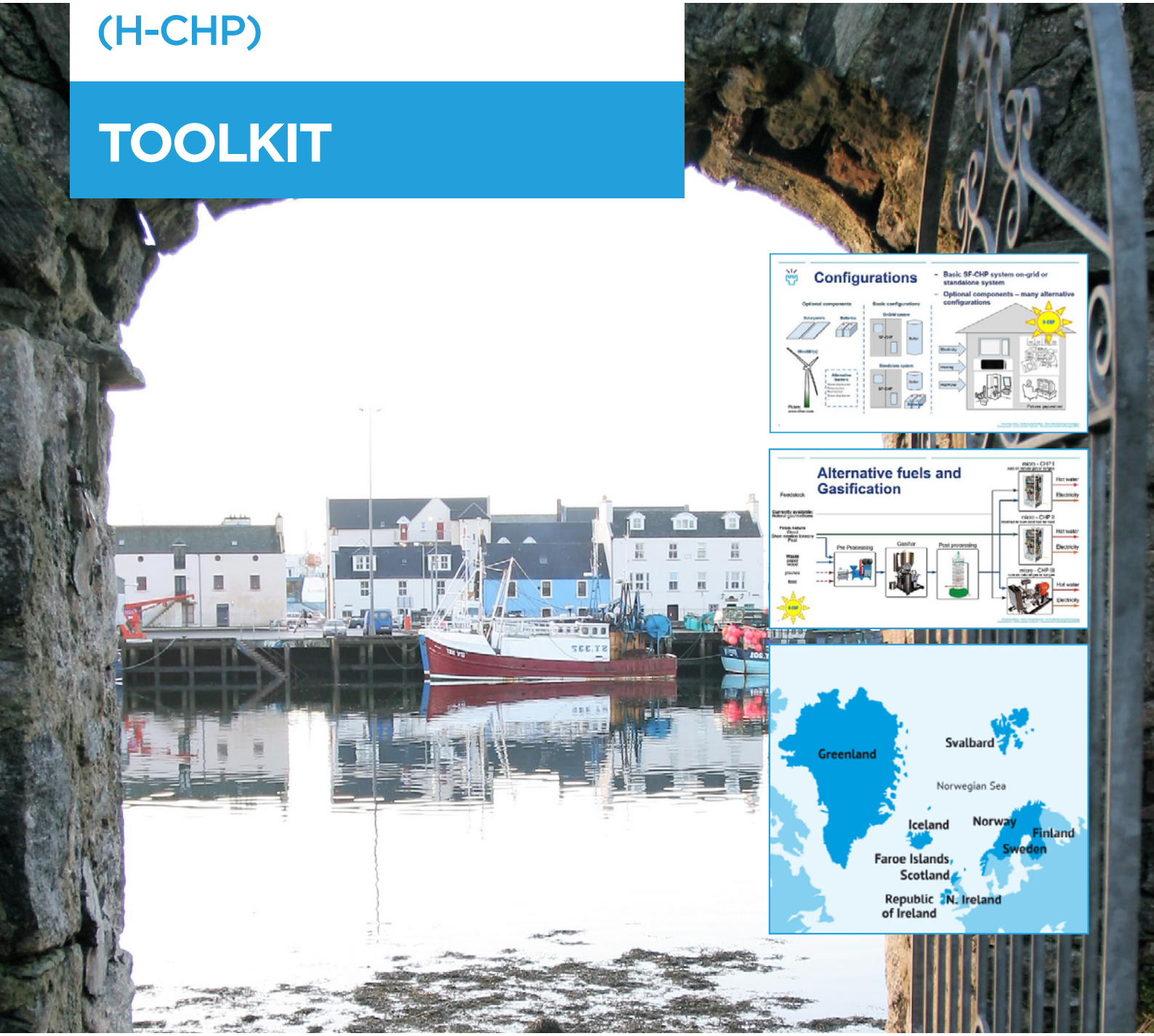
HOUSEHOLD COMBINED HEAT AND POWER

(H-CHP)

TOOLKIT

Northern Periphery and Arctic Programme
2014–2020

EUROPEAN UNION
Investing in your future
European Regional Development Fund



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Northern Periphery and Arctic Programme 2014–2020

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University of the Highlands and Islands
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Oilthigh na Gàidhealtachd agus nan Eilean
Colaisde a' Chaisteil

TIGHEAN INNSE GALL

Supply Chain

Any combined heat and power system require a constant Biomass fuel supply. All supply chains start with the production phase, which includes the growth and harvest of the raw materials (wood in this case). The same raw materials will then be pre-processed and converted to be stored and used.

The final phase is naturally the consumption one, with the fuel being burned in the HCHP unit to generate heat and electricity.

Among all these stages, the major issues concern transport, storage and handling of the Biomass fuel, and those are all factors that need to be taken into account.

