**Manual XylArch 2.0**

# Welcome

Welcome, dear wood/energy - consumption enthusiast.

This RShiny application is built as a replacement of the original XylArch tool, conceived for the [paper](https://doi.org/10.1016/j.jasrep.2016.12.029) "Fuel for debating ancient economies. Calculating wood consumption at urban scale in Roman Imperial times" by Janssen *et al*. (2017). The original is still available over at the original publication, but leaves much to be desired. XylArch 2.0 is meant to be a much more flexible, interactive and faster tool.

However, as these projects go, the new application itself remains unfinished. If you try anything funny (like running a calculation where the minimum value is larger than the maximum), the app will crash. So play nice. And don’t look at the code. It hurts my own eyes.

# What can the app do (at this stage)?

* Calculate the energy requirements of firing pottery and heating water for a bathhouse, as in the original work. There is currently no module for heating the bathhouse, i.e. the construction itself.
* Run several of these energy requirement calculations side-by-side. Useful for comparing the outcomes of different settings.
* Attribute different wood species (with, for instance, different energetic content) to the energy-consuming processes.
* Convert these different wood species to charcoal if desired.
* Allow you to name the different woods and processes generated.
* Generate boxplots.
* Provide a summary of all energy/wood requirements.

# What can’t it do?

* Tell you the right value of the variables involved. These depend on your own context. The values shown are purely meant as an example; in the case of wood and charcoal, they are standard values.
* Tell you the right distribution of the variable values. A normal distribution was assumed in the original paper, but in your specific case, a uniform distribution might be more realistic. Uniform distributions are however an option for all variables defined in the app.
* Run a sensitivity analysis. The original XylArch Excel macro featured the option to run a sensitivity analysis. That option is, as of yet, lacking in this incarnation.
* Calculate wood/energy requirements for households. My research is very much concerned with household wood consumption in the past and at some point in the future, I hope to transfer my findings into the app. This would however presuppose a simplification of the existing application code, as well as a clearer quantitative model than has at present been constructed.

# How to use?

1. Before launching:

You need to download the R code from my GitHub page. R and RStudio need to be installed, preferably in a recent version. The “shiny” package needs to be installed as well. Other packages may be installed while you first run the app. This may take a while.

1. To launch:

Open RStudio. Type the command

runApp(‘path to app/XylArch\_2021’)

where you substitute “path to app” by you’re the correct path (R uses forward slashes /) and press enter.

1. To use while running:

* **Introduction tab**: You are greeted with a welcome screen. This tab has no further uses at this stage. Click one of the other tabs in the banner at the top of the page.
* **Ceramics tab:** On this tab, you can calculate the energy requirements (abbrev. EQ) for firing pottery or bricks. Later, we’ll select one or several types of wood to fulfil these requirements.

In order to calculate EQ for pottery, select the option “Pottery” under “Additional Object Type” and click “Additional Entry”. The different variables determining the EQ (as defined by Janssen et al. (2017)) appear on screen. You can name the instance by typing in the box under “Name”. This name will be used throughout the application. Set the variables to your liking and click “Calculate Subtotal”. A boxplot of the calculated EQ appears at the bottom of the page. If desirable, you can hover your indicator over the graph for more information or click and drag to zoom in on a region. The boxplots can also be saved as images.

You can add as many instances of “Pottery” as you like by using the “Additional Entry” button. Conversely, “Delete Additional” deletes the last instance added. This deletion is irreversible, so exercise caution. Only after clicking “Calculate Subtotal” will the final tally be made, in order to save computational power by not rerunning calculations for every small change in a variable or every accidentally added instance. Pressing “Calculate Subtotal” is however required to write the different energy requirements away to the central registry, so be sure to click the button when you are finished tweaking everything on the tab.

Alternatively, you could add instances of “Brick”, which calculates the energy requirement of firing brick kilns. The formula used is however unpublished and therefore requires further documentation (which I will provide in due time).

