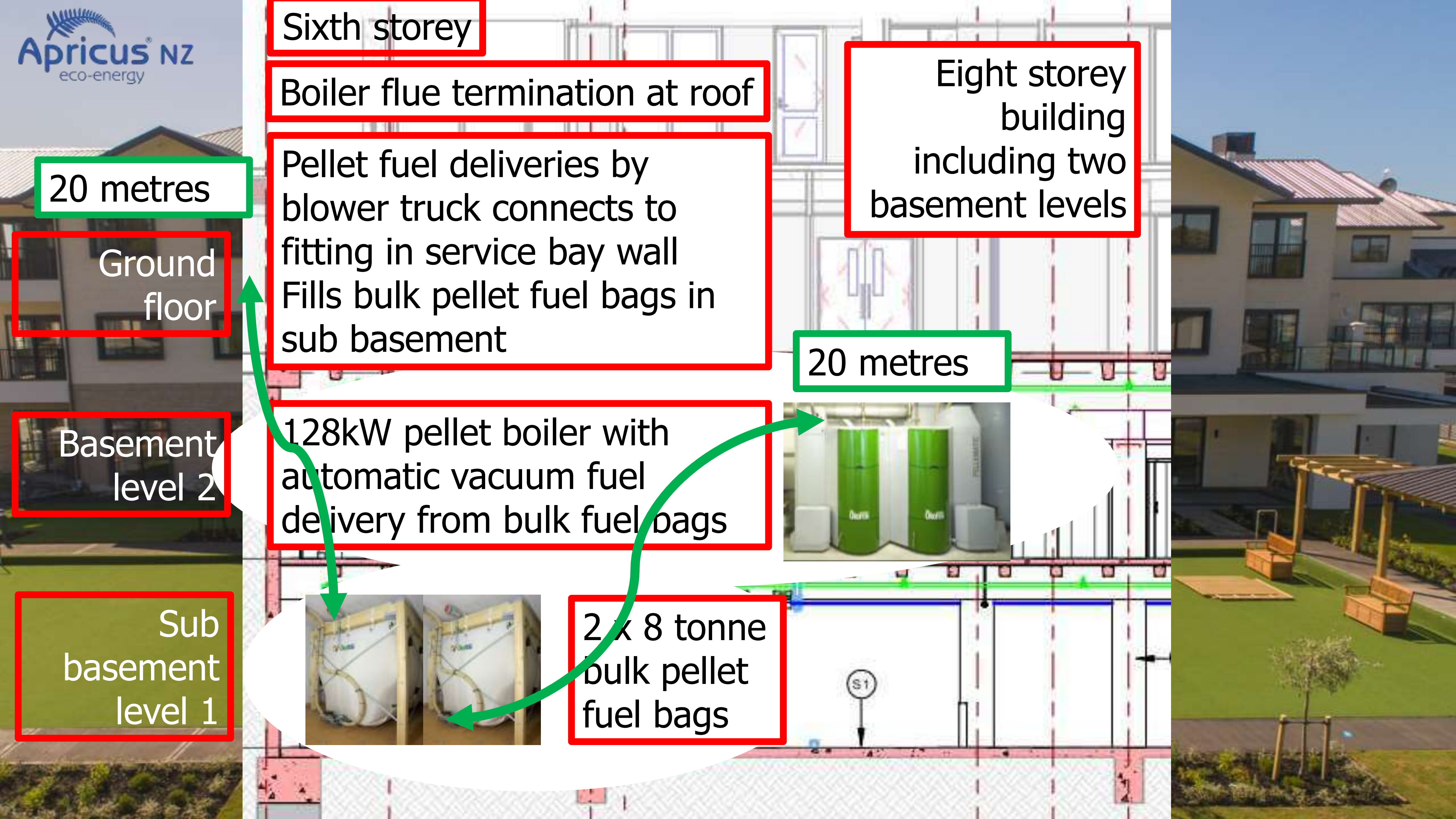
ONE OF THE LEADING RETIREMENT VILLAGE OPERATORS

Latest development St Johns Street, Meadowbank, Auckland for 400 residents

Site offers full Continuum of Care = includes hospital and Memory Care Centre for dementia