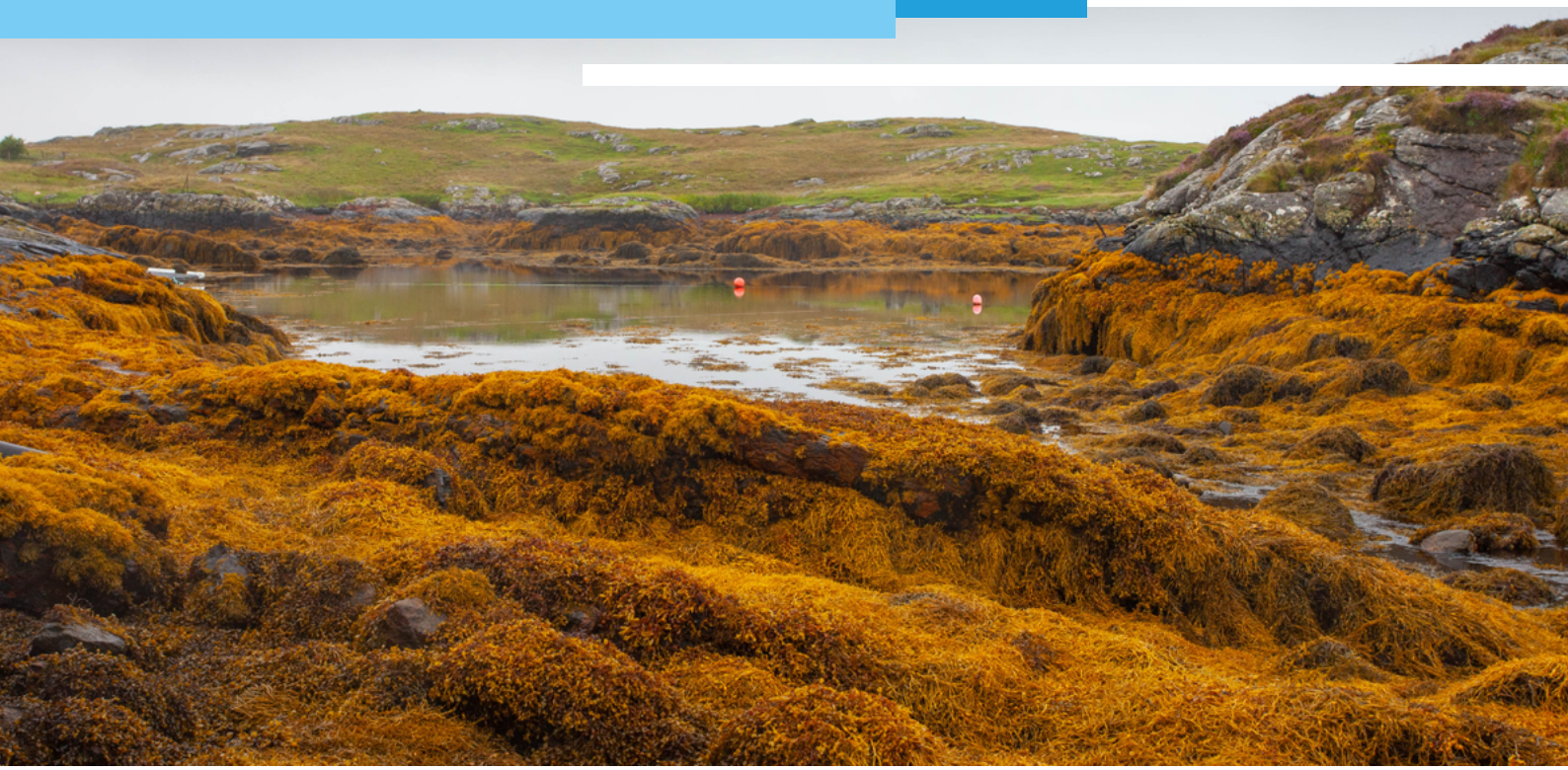
There are different types of Biomass that can be used:

- **forestry, or virgin wood;**
- **energy crops (beet or wheat);**
- **waste from agricultural/food/industrial processes (barley straws, paddy husks, coconut shells);**
- **aquatic biomass (algae, seaweed).**

From these types of raw Biomass, different fuels can be obtained:

- **wood pellets;**
- **wood chips;**
- **wood logs.**

The user will need a proper continuous fuel supply chain, from the Biomass producer (which could be far from the HCHP unit location) to an appropriate local dry storage with good ventilation and moisture control. Supply chains have to be carefully organised and all their economical and logistic impact calculated, before proceeding with the installation of an eventual HCHP unit.