* **Baths tab:** On this tab, you can calculate the EQ for heating water for public baths (following Janssen et al. (2017)). Everything on the tab functions in exactly the same way as on the Ceramics tab. Remember to click “Calculate Subtotal” to include every entry in your final calculations.
* **Wood tab:** On this tab, you can pair the different energy-demanding processes from the earlier tabs with one or several types of wood. Higher amounts of wood will be required to perform the same energy-demanding activity when a wood type with lower energetic content is selected. A minimum of one wood type is always present (Wood1), which you can rename and tweak to your liking. As in previous tabs, several instances of wood types can be added by clicking the “Additional Wood” button. Next to the variables relating to the wood type (“MJ/kg ovendry wood” and “% MC (wb) at time of combustion”) , a checklist of the different energy-demanding activities (e.g. Pottery1, Pottery2, Baths1…or any name you’ve come up with) allows you to indicate for which purposes this specific wood type should be used. Energy-demanding activities are split evenly between the wood types for which they are selected. For instance, if two wood types are open in the Wood tab, and one activity (Pottery1) is selected for both types, half of the energy requirement is attributed to one wood type and the other half to the other. Make sure every activity is ticked at least in one instance, otherwise it will not be translated into wood requirements.

For each wood type, you can also indicate that it should be converted to charcoal before serving in the energy-demanding activity. It is unlikely that ceramics would be fired or bath water would be heated using charcoal, but the option is there if you want to explore the effect of conversion. At the bottom of the page, you can access the variables relating to charcoal conversion.

The different variables present on this page:

* + MJ/kg ovendry wood: the net calorific content of ovendry wood (NCVo in the formula below). This depends on the species of tree and typically lies in the range of 18.4 - 19.2 MJ/kg for deciduous species and 18.5 – 19.8 MJ/kg for coniferous ones (European Committee for Standardization (2010)). The default setting in the app is 18.4 – 19.8 MJ/kg, representing the full range of possibilities.
  + % MC (wb) at time of combustion: the wood moisture content, weighed on a wet basis and expressed in percentages:

FAO (2015) proposes the following general ranges in MC: 50-60% for fresh timber, 25-35% for wood stored over a single summer and 15-25% for wood stored for several years. The 25-35% range is taken as the default in the app.

Moisture content drives down the calorific content of wood because energy is required to evaporate the remaining water. The resulting “lower heating value” or net calorific value (NCV) depends on MC and NCVo as follows (Francescato et al., 2008):

It is this NCV that is used by the app when calculating wood requirements.

* + Energy content charcoal (MJ/kg): the net energy content of charcoal resulting from incomplete combustion in pits or mound kilns. No further consideration of charcoal moisture content (after production) was made. The default range, 28 – 32.4 MJ/kg, is based on the general orders of magnitude mentioned in Maes and Verbist (2012), as well as the measurements of Schenkel et al. (1998) (Table 5, mound kilns only).
  + Mass conversion dry wood (%): the mass conversion percentage of ovendry wood to charcoal. The same two sources mentioned in the previous point provide a range of 10 – 31.5 %.

Wood requirement is then calculated as follows:

However, the ratio “mass woodMC / mass charcoal “ is not simply equal to the inverse of the 10 – 31.5% range defined above, because that range is based on the conversion of ovendry wood. The app corrects for the effect of wood moisture content at the time of charcoal production as follows:

Where NCVo and NCV are taken as illustrated above for each wood type that is turned into charcoal.

* **Total tab:** here, you can show summarizing boxplots for energy consumption and calculate the final wood requirements, after correction for charcoal conversion if required. Just hit the “Calculate” button.

That’s it. Feel free to contact me on any particular issues you found, suggestions, general questions etc. I have quite a bit of research on wood consumption laying around and might be able to help you out with a few things there as well.

The tool has not been used in a publication before, but I did present on it at a conference. If desired, you may refer to my presentation when making mention of the app. You can find details [here](https://www.caanlfl.nl/sites/default/files/CAANLFL_Abstracts.pdf).