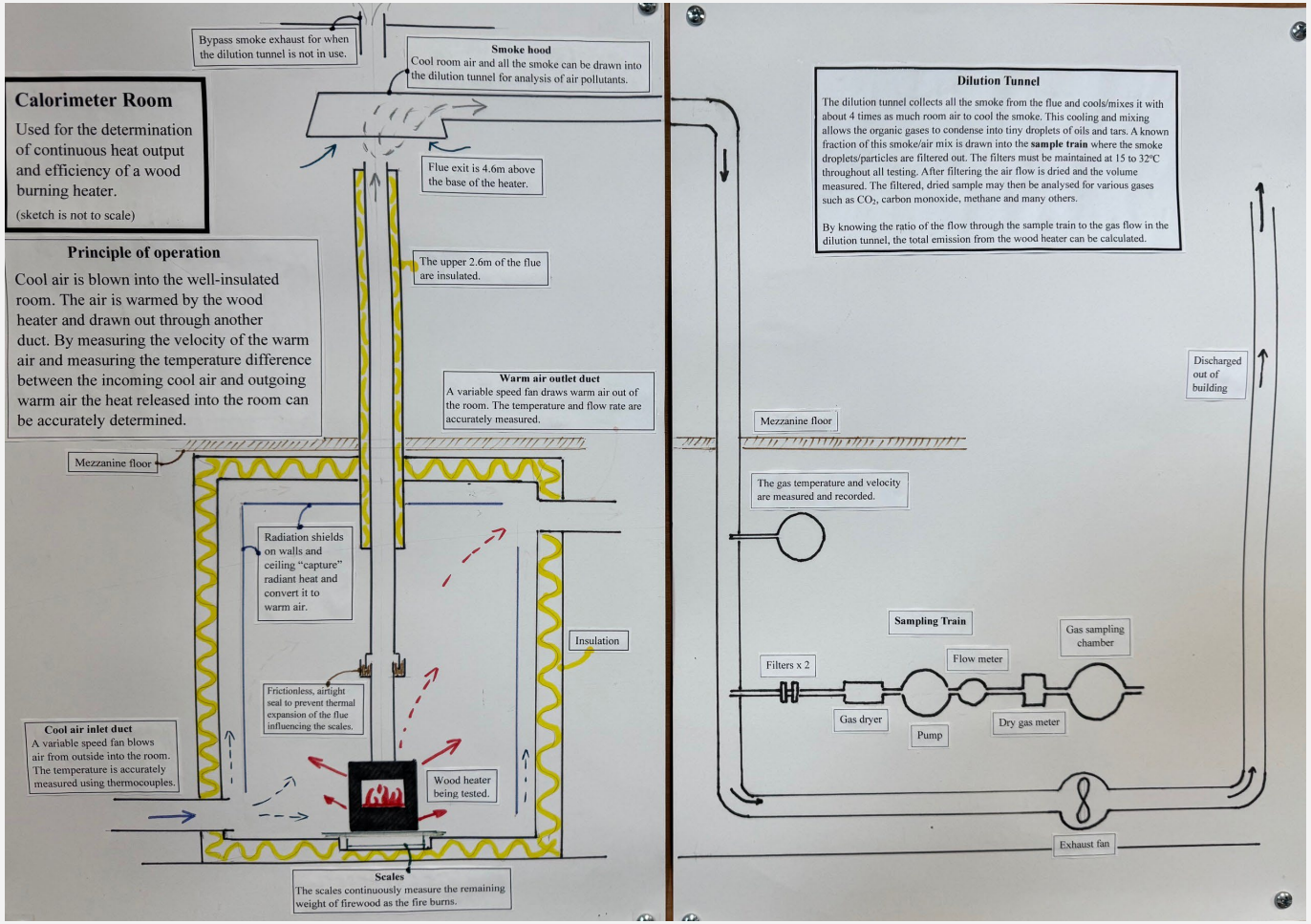
Developing a ‘Real World’ Protocol

John Todd and the FireLab^3 Team



Explanation of the PowerPoint slides.

- The title slide shows a sketch of the calorimeter room (used for measuring heat output and efficiency) and dilutions tunnel (used for capturing smoke particles on fine filters to measure the heater's fine particle emissions) The facility was built and commissioned between 2021 and 2023 by the FireLab^3 team. The photo is one of the heaters in the calorimeter room ready for testing.

- The following slide summarises our approach to development of a more effective test procedure (Protocol) for wood heaters. A new approach is required because the standard AS/NZS 4012/4013 is not achieving the desired reduction in wood smoke emissions. The Australian Protocol we are developing is based on the successful NZ Canterbury Method 1, which has contributed to measured reductions of wood smoke in parts of NZ. An earlier test method commissioned by Environment Australia has also been used (Todd 2005).
  Another commissioned study of wood heater operation and firewood parameters (Todd 2008), which gathered detailed information on thousands of heater refuellings across Australia and the quality of firewood being burnt, was also important in developing our Protocol.
  Any test method used for certifying wood heaters must also be practical for laboratories to carry out in a reasonable number of days, so that it is not prohibitively expensive.
  We have been observing reasonably repeatable results in the testing we have done so far. But advice from NZ, where they have carried our more testing across more than one laboratory, suggests differences in density of commercial firewood from different regions will increase the statistical spread of emission results.
  We are about to begin a series of test using our latest draft of our Protocol.

- The four following slides provide examples of some of our results obtained while using several variations of a draft protocol. We have now reached the point where we are comfortable with the draft Protocol. The next step is to run the four low emission NZ wood heaters through the final version of our Protocol.

- The slide headed 'overview' shows the power (rate of heat output into the calorimeter room) from one test on the Tropicair Rua. The power curve is a useful way of showing the 3 stages of operation of the heater. We measure the smoke emissions (mass of fine particles) separately for each of the 3 stages. In this example, the highest emission rate (grams of particles emitted per hour) is Stage 1. Any wood heater will emit some smoke until the combustion chamber heats of to normal working temperature. The emission rate is lower for the high burn period (Stage 2). The heater has its lowest emission rate for the slow burn (Stage 3) reflecting the heater's good design. Most heaters in Australia have their highest emissions when burning slowly.

- The next 3 slides provide a bit more detail on each of the three burn stages that we measure.

- The last 2 slides sum up the progress to date. There had been some concern that the successful NZ ultra-low wood burners (ULEBs) might not perform well when burning Australian hardwoods. Our preliminary work suggests that hardwoods do burn very cleanly in these designs of heater.
  The table shows that, despite small differences in the three test methods shown, the heaters burn softwoods, mixed softwoods and hardwoods and hardwoods very cleanly.
  We have run three different models of wood heater that comply with the AS/NZS standard through the draft Protocol method and all three had significantly higher emissions. This is not surprising, as these heaters were designed to perform well under the Australian testing method.
  We will now run a final set of measurements to ensure that the Protocol achieves what we set out to do – have a test method that ensures heaters are designed to burn cleanly when operated in people's homes.

Our general approach to the protocol and preliminary outcomes

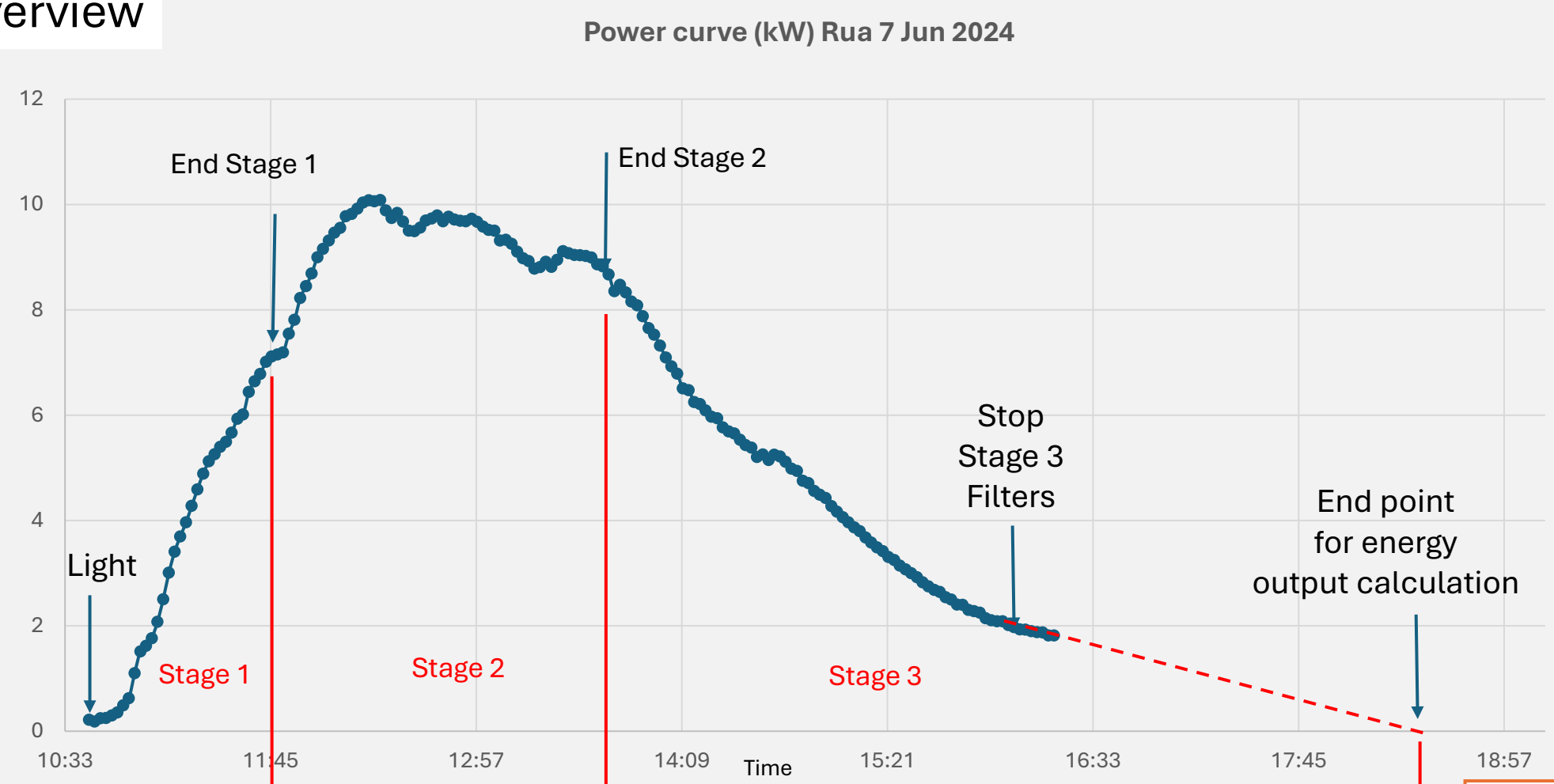
- We developed the protocol from CM1 & a 2005 study for Commonwealth EPA
- Real world operation informed by National Wood Heater Operation and Firewood Parameters Study (2008), also some smaller recent surveys

- The approach must be practical (e.g. using the same laboratory configuration as AS/NZS4012/13). Must not require excessive test time; say, be carried out within 1 week (aiming for 4 days of testing per heater).

- Results must be repeatable (~ 1 SD of 0.15g/kg reducing to half this by averaging 4 full tests). This is similar to AS/NZS4012/13 uncertainty.

- Preliminary work: we have tested 4 NZ ULEB heaters and 3 AS/NZS tested heaters. We will now retest, using the refined Protocol.

Overview



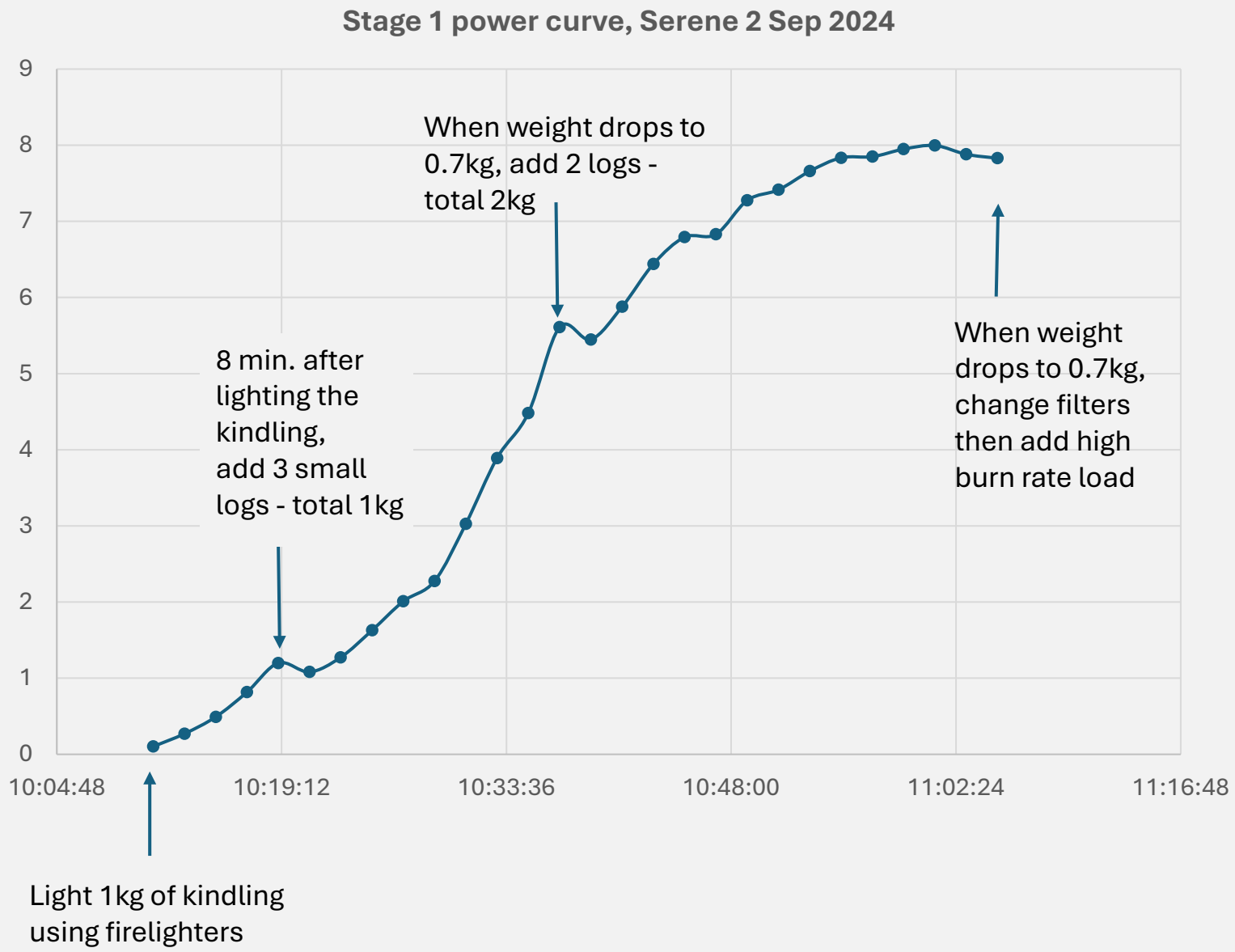
	Stage 1	Stage 2	Stage 3
Emissions	4.5g/h	1.3g/h	0.18g/h
Firewood added	4.08kg	5.4kg	2.34kg