Accreditations

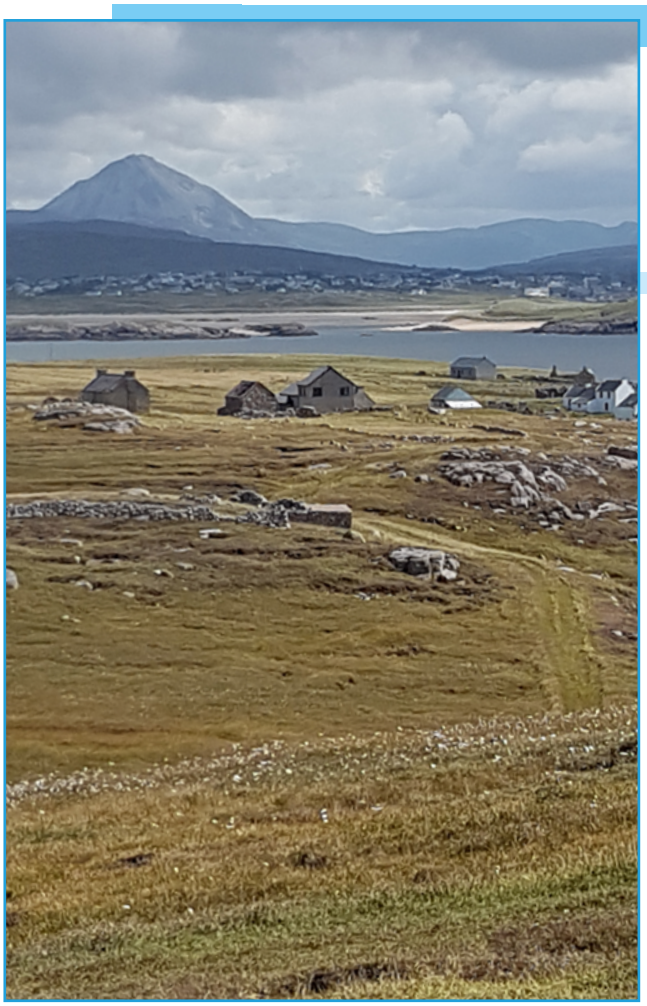
The first results of a study on CHP legislations in the various countries of the NPA area show that the regulations are mostly dedicated to large CHP plants, with high generation capacity (most of them are focused on the more than 1 MW production), and only recently there has been the introduction of legislations regarding small CHP units.

Nonetheless, they are a good starting point for a HCHP project and installation, since it gives the insight on what the country is already doing in and for this particular sector.

An important note to remember is that regulations can change easily, promoted or cancelled in reflection of the ongoing political interests.

To offer a sample guideline, the legislations of two countries in the NPA area (Finland and the UK) have been analysed below. However, each final user has the task to acquire the necessary information from the relevant authority.

Regarding Finland, there is an (electricity) Energy Aid Scheme in place, which includes state grants for investments in renewable energy sources (such as HCHP), approved against fixed asset investments. Similarly, a tender scheme is in action, with the promotion of electricity production through renewable energy sources.



For Heating and Cooling, a Heat bonus is present, which will be paid for a set amount of heat produced from CHP plants. Furthermore, there are supports on the capital costs of installing a CHP unit, with an option dedicated to farmers.

Regarding the United Kingdom instead, for electricity, there is a Carbon price floor, with supports for both biogas and biomass, and a tender scheme, with payments between customers and the state based on market prices and a predetermined strike price.

For the Heating and Cooling portion there are two renewable heat incentives available, classified non-domestic and domestic. There is also to remember that Northern Ireland has different schemes in place compared to the ones of Great Britain.

WOOD LOG GASIFIER

Part 1
Before Start-up Procedure

1. Cleaning

a. Remove ash from the upper chamber
b. Remove ash and cinders from the lower chamber
c. Cinders (burned coils) could be reused in the upper chamber
d. If needed, the convection channels to be swept

Part 2
Start-Up Procedure

2. Starting up of the furnace

a. Push the touch screen once
b. Make sure that indicator light is green, if not, push the reset button twice (the button is on the right side of the control panel)
c. Ignition (set up the fire),

Open the upper and the lower hatches (= doors 2 and 3 in the manual)

- Put some bark and small pieces of wood in the upper chamber
  - When burning properly, increase small pieces of wood to the upper chamber
  - Nearly close the lower hatch (let air still flow)
  - Increase small wood pieces / wood particles to the upper chamber
  - Close the upper hatch
  - Wait until the flue gas reaches approximately 150...180 degrees of C.
  - Close the lower hatch
  - Close the upper hatch

Part 3
Operating Instructions

3. Using the wood log gasifier

a. Close the direct circulating hatch (the direct flue gas outlet),
   - burning of flue gas starts automatically

b. Fulfil the upper chamber with wood

c. When temperature of the hot end of the Stirling generator (SG) reaches 150 deg. of C

d. SG will automatically start when temperature of the SG's hot end is over 150 deg. of C, also the the cooling pump of SG should be starting to rotate

e. The indicator light should be green

f. The temperature of the hot end of the SG temporarily drops

g. If proper fire is burning the SG hot end temp. should rise again

4. Heat + electricity

a. When, the wood log gasifier +SG is running it will produce heat and electricity

b. Overheating of the boiler – avoidable but Watt's safety thermostat will cool the boiler in the case of over heating

c. Laddomat should keep temperature of the wood log gasifier water content above 60 deg. of C.

d. When temperature of a heat storage tank (about 1500 litre) reaches above 75 deg. of C, do not add wood anymore.