Regular fossil fuel use **completely removed** from site

- ✓ ÖkoFEN pellet boilers – DHW in care area, swimming pool & spa heating
- ✓ Heat pump HVAC system
- ✓ Ozone commercial laundry system
- ✓ Induction hobs, electric ovens & fryers in commercial kitchen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Sixth storey
Boiler flue termination at roof
Eight storey building including two basement levels
20 metres
Ground floor
Pellet fuel deliveries by blower truck connects to fitting in service bay wall
Fills bulk pellet fuel bags in sub basement
20 metres
Basement level 2
128kW pellet boiler with automatic vacuum fuel delivery from bulk fuel bags
Sub basement level 1
2 x 8 tonne bulk pellet fuel bags

FINANCIAL & RISK ASSESSMENT

Company internal business analysis undertook comprehensive financial & risk assessment

Reticulated natural gas boiler compared to OkoFEN pellet boilers

- Benefits
- Risks and mitigations
- Background – supplier company profile
- What is a pellet boiler – technology explained
- How does this serve the hot water requirements of the buildings?
- How is the wood pellet boiler different to gas

FINANCIAL & RISK ASSESSMENT

In service use of pellet boilers

Continuity of hot water critical = reliability of equipment is key

References from similar facilities with long in-service history – references from owners not from the supplier

Risk averse, no desire to be an innovation leader - not the first but the first of the building typology to take up the technology

Environmental benefits – emissions reduction, up-coming legislation

Increased cost of gas

Risk analysis

- Supply of consumable / spare parts within NZ
- Supply of quality pellets
- Unforeseen event disrupting delivery
- Long term supply of fuel
- Fuel supply cost increases over time
- Real understanding of maintenance costs now and into the future.
- Reliability of the brand

FINANCIAL & RISK ASSESSMENT

Financial analysis

Financial model developed to compare gas, pellet boiler buy, pellet boiler lease, pellet boiler lease then buy

Compared over a 50 year period

Includes Capex, Opex and carbon credits (converted into $ savings)

Sensitivity analysis carried out to test various assumptions

Energy usage and fuel credits

Estimated useful life

Maintenance

End of life disposal and replacement

Energy loss and efficiency

Financial conclusions

- Gas system capex $120k for a comparable installation
- Pellet boiler capex $230k inc installation
- Two pellet boilers included for resilience
- Gas boiler maintenance over 50 years is about double that of the pellet boiler
- Gas has approximately double the cost of fuel, <u>excluding</u> escalating carbon cost
- The gas install has a shorter life expectancy a factor that really tips the balance in the financials over time

FINANCIAL & RISK ASSESSMENT

Benefits analysis

Financial benefit over the long term

Reduced carbon footprint

Brand benefit, marketing opportunities

Staying ahead of legislative changes

Less system replacements over the long term when compared to gas

Ability to roll out across multiple sites and potential to retrofit existing sites

Final decision & outcomes

- ÖkoFEN pellet boilers to be used at St John Street, Auckland development
- Working with building services consultants on design for pellet boilers for new retirement village development for DHW & other heat loads
- On-going feasibility assessments at existing sites to replace gas boilers with pellet boilers for DHW and central heating

MINISTRY OF EDUCATION SCHOOL BOILER REPLACEMENT PROGRAMME

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- At least 90 schools to have coal boilers replaced in next 3 years
- Pellet boilers most appropriate technology in most cases
- Plant room or containerised installations
- Low cost of fuel and no manual handling required
- Fully automatic operation = very limited day to day maintenance
- Remote monitoring and smart phone control = expert oversight anywhere in country

- More frequent pellet fuel deliveries to almost all areas across country = aggregated deliveries for multiple sites improves freight efficiency & potentially reduces costs
- Much wider spread use of pellet boiler technologies and acceptance by key government Ministry will improve acceptance & uptake in other situations across NZ