Full test results

Emissions
0.74g/kg, 0.057g/MJ

Efficiency
68%

Stage 1: lighting the heater and achieving a good, hot fire



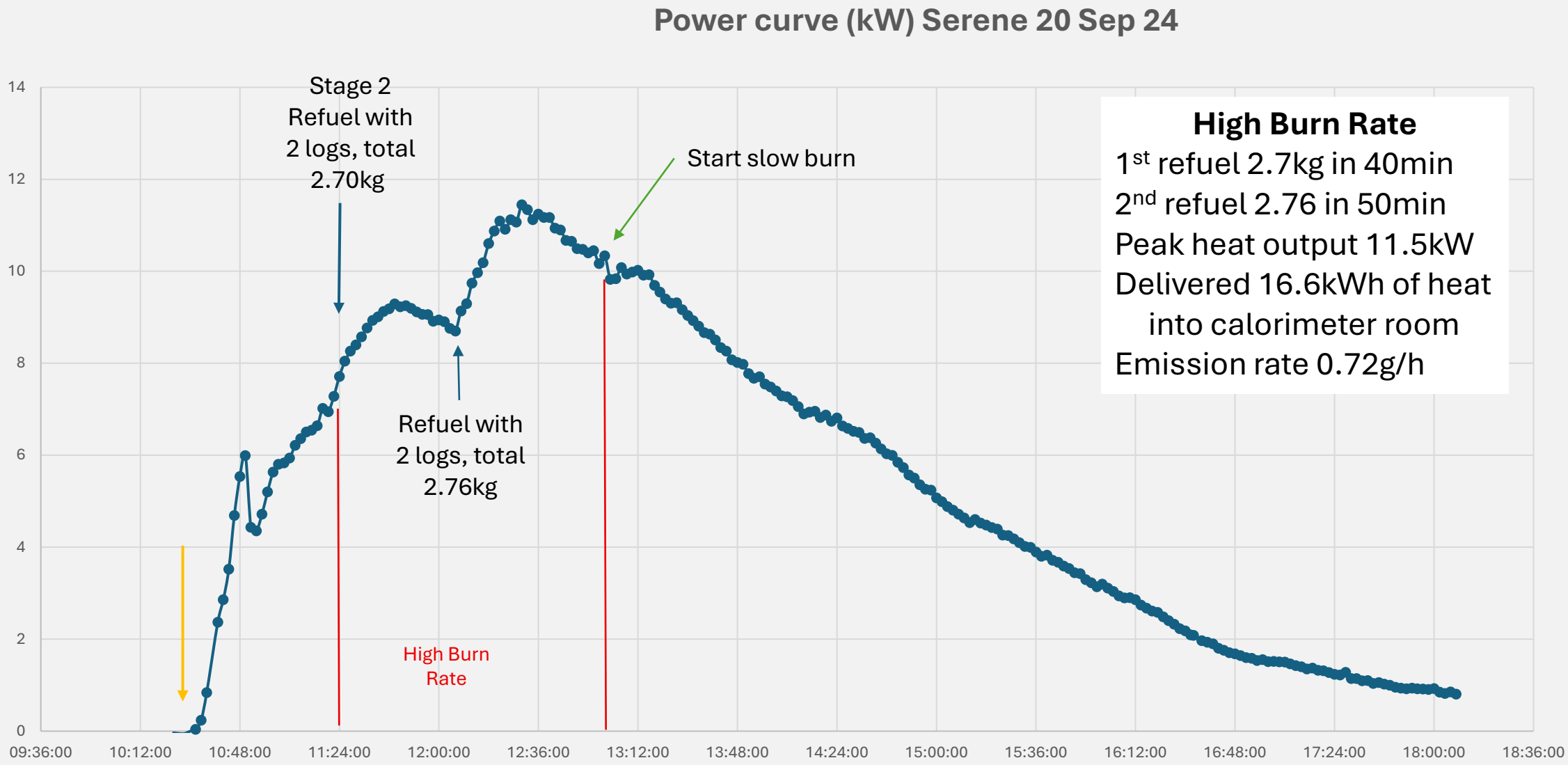
Stage 1
Light with firelighters (2 tests)
Newspaper (1 test)
2 logs + kindling (1 test)

Kindling, then small logs
then bigger logs (3 tests)
Logs + kindling (1 test)

10 minutes about 1kW
20 minutes about 3kW
30 minutes about 6kW

Emission rate 3.36g/h

Stage 2: High burn rate, air control fully open, maximum heat delivery into living space