5. Adding Wood

a. Press the touch screen in twice

b. Open

c. Compress the wood the burning wood

d. Pile (add) wood logs of max. 50 cm in length tightly to the upper chamber, half or ¾ of it's volume

e. Close upper hatch

f. Press touch screen once

g. Time calculator starts running, after about 60 sec. Close the direct flue gas outlet

Part 4
Shutdown

6. Ending

a. When water temperature hot enough (between 60-90 deg. of C)
b. Power of the SG drops (SG stops)
c. Press the touch screen twice
    i. Open the direct hatch (the rod in the front of the door 2)
    ii. Move embers in the centre of the heater
    iii. When completely burned, close all hatches
d. Press the touch screen once

If temperature of the flue gas is over 50 deg. of C. the flue gas fan is still running, it will be stop automatically.

UNIVERSITY OF ICELAND

GASIFIER EXPERIMENTERS KIT

STANDARD OPERATING PROCEDURE

Part 1
Before Start-up Procedure

Every time the GEK is operated, and before the "**Startup SOP**" begins, the following tasks must be completed.

Startup Tasks to be Done Before Every Run

Before proceeding to these tasks, check the previous run's ***Post Run Maintenance*** for any unchecked tasks. Any unchecked tasks MUST be finished BEFORE continuing.

Tasks that MUST be Done Before Starting the GEK:

Before proceeding to these tasks, check the previous run's ***Post Run Maintenance*** for any unchecked tasks. Any unchecked tasks MUST be finished BEFORE continuing.

- **Charcoal in GEK Gasifier**
  - Charcoal should Completely fill the space above the Ash Grate and the reduction bell and about 15 cm (6 inches) below the PyroReactor viewpoint
- **Hopper filler with feedstock**
  - The hopper should be filled at least halfway before start. (refer to feedstock requirements)
- **Gas Filter**
  - Filter must be packed according to the specifications.
  - If already packed, confirm that the filter is not clogged (Pfit must be < 300 during engine operation. If it reads > 300 it is time to change the filter.)
- **Condensate Vessel**
  - Should be empty- drainstock must be securely shut.
- **Ash Collection Vessel**
  - Should be empty.
- **Cyclone Can**
  - Should be empty and attached with an airtight seal.
- **All seals and connections are airtight**
  - See **"Leak Testing the Power Pallet"**
- **Air Filter**
  - Engine air filter clean enough for sufficient airflow
- **Engine Coolant**
  - Filled to the proper level with the appropriate coolant (see the engine manual for specifications)

- **12V DC Battery**
  - Battery should be fully charged.
  - Minimum voltage on the battery is 12V, but 14V is preferred
  - Governor Throttle Control Check
- **Disconnect gas line to verify that governor is freely moving**
  - Check That the Blowers Work
  - Blowers are able to put at least 50-60 units vacuum on reactor (Preac)
- **Oxygen Sensor Reading**
  - Oxygen sensor number displays should read 1.5 at startup; DO NOT run if error condition shown.
- **Flare**
  - Igniter should turn ON when Preac (Indicated on the PCU display) is greater than 5.
  - Check visually to make sure the Igniter turns on (glows red).
- **Biomass Auger Feed**
  - Runs properly (not obstructed) and fills reactor with feedstock.
  - Alarm will sound if not working properly
- **Clearance for Rotational Components**
  - Make sure nothing is obstructing the rotational components of the generator, engine, or gasifier (ie: wood chips, tools etc.)
- **Flare or Exhaust Stack**
  - Make sure nothing is obstructing the hot gas exits of the exhaust and flare stack.
- **Check CO (Carbon Monoxide) Meter**
  - CO meter is working and is near the operator
- **Walk Around**
  - Double check bungs (plugs), latches, gas connections and bolts

Leak Testing the Power Pallet

- **Turn on the automation assembly**
- **Open the valve to the flare and close the valve to the engine**
- **Seal off the air intake check valve; use a 1.5” pipe plug.**
- **Turn the gas blower up to 11 (the maximum setting). This will apply the vacuum to the entire gas circuit.**
- **Shut the valve to the flare, then turn off the blower. The valve should lock in the vacuum pressure.**

Test criteria #1: when the numbers indicated for the Preac and Pcomb

- If the Pratio is near or >90, the reactor passes the leak test
- If the Pratio is <90, it may be that the battery has insufficient charge, there is a significant leak, or there is a large pressure drop in the system.

Test criteria #2: After closing the valve, the pressure will begin to drop. Start timing the pressure drop on the PCU right after the valve is closed

Takes >60 seconds to reach 0. You are good to continue.

Takes <30 seconds to reach 0, the reactor fails and should not be operated until the leak is repaired.

Part 2
Start-up Procedure

Every time the GEK is operated, after the "**Before Startup Procedure**" is completed (see Part 1), the following tasks need to be completed when starting up the GEK.

Start up checklist

Before starting up, check the following items to make sure everything is done.

