REFLECTION | P4 PHASE.

THESIS TITLE	: BIM: AIDING ARCHITECTS TOWARDS A SUSTAINABLE FACADE DESIGN
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This document is a mandatory requirement for the P4 Phase. This document represents the reflection of the method approached and the design developed by self-analysis of planning phase, process phase and product phase.

PLANNING PHASE

The goal of the research during this phase was to define the contents of a LOD 200 based metal library. In order to find what is relevant to the designers at the design stage, it was essential to interview the designers. A basic set of questionnaire was formulated along with basic case studies revolving around BIM - understanding this new topic from the user point of view. At the same time, it was essential to define which aspect of sustainability will be useful to study.

Furthermore, it was clear that the research is for the AEC industry in the Netherlands. Case study from UK was considered to get a general idea about BIM, but the interviews obtained from other countries were discarded. Similarly, the Green Building Rating systems and tools relating to other countries were also discarded.

During the planning phase, it was decided to make literature research regarding the LOD levels, interviews, case studies regarding the problems in the current BIM process as well as in the current BIM libraries. Basic background research regarding the individual topics of BIM, Sustainability and facade was also planned.

Initially, the focus was only on the Parameters required to define this library. At this time it was still unclear which design stage and the level of detail of the library. However the boundaries set were research within the Netherlands: thus the laws and concepts relating to the Dutch AEC industry and LOD 200.

During the planning phase, I was concerned more about understanding the depths of the topics. This meant that there were many un-defined loops that were based on future research. However, if the planning phase was elaborated more, it would have been smoother for the design and process phase. In hind-sight, some literature research could be done faster. Also, getting to talk to architects was difficult considering their busy schedules and the fact that I didn't have many references. In planning phase, I had under-estimated the time it would take me to get the interviews, which delayed the product phase.

PROCESS PHASE:

The product and process phases were iterative. It was clear that design stage, and Parameters needed to be defined. However, on developing the final product and the tool it was realised that some pieces in the product were incomplete. These were defining the database for the tool, the LOD level and the design stage applicable to the Library. The parameters and role of library became clearer once these were defined.

It was clear that the boundaries decided in the planning phase were not sufficient and these were redefined in the process phase. There was a lot of room un-clarity and the aspects defined were too broad. For example, during the initial phase, all the design phases were considered. Also the facade was generalised as curtain wall facade. Thus in the process phase, these boundaries were re-defined, based on the literature research. (Define the boundaries)

During the process phase, a further in-depth analysis of the LOD was made. The conclusion drawn was that the library best fits the criteria between 200 and 300. Thus a new LOD 250 Level. A crude tool was developed and a round of interviews was made, to see the workability of the tool and missing parts. This was then elaborated in the product stage.

During this phase, environmental impacts by kg CO2(e) emissions were selected as a product comparison value. In order to have this value, it was also observed that it is essential to have embodied energy and operational energy in a comparable formula. Thus the formula of total primary energy : considering the yearly operational energy and embodied energy divide by service life was developed to provide the comparable $kgCO_2$ value of products

PRODUCT PHASE:

Based on the research, an initial tool was developed that liked the Parameters and gave information regarding the legislations and Green Building Rating Standards. However, while developing he tool, I realised case studies of embodied energy and operational energy needed to be performed. These case studies helped not only define the kinds of parameters but also the kinds of user interfaces in which this library can be developed.

The way in which this phase could be developed is by coding and making this library and eventually testing on a live project. However, the building project time spans are much larger than that of the thesis duration. Hence, the testing of tool in real life was discarded, but a small case study was still undertaken where it was tested and the tool was refined.

The research project is an attempt to close the gap between manufacturers and designers. It is observed that the information provided by the manufacturers is not used by the architects. By providing the exact information to the architects, manufacturers get a better understanding of how architects think and ways to develop their products. On the other hand, the architects can use the information provided by the manufacturer in early design stages. This results in better engineered buildings and reduction in construction and performance related errors.

During this stage, I was trying to get all the interviewees in one room and have a communication between them. The invitees included 4 manufacturers, 4 sustainability specialists, 2 BIM& sustainability Specialists and 4 BIM specialists. This would give me more insights on how to bridge the gap of information and ways to make the information flow faster. However, this was not possible and I took individual interviews. Due to time restrictions, I could manage to talk to 5 professionals but I probably gained more insights about my product: BIM tool and Window parameters for the library.

On a larger scale, the thesis proposes the consideration of embodied energy and service life, the 2 aspects that are largely overlooked in the AEC industry as observed from the interviews. The proposal of the tool includes calculation of a total primary energy that accommodated Carbon footprint generated by embodied energy and operational energy and connecting it in relation to the service life. This proposed tool gives a better overview of the carbon foot print as well as gives a total picture as against the common carbon footprint calculation considered at present - the operational energy calculations.