High Burn Rate

1st refuel 2.7kg in 40min

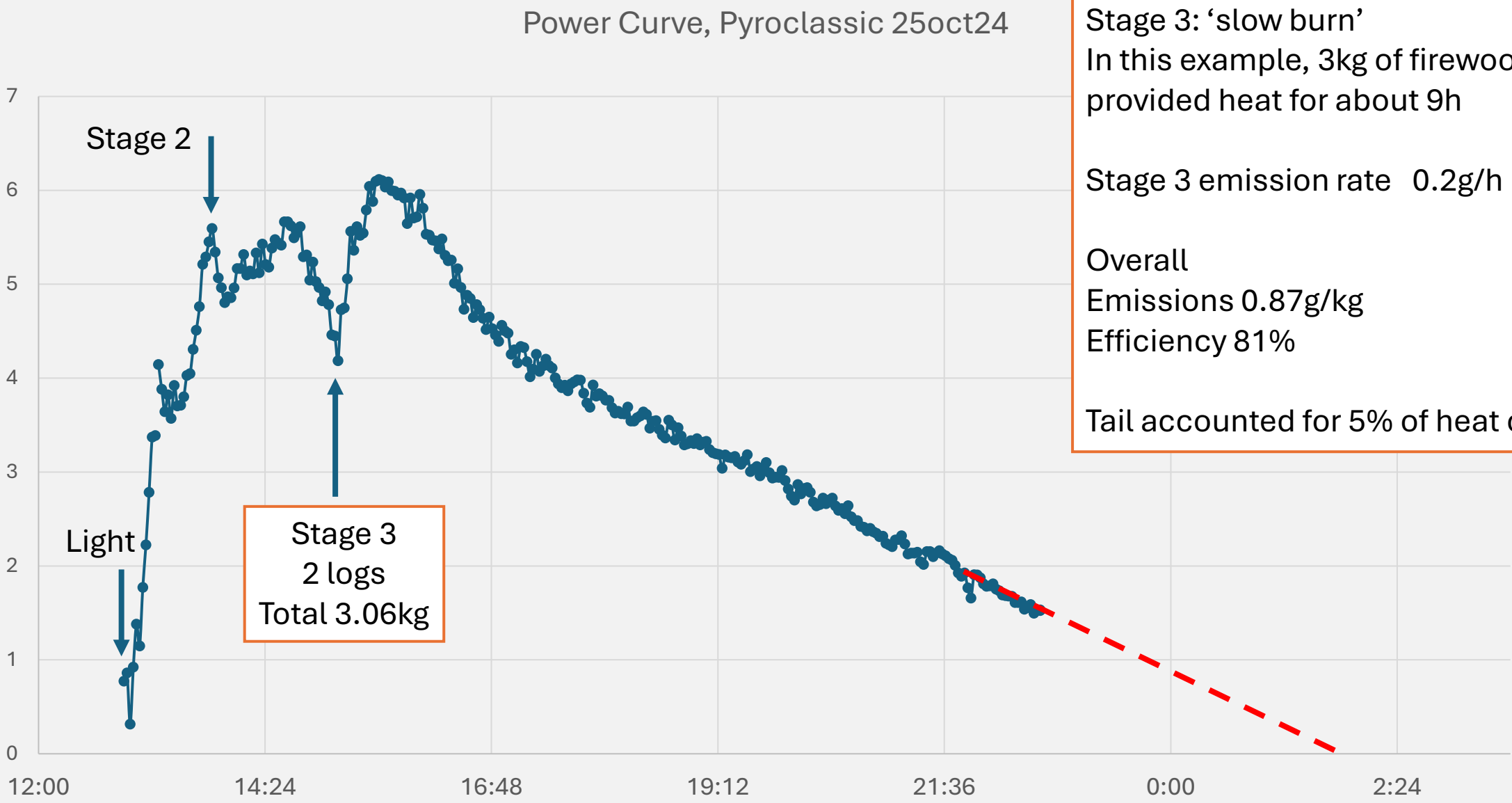
2nd refuel 2.76 in 50min

Peak heat output 11.5kW

Delivered 16.6kWh of heat into calorimeter room

Emission rate 0.72g/h

Stage 3: Slow burn, and extrapolate until power curve back to zero,
Pyroclassic is unusual because it has a fixed combustion air inlet



Stage 3: ‘slow burn’
In this example, 3kg of firewood provided heat for about 9h

Stage 3 emission rate 0.2g/h

Overall
Emissions 0.87g/kg
Efficiency 81%

Tail accounted for 5% of heat output

Summing up

- The draft test method (Protocol) shows NZ ULEB heaters can perform very well burning eucalypt.
- Our results (even with slightly different detail in the method) are not very different from NZ
  Emissions g/kg (for the ULEB certified heaters)

	Rua	Serene	Pyroclassic	Blaze King
CM1sw	0.41	0.33	0.44	1.40
CM1 hw	0.99	0.86	1.05	1.45
FireLab[3]	0.81	0.50	0.47	1.18

I will close some personal observations

- AS/NZS tested heaters performed poorly compared to ULEBs
  Not surprising given the differences in test methods
- There will be small changes in operating procedures in our final test method, to cover some additional home operating practices.

Above: a heater with a large, preheated secondary air supply. A load of firewood has just been added to a hot heater and the combustion air control immediately set to minimum. The polluting gases are burnt well in the swirling mass of flame above the wood thanks to the secondary air supply.

Below: a heater that, when hot, draws the gases emitted by the wood down through the base of the fire chamber where they are mixed with pre-heated secondary air.