- Charcoal in Gasifier: Completely fill the space above Ash Grate and reduction bell, ~6 inches below the PyroReactor viewport.
- Hopper Barrel: Should be filled with feedstock; **DO NOT** run the machine on an empty hopper. Hopper should be ¼ full at **ALL TIMES**.
- Gas Filter: Should be packed according to the Technician's Handbook's instructions. Check so filters are not clogged. **Pfilt** <300 during operation. Greater than 300, change filter. If **Preac** is more than 30 above the **Pfilt** reading, re-pack the filter.
- Condensate Vessel: Should be empty; draincock must be securely shut. Turn counterclockwise tighten.
- Ash Collection Vessel: Should be empty.
- Cyclone Can: Should be empty and attached with an airtight seal.
- Connections: No air leaks in system, Part 1 has a leak check.
- Air Filter: Engine air filter clean enough for sufficient air flow.
- Engine Coolant: Filled to proper level.
- 12V DC Battery: Should be fully charged, 12V minimum, 14V preferred.
- Governor: Disconnect gas line to verify that governor throttle is freely moving.
- Blowers Check: Blowers are able to pull at least 50-60 units on reactor. (**Preac**)
- Lambda Display: Should display 1.50 on the circle display.
- Obstructions: Are there any tools, woodchips left on the machine that might fall into rotating parts?

Start up tasks

Once the before procedure in Part 1 is completed and the checklist above is complete, then you are ready to do the following steps for running the engine:

Caution: At all-time do not breathe any gas emitted from the gasifier or a tube. Keep a CO sensor right with you. Use the thermal gloves to handle all parts until you are sure they are cold.

- Disconnect electrical loads before starting the engine.
- After 20 mins., if **Trst** is above 800 and **Tred** is above 700, you can start the engine.*
- Upon start-up, be sure to keep all openings in the gasifier sealed. Do not loosen the handwheel or open the access door.
- Quickly close the valve to the flare and turn the gas and blower knobs to 0.
- Close the flare valve and open the gas valve to the engine.
- Turn the key to engage the starter. Unlike a normal engine, you might need to crank a few times before it starts, and this is normal. **DO NOT** crank for more than 5 seconds at a time before waiting 15 seconds for the starter to cool.
- To turn off, turn the key into the off position, wait until the engine has stopped turning and close the engine valve. Switch the system over to flare mode.

** If it's been more than 20 minutes of running and both gas and air knobs are at 11 and Tred is over 600 but stopped going up, try starting your engine anyway.*

Notes

- Do not open the hopper without suction from the gas blower or engine.
- Refill the hopper before it reaches 1/4 level. To check, bang on the hopper and if there is a hollow ring, the hopper might be empty.
- **WARNING**: An empty hopper full of gas can explode.
- If the engine has trouble starting, you might have to refer to Troubleshooting.

For further information about start-up, see the operators manual section 7.5.3, and relevant sections of the technician's manual for troubleshooting.

Part 3
Operating Instructions

After the start-up procedure in part 2 is completed you are ready to do the following steps:

Turning on the engine:

- Make sure that the electric load is disconnected from the generator
- Close the valve to the flare (lever arm 90 degrees to the flow direction)
- Turn off both blowers
- Open the valve to the engine (lever arm parallel to the flow direction)
- Turn the engine key to the right to engage the starter. Note that you may need to crank it long enough for the gas to fully purge. Do not crank for longer than 5 seconds at a time before waiting 15 seconds for the starter to cool *
- When Tred on the PCU reaches 700°C, connect electric load to the generator (min. 3kW)

Things to check while running:

- Make sure that the hopper is at least ¼ full when running**
- Check for bridging in the hopper and reactor
  - i. If the feedstock auger does not stop, there may be a bridge in the hopper***
  - ii. If Pratio is above 60, there may be a bridge in the reactor****
- Trst should normally be between 800 - 1020°C. Minimum 750°C
- Tred should be higher than 650°C
- Pratio should be between 20 - 60
- Pfilt should be below 300

** The engine may take up to a minute or more to start. If the engine fails to start after 3 attempts, let the starter cool for 5 minutes and troubleshoot the system. See the Troubleshooting section of the Technician's Handbook.*

***** Caution: Do not open the hopper without suction from the engine (or blowers). Do not breathe any gas emitted from the hopper when you open it.***

**** To resolve this try first to hit the outside of the hopper. If this doesn't work you need to open the hopper and stir or poke the feedstock with a long stick until you can hear the feedstock auger has stopped. Make sure there is a tight seal when you close the hopper.*

Caution: Do not breathe any gas emitted from the hopper when you open it.

***** If there is a bridge in the reactor you need to open the reactor viewport and poke the bridging with a long stick until the feedstock auger starts.*

Caution: Wear thermal gloves. Do not breathe any gas emitted from the reactor's viewport when you open it. Keep a CO sensor close by.

Part 4
Shutdown

For shutting down the gasifier, the following tasks need to be completed.

Gasifier Shutdown Procedure

Turn the blowers down until Preac is 1 and let the system run for 5 minutes (or until Tred is 650˚C) before completely shutting all valves off. This is because the gasifier will have enough heat in it to continue to produce gas and smoke even after the engine is stopped; all of the gas produced by this residual heat will result in the Power Pallet leaking smoke and carbon monoxide rich gas into its surroundings. If the gasifier is very hot and is shut down without a cool-down period, the large quantity of tar gases produced by the residual heat may even condense on the feedstock in the pyrolysis column and may increase the risk of jams when cooled down.

Shutdown check list

Caution: keep the carbon monoxide detector nearby at all times.

Caution: there may be hot liquid tar and condensate in the hoses after shutting down the machine. Have a container nearby into which you can pour the tar and condensate into.

- Disconnect the hose between the air mixer and the engine governor to drain condensate and tars.
- Inspect the engine governor throttle plate for tar accumulation, and clean accordingly while the tars are warm and soft. Reconnect when finished.
- Drain the condensate vessel and close the draincock securely. Rotate clockwise to open and counter-clockwise to close.

Display Alarms and System Responses

Alarm Name on Screen	Alarm Conditions	Time until Alarm	System Shutdown Time	Advice Displayed on Screen
Auger on too long	Auger on	4 min	Auto Engine Shutdown at 6 mins	Check Fuel
Auger off too long	Auger off	8 min	Auto Engine Shutdown in 10 mins	Bridging?
Bad Reactor P_ratio	if P_ratio value is <p_ratio low value and >p_ratio high valure (user configurable; default = 30,60)	Variable	No action	Reactor Fuel Issue
Trst low for engine	<700°C (default; user adjustable) for trest	3 sec	No action	Increase Load
Tred high for eng.	Engine on and reduction temperatures above 950°C	Immediate	Engine shutdown at 60 sec	Low Fuel in Reactor?
Check Oil Pressure	Oil pressure less than user setting (default = 6psi)	No alarm	Auto engine shutdown after 0.5 sec. Note: first 3 seconds during start up ignored	Check Oil Pressure
No O_2 Sensor Signal	Greater than 0.25 sec	30 sec	Reset oxygen sensor at 0.25 sec. Auto engine shutdown after 60 sec	No O_2 Sensor Signal
Auger Low Current		1 min	Auto engine shurdown after 3 min	Check Fuel
FuelSwitch/Auger Jam	10 auger fwd/rev cycles	Immediate	Auto engine shutdown at 20 forward/reverse cycles	Check Fuel & Switch
High P_comb	Combustion vacuum > 300 units	No alarm	Immediate	Check Air Intake
High Coolant Temp	Greater than 98°C default (user configurable)	0 sec	Engine shutdown 3 sec	High Coolant Temp
Reduction Temp Low	Engine on and top restriction temperatures below 790°C	3 sec	Engine shutdown 7 sec	Increase Load
Restriction Temp High	Engine on and Trst > 1050°C (user configurable)	No alarm	Engine shutdown 15 sec	Reduce Load
Reduction Temp High	Engine on and Tred > 975°C (user configurable)	No alarm	Engine shutdown 60 sec	Reduce Load
Grate Motor Fault	Electrical or mechanical issue with grate shake system	Immediate		
Ash Auger Stuck	Mechanical issue with ash removal system	Immediate		
Ash Auger Fault	Electrical issue with ash removal system	Immediate		

Part 5
Post Shutdown Maintenance

Every time the GEK was operated, after the shutdown SOP is completed (see part 4), the following maintenance tasks need to be completed.

Maintenance tasks to be done after every run

After the shutdown procedure in part 4 is completed you should have both the ball valves shut (lever arm 90 degrees to the flow direction), all blowers off, the engine off, and on the display you should have Tred < 650 C. Then you are ready to do the following steps:

Caution: At all-time do not breathe any gas emitted from the gasifier or a tube. Keep a CO sensor right with you. Use the thermal gloves to handle all parts until you are sure they are cold.

Caution: The tar liquid and condensate may be hot, sticky, stinky and irritate the skin. Do not touch or spill it.

- Turn on both gas blowers to 3 or 4**.
- Disconnect the hose between the air mixer and engine governor at both ends. Hang the hose on the hook with both ends inside the drainage bucket. Let the condensate and tar liquid drain into the drainage bucket while you continue with the next task.
- The engine governor throttle cavity is now exposed. Use the alcohol squirt bottle and a paper towel to clean all tar and residue from the cavity and throttle plate.
- Use a screwdriver to check that the throttle plate can open and close freely.
- Drain the condensate vessel using the stopcock at its bottom. (Clockwise to open.)
- Shut the stopcock securely when all condensate is drained. (Counterclockwise to seal.)
- Detach and empty the cyclone can. Re-attach it airtight.
- Detach and empty* the ash collection can. Re-attach it airtight.
- Reconnect the hose to the air mixer and engine governor.
- Turn off both gas blowers.
- Turn the main power switch off.
- Pour the tar liquid into the plastic waste bottle labeled “tar liquid”.
- Complete and sign the shut-down sheet on the clip board and log the hours the gasifier and engine was running today.

** If you do not have time to wait until the ash collection can is sufficiently cold to handle, then do not empty it. Instead circle the “empty ash can if necessary” bullet on the next start-up checklist on the clipboard, and write “not empty: X hours” next to it where X is the number of hours the GEK was operated since last emptied (the ash can hold between 12 to 24 hours of char ash).*

*** This is to help vent residual CO from stack instead of the openings you will create by removing the collection cans, hoses and draining the condensate.*

Other less frequent maintenance tasks

- The char ash and cyclone ash can be accumulated in a garbage bag. When full it can be Mixed with soil (it's a good fertilizer component) or disposed in the municipal garbage like regular organic waste.
- The tar liquid needs to be disposed just like used automotive oil. Hand it over to the hazardous waste disposal personal of the university like other chemical laboratory waste. (The typical composition of the tar liquid is)

For other weekly, monthly and annual maintenance schedule and instructions, see the operators manual section 8, and relevant sections of the technician's manual.

