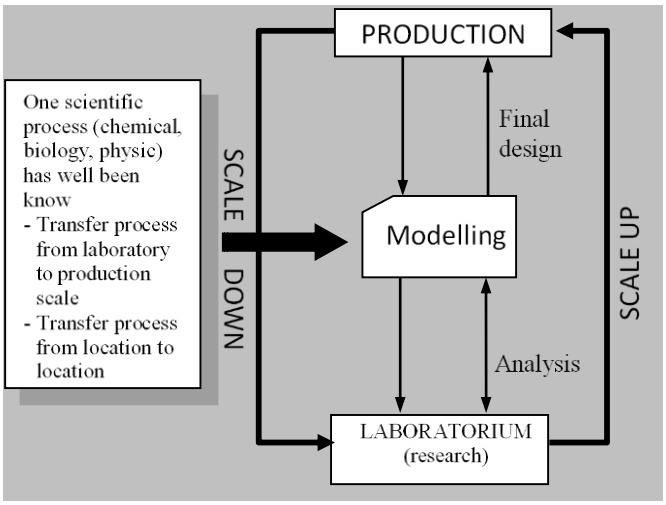

Figure 4. General schema modeling of scale duplication and scaling process (Bentolila, 2013 processed).

4. Result and Discussion

The choice of bioethanol production technology developed consists of four main stages: 1) delignification; 2) liquification or saccharification; 3) fermentation; and 4) distillation. The method chosen for the calculation is a chemical method with easier consideration and higher productivity per unit time. Stages of the process are washing of bunches to dispose of the remaining oil, mechanical empty bunch destruction, removal of lignin by soda method, liquification that is transforming cellulose into monosaccharides, fermentation, and distillation to produce alcohol with the desired concentration. Operational scenarios used are presented in Table 3.

Table 3. Scenario of bioethanol production from empty fruit bunches

Description	Benchmarks	Referens
Capacity of palm oil plant	30-45 ton EFB/hour	
Empty Fruit Bunches (EFB)	1.88/6.25 = 30% EFB	Pleanjai *et al* (2004)
	23% fresh fruit bunches	Najafpour *et al* (2006)
Sellulose	50% EFB	Najafpour *et al* (2006)
Gula Terlarut	24-32 %	Najafpour *et al* (2006)
Bioethanol plant	2-3 CPO plant	

Delignification is the step of separating the fibers from lignin, carried out by a combination of a mechanical milling method with a chemical treatment, which is cooked with NaOH. The resultant process is a cellulose pulp that can be separated from lignin.Saccharification is the process of cooking cellulose fibers into a simple sugar solution. The fiber, which is a long-chain cellulose, is cooked into simple sugars using sulfuric acid. The result is a sugar solution still mixed with the cellulose slurry. Gong and Tsao (2010) reported that hydrolysis yields a mixture of glucose and xylose.

The next process is washing with hot water and then carried out screening. Report of Samsudin *et al* (2012) that washing with hot water separates glucose. Glucose dissolved in the hydrolysis process is generally low, so it should be concentrated at least up to 14%. Evaporation process is required to produce sufficient concentration for yeast culture Saccharomyces cereviceae.After the sugar solution reaches a concentration of about 14%, then the fermentation stage is performed. Nutrient ingredients for yeast life such as urea are added. Fermentation is carried out for 40-50 hours depending on the sugar concentration.

The ethanol concentration resulting from the fermentation of S. cerevisae of an alkaline sugar solution resulted in 262 ml/kg of FFB, while acid hydrolysis produced only 179 ml/kg of ethanol (Richana *et al*., 2015). Ningsih *et al.* (2012) found that fermentation was done by using *Saccharomyses cerevisiae* result of hydrolysis of EFB yielding highest result of bioethanol content equal to 9,698%. To make bioethanol fuel, further distillation process. The calculation of scale material balance from production of bioethanol plant made from empty palm oil bunch feedstock is further presented in Figure 5.