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MINISTRY OF EDUCATION SCHOOL BOILER REPLACEMENT PROGRAMME

Last month pellet boilers replaced coal & diesel in following schools for central heating

Edgecumbe College, Bay of Plenty
256kW boilers & 15 tonnes fuel storage

Bayswater School, Auckland
64kW boiler & 6 tonnes fuel storage

Te Kura Kaupapa Motuhake, Murupara
128kW boiler & 8 tonnes fuel storage

MINISTRY OF EDUCATION SCHOOL BOILER REPLACEMENT PROGRAMME

MINISTRY OF EDUCATION SCHOOL BOILER REPLACEMENT PROGRAMME

Before and after at Te Kura Kaupapa Motuhake o Tawhiuau, Murupara

ALTERNATIVE DEPLOYMENT - CONTAINERISED PELLET BOILERS

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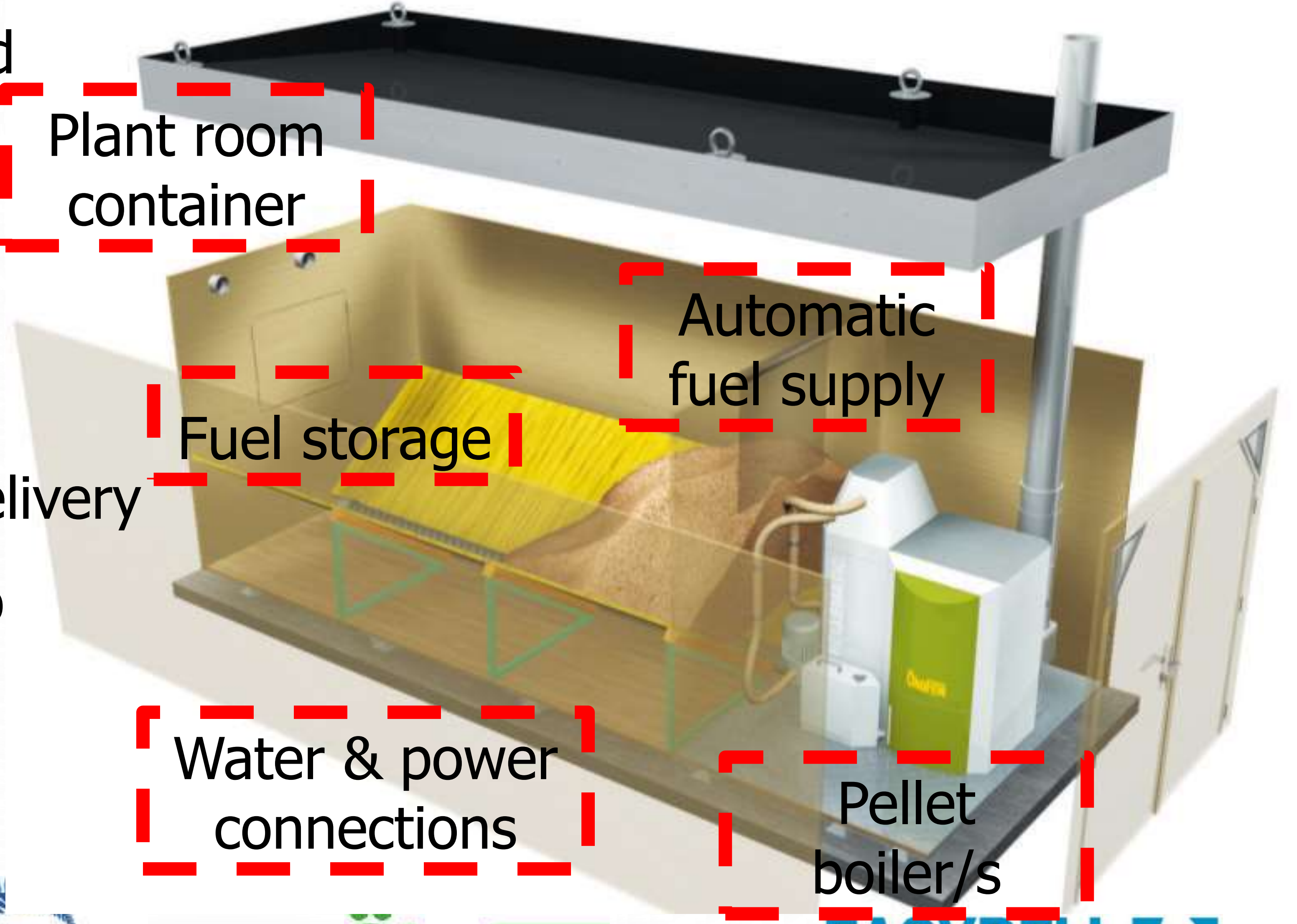
- ✓ "Energy Box" containerised systems
- ✓ All components for pellet boiler system
- ✓ High level cost control
- ✓ Consistency of design & delivery
- ✓ Guarantee of workmanship
- ✓ Flexible site placement
- ✓ Modular and expandable