Clipboard Checklist

Responsible operator: _____ **Date:** _____

Other personal: _____

Purpose of session: _____

_____

Feedstock type & moisture level:

_____

Before start-up

- ☐ 1. Empty ash can if necessary
- ☐ 2. Empty cyclone can can if necessary
- ☐ 3. Empty condensate vessel if necessary
- ☐ 4. Confirm that there is Charcoal in GEK (up to 15 cm below reactor viewport)
- ☐ 5. Fill hopper with feedstock
- ☐ 6. Check that CO meter is working and is near the operator
- ☐ 7. Walk Around and check that all lids, plugs, latches and fittings are secured

Leak test (To be done before every start-up)

- ☐ 8. Turn on the automation assembly (control panel)
- ☐ 9. Open the valve to the flare and close the valve to the engine
- ☐ 10. Seal off the air intake check valve
- ☐ 11. Turn the gas blower up to 11

Wait for vacuum to form, then write down maximum values for:

Pcomb [mmH2O] _____ Preac [mmH2O] _____

Pratio _____ Pratio >90 ☐ Yes ☐ No

☐ 12. Leak test 1 passed?

☐ 13. Shut the valve to the flare, then turn off the blower

☐ 14. Immediately start timing the pressure drop

Time until Pcomb = Preac = 0:

Time to Zero: _____ Time > 30 sec? ☐ Yes ☐ No

☐ 15. Leak test 2 passed?

Note: If Pratio < 90 or vacuum loss time < 30 sec then the leak test is failed and the leak needs to be identified and fixed. Redo the leak test until it passes. Write here that the leak test needed to be repeated and what fixed the problem (future operators can thus learn the most likely sources of leak test failure). Notes on leak tests (if any) :

Start-Up Checklist

☐ 16. Make sure that the electric load is disconnected from the generator

☐ 17. Check that oxygen sensor read 1.5 (do not run if error)?

☐ 18. Poke the flap on the air intake valve to make sure it is not stuck.

☐ 19. Open the flare valve.

☐ 20. Close the engine valve.

You are now ready to turn on the blowers, light up the gasifier and vent to the flare. Go ahead and go through all the startup steps. (See training video 17)

☐ 21. Did the gas blower get Preac to -10 to -20 before you opened the lighting port?

Gas blower setting: _____ Air blower setting: _____

22. Did you need to add lighter fluid to light this feedstock (get smoke)? ☐ Yes ☐ No

☐ 23. Did the flare ignitor light the tar gasses in flare when Trest >= 51

24. Lowest Air blower setting that keep flames burning (roar) within flare with Preac = -40

Air blower setting: _____ with Gas blower setting: _____

☐ 25. Replace and lightly tighten lighting port cap when Trest >= 80

Wait until Trst >= 800 and Tred >= 700 to start engine. Increase both the gas and air blowers if the gasifier does not get hot enough. Wait until one of the two following engine start criteria is met:

26. Approximately how long did it take to reach Trst >= 800 and Tred >= 700? _____ (min)

☐ 27. Or, did you only reach Tred >= 600 after > 20 min and start the engine?

☐ 28. Make sure that all electric load is disconnected from the generator

☐ 29. Close flare valve, open engine valve, turn both blowers to zero

30. How many attempts did it take to ignite engine? _____

☐ 31. When Tred >= 700°C, connect the electric load to the generator (min. 3kW)

32. Please record the approximate steady state operating conditions for your feedstock and load combination.

Electrical load [kW] _____

Trest _____ Pcomb _____

Tred _____ Preac _____

☐ 33. Is Pfilt < 300 and |Preac – Pfilt| < 30 (i.e. filter operating normally) ?

Things to monitor during steady state operation:

- Trst should normally be between 800 - 1020°C. Minimum 750°C
- Tred should be higher than 650°C
- Pratio should be between 20 - 40
- Pfilt should be below 300.

Notes on deviation (if any)

_____

_____

_____

_____

Shut-down procedure

- [ ] 34. Disconnect the electric load from the generator
- [ ] 35. Shut down engine (turn key to off)
- [ ] 36. Immediately close engine valve, open flare valve
- [ ] 37. Turn gas blower knob until Preac <= -5
- [ ] 38. Did the flare ignite?
- [ ] 39. Turn up air blower to pull flames into the flare to produce roar sound
- [ ] 40. Gradually lower blowers down ton 1 as gasifier cool and flare dies out, run like this for >= 10 min until Trest < 650°C.
- [ ] 41. Turn both blowers to zero
- [ ] 42. Turn both engine and flare valves to shut position