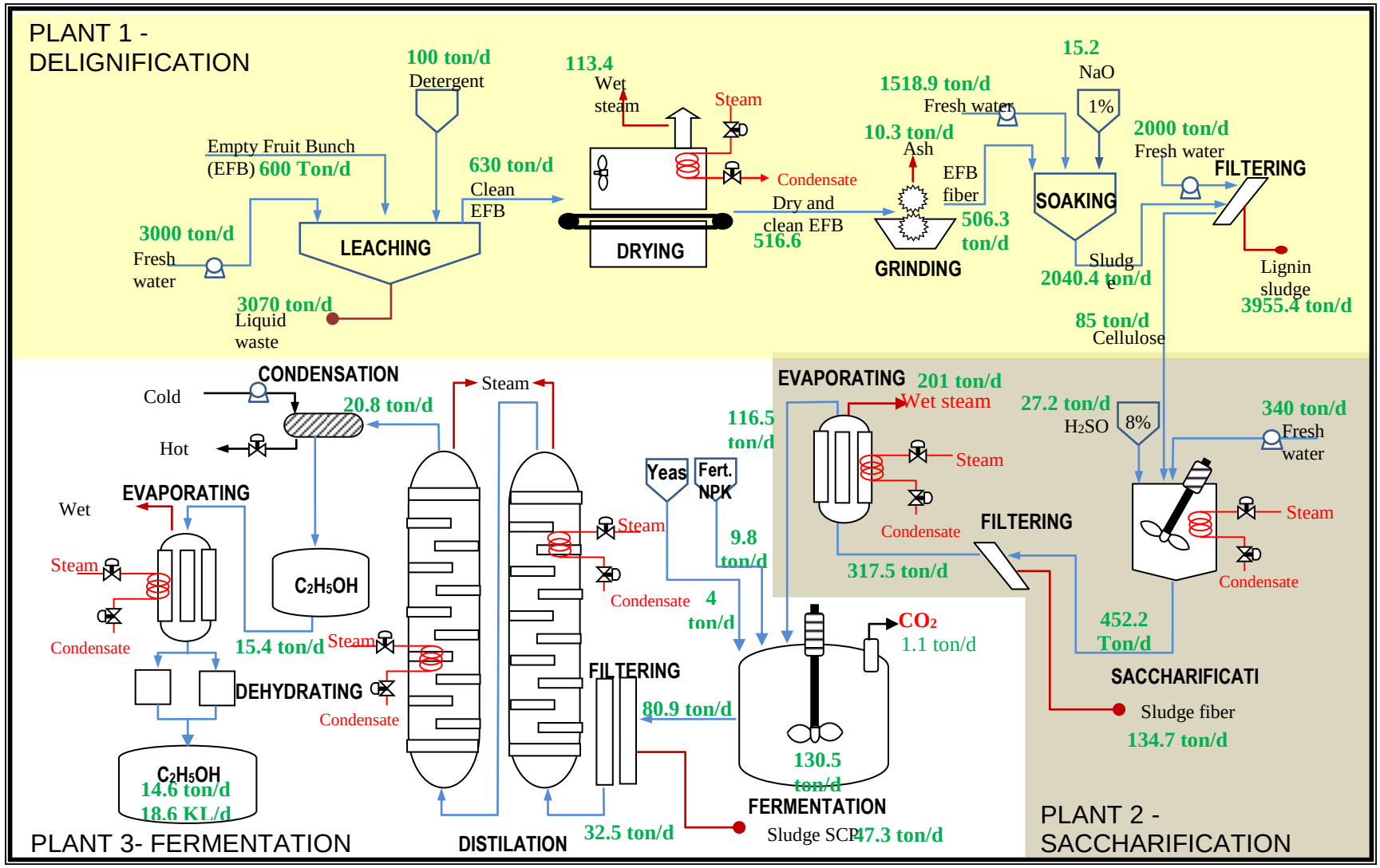

Figure 5. Scale multiplication model for the development of G2 bioethanol industry using acid hydrolysis method, made from palm oil empty bunch

5. Conclusion

A scale multiplication study is needed to support the success of second-generation bioethanol production (Gen2) on a commercial scale. These efforts provide support for the utilization of palm oil mill waste and produce renewable alternative fuels. Second-generation bioethanol production process using chemical hydrolysis pathways is an option, especially when considering industrial productivity. The use of chemical processes will shorten the processing time.

The multiplication of the scale shows that a number of processes found on the scale of laboratory experiments need to be developed more fully, especially in supporting processes such as leaching of empty bunches, empty bunch drying, mechanical fiber pretreatment separation. The addition of an industrial scale process is also required for the separation of the glucose solution and concentration of the solution before it becomes a fermentation substrate. In industrial scale also developed purification step by distillation to become main product either as solvent ethanol, pharmaceutical grade ethanol, and also fuel.

In the modeling process, it is calculated that for the production of ethanol 99.5% as much as 18.6 KL/day required the support of at least three palm oil industries with a capacity of 30-45 ton empty fruit bunches/hour.

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