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ÖkoFEN

EASYPELL CENTRAL HEATING PELLET BOILER

EDUCATIONAL & MARKETING OPPORTUNITIES WITH CONTAINERISED SYSTEMS

QUICK PELLET BOILER TOOLKIT

Apricus NZ eco-energy

ÖkoFEN PELLET HEATING

Pellet boiler toolkit

DOWNLOAD QUICK PELLET BOILER TOOLKIT

WWW.ECOHOTWATER.CO.NZ

OKOFEN - CALCULATORS

OkoFEN pellet boiler maintenance & service guidance

Cost per each single OkoFEN boiler

Does not include any labour or materials for servicing any other components of the system, e.g. travel, management oversight, heating system servicing and any consumables are not included

NOTE - servicing required after 40 tonnes pellets or 3,000 hours, whichever sooner

Number of OkoFEN boilers at site	4	
Total tonnes of pellets for site / yr	94	0.5875 Boiler annual servicing factor
Number of services / boiler / yr	1	

Hours per boiler (4 hours suggested)	Hourly rate	Mark up on parts	Labour cost per boiler	
4	$ 120	1.3	$ 480	Modify any figures in yellow to change total costs

STANDARD SITES - DHW NOT CRITICAL SERVICE

All replaceable parts covered under warranty for first 2 years

Years	Expected Visits	Labour	Parts	Total per boiler	Total for site	Total for site over period	5 year maintenance costs estimated	Years
1-2	1	$ 480	$ -	$ 480	$ 1,920	$ 3,840		
3-5	1.5	$ 720	$ 874	$ 1,594	$ 6,378	$ 19,133	$ 22,973	1 to 5
5-10	[illegible]	$ [illegible]	$ 1,019	$ 1,979	$ 7,918	$ 39,589	$ [illegible]	5 to 10
10-15	[illegible]	$ [illegible]	$ 1,423	$ 2,623	$ [illegible]	$ [illegible]	$ [illegible]	10 to 15

Average annual maintenance costs for site over 15 years	$ [illegible]
Per boiler over 15 years	$ 1,917

SITES WITH DHW AS CRITICAL SERVICE - ONLY SERVICE 1 BOILER PER VISIT				2.0	additional time for repeat visits, i.e. not all boilers can be serviced on same day for redundancy reasons				
Years	**Expected Visits**	**Labour**	**Parts**	**Total per boiler**	**Total for site**	**Total for site over period**	**5 year maintenance costs estimated**	**Years**	
1-2	2	$ 960	$ -	$ 960	$ 3,840	$ 7,680			
3-5	3	$ 1,440	$ 874	$ 2,314	$ 9,258	$ 27,773	$ 35,453	1 to 5	65%
5-10	4	$ 1,920	$ 1,019	$ 2,939	$ 11,758	$ 58,789	$ 58,789	5 to 10	
10-15	5	$ 2,400	$ 1,423	$ 3,823	$ 15,292	$ 76,461	$ 76,461	10 to 15	
					Average annual maintenance costs for site over 15 years	**$ 11,380**			

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