Post shut-down maintenance

- [ ] 43. Turn on both gas blowers to 3 or 4**
- [ ] 44. Disconnect the hose between the air mixer and engine governor at both ends. Hang the hose to drain tar condensate into the drainage bucket.
- [ ] 45. The engine governor throttle cavity is now exposed. Use the alcohol squirt bottle and a paper towel to clean all tar and residue from the cavity and throttle plate.
- [ ] 46. Use a screwdriver to check that the throttle plate can open and close freely.
- [ ] 47. Drain the condensate vessel using the stopcock at its bottom. (Clockwise to open.)
- [ ] 48. Shut the stopcock securely when all condensate is drained. (Counterclockwise to seal.)
- [ ] 49. Detach and empty the cyclone can. Re-attach it airtight.
- [ ] 50. Detach and empty* the ash collection can. Re-attach it airtight.
- [ ] 51. Reconnect the hose to the air mixer and engine governor.
- [ ] 52. Turn off both gas blowers.
- [ ] 53. Turn the main power switch off.
- [ ] 54. Pour the tar liquid into the plastic waste bottle labeled “tar liquid”.

** If you do not have time to wait until the ash collection can is sufficiently cold to handle, then do not empty it. Instead circle the “empty ash can if necessary” bullet on the next start-up checklist on the clipboard, and write “not empty: X hours” next to it where X is the number of hours the GEK was operated since last emptied (the ash can hold between 12 to 24 hours of char ash).*

*** This is to help vent residual CO from stack instead of the openings you will create by removing the collection cans, hoses and draining the condensate.*

Complete one of the following:

I did empty all collection vessels (items 44 to 51) and clean and check the throttle cavity.

Sign name here

The gasifier was too hot and cooled overnight. The ash can has _____ total hours of ash in it (the ash can holds 12 to 24 hours of char ash).

Circle the "empty ash can if necessary" bullet on the next "before start-up" checklist on the clipboard for the next user, also write "not empty: X hours" next to it where X is the number of hours the GEK was operated since last emptied.

Also circle any of the "before start-up" items on the next checklist if any other of the item 44 to 51 tasks (empty condensate, cyclone can, tar liquid from hose and throttle check) still needs to be done and write a note there for the next operator and what exactly needs to be done.

Sign name here

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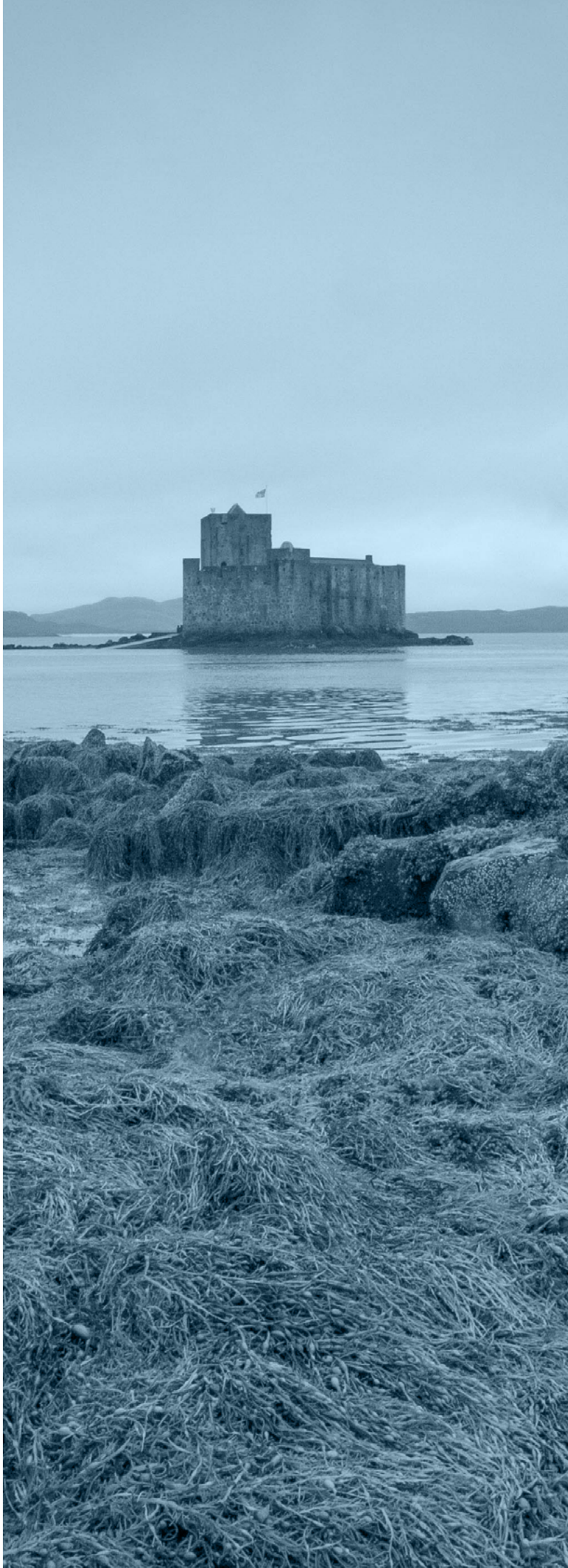

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