Implementation of sustainability concepts in the sense of circular economy in alpine hydropower plant construction

Circuit construction site "Kraftwerk Sellrain"

Friedrich Darimond, BSc
Advisor: assoz. Univ. Prof. Dipl.-Ing. Dr. sc. ETHZ Florian Gschösser
Unit of Construction Management and Tunnelling
University of Innsbruck
ibt@uibk.ac.at | *www.uibk.ac.at/ibt*

ABSTRACT: In the Sellrain Valley, construction work on the hydropower plant project "Sellrain Power Plant" has started in autumn 2021. This is the basis for describing sustainable concepts in the sense of the circular economy. In this context, the legal framework that played a role in the implementation is explained. The concepts are mainly based on the internal material processing of the excavated material and a transport logistic concept. For clarification, a GHG-balance is carried out in which the variant of internal material processing is compared with the variant of an external raw material producer and an external landfill. The system limits are the production of the pipe trench and the excavation pits of the key structures as well as the associated transport journeys. The GHG reduction potential is 35 percent compared to variant 2. This result can be attributed to the significantly lower transport distances.

Complete thesis: *www.uibk.ac.at/ibt/lehre/abgeschlossene-masterarbeiten/*

KEYWORDS: Circular economy, hydropower plants, GHG-balancing, "Abfallwirtschaftsgesetz", Sustainibility

1 INTRODUCTION

The current Federal Waste Management Plan states that 60 percent of the waste produced is excavated material. In order to reduce this proportion and to conserve resources, material processing and reuse in the sense of the circular economy play a very important role. By describing and analysing the construction process of the hydropower plant project "Sellrain Power Plant", the concepts that enabled a process under sustainable aspects are highlighted. A subsequent GHG balancing is intended to clarify the GHG reduction potential. [1]

2 MAIN BODY

2.1 Legal Frame

For the processing and reuse of excavated soil materials, number of laws and guidelines must be observed. First of all, the legal framework for dealing with waste is regulated at the European level by the "EU Waste Directive". The "Waste Management Act 2002" is the national implementation of this directive in Austria. This is intended to promote waste avoidance and reuse, i. e. Figure 2-1. Other important provisions are laid down in the "Deponieverordnung" and the "Altlastensanierungsgesetz". [2], [3]

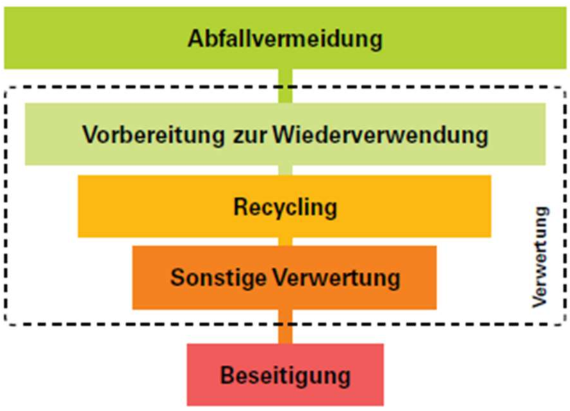


Figure 2-1 Waste hierachy [4]

2.2 Project description

The Sellrain power plant is designed as a diversion power plant. The key structures are the two water intakes, the pressure pipeline (cast iron and steel pipeline), the unification structure and the powerhouse, which is in a cavern (i.e. Figure 2-2). The intake waters for the power water are the Melach and the Fotscherbach in the Sellrain valley.

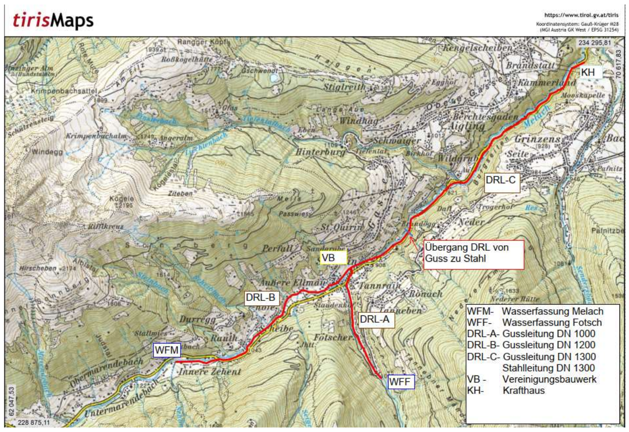


Figure 2-2 Project area KW Sellrain [5]

Characteritics	Value
Total volume excavated water	3,6 m³/seconds
Pipeline length	9235 m
Diameter material	DN 1000, cast-iron (1625 m) DN 1200, cast-iron (4070 m) DN 1300, steel (3540 m)
Gross drop height	416,83 m
Net drop height	387,13 m
turbines	2 pcs, 4-jetted Pelton turbines
Predicted bottleneck output	12,38 MW
Expected annual output	55 GWh

Table 2-1 Conclusion characteristics KW Sellrain

2.3 Approaches and implementation of sustainable concepts in the construction phase

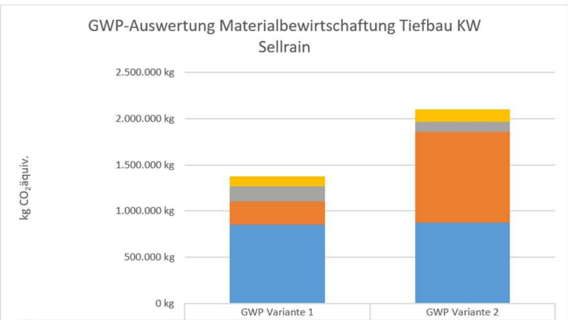
The basic principle in the implementation of the construction project followed the circular economy. The excavated soil and the excavated material from the underground workings were processed for further utilization using mobile processing plants (crusher and screening plant). This made it possible to produce bedding material, hint filling material and frost cases. This meant that only a small amount of surplus material had to be transported to a landfill site in the construction area and no new material had to be purchased from a raw material producer. The corresponding logistics concept helped to avoid empty runs and to make the transports as efficient as possible. Furthermore, regarding to social sustainability, care was taken to limit the impact on residents due to noise and traffic disruption. By means of a targeted information policy, it was possible to achieve understanding among those affected. [6]

2.4 GHG-balancing

In the GHG balancing, two variants are compared with each other. The first concept assumes that all excavated materials resulting from the construction work will be processed in mobile processing plants in the valley, so that no external deliveries of the newly required installation material are necessary (variant 1). This is contrasted with variant 2, which involves transporting all the excavation raw materials to an external final landfill site so that they do not have to be processed for further use. The newly required raw material is procured from local mineral raw material producers and must be transported to the construction site accordingly. The two variants described above are basically divided according to the same scheme in the balancing. The GHG reduction potential refers to the following processes, which represent the system boundaries of the analysis:

- Production of pipe ditch
- Transport routes pipe ditch excavation
- Excavation pits key structures and underground mining
- Transport routes for excavation pits, key structures and underground mining

2.4.1 Results GHG-balancing



	GWP Variante 1	GWP Variante 2
Transporte Untertagebau und Baugruben	105.884 kg	137.623 kg
Untertagebau und Baugruben	161.108 kg	109.962 kg
Transporte Künettenherstellung	252.366 kg	979.488 kg
Herstellen Künette	853.302 kg	874.937 kg
Summe	1.372.660 kg	2.102.010 kg

Figure 2-3 GHG-balancing, comparison results

Figure 2 3 compares the total GHG potential of the two variants. The total sum of variant 1 is 35 percent lower than variant 2. The reason for this lies in the process section of the transports for the ditch production (orange part). Here, the value of variant 1 is only about a quarter (26 per cent) compared to the second concept.

3 CONCLUSION

In this master's thesis it was shown to what extent it is possible to implement sustainable variants during a power plant project using the concepts described. The method chosen in the Sellrain Valley for managing the mineral raw materials is based on the principle of circular economy. Accordingly, the material flow could be maintained by processing and reusing a large part of the excavated soil material. This has several positive consequences. On the one hand, resources can be conserved since no new material needs to be excavated. The space required for landfills can also be reduced because the quantities to be landfilled are significantly lower. On the other hand, this approach saves a very high number of GHG emissions due to the short transport routes.

4 OUTLOOK

By means of a GHG balance, as was carried out in this study, a sustainable variant can be presented in a striking way. This would make it easier to convince critics. It is not necessary to determine quantities and collect data down to the last detail, but rather it is important to achieve comprehensible and comparable results in accordance with the objective of the study. The share of high GHG emissions in the construction industry is well known, which is why it can be assumed that in the future the inclusion of sustainable concepts in tenders will be increasingly required. Thus, simply presented GHG balances for construction companies can be a means to convince building owners of their concepts. Likewise, the implementation and documentation of sustainable strategies will play an even more important role for construction companies in the future, as an information obligation on sustainability aspects is to be introduced in the EU. [7]

5 REFERNECES

[1] Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, „Bundes-Abfallwirtschaftsplan 2023," Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, Wien, 2023.

[2] European Union, „EU-Abfallrichtlinie," 16 Juni 2022. [Online]. Available: https://eur-lex.europa.eu/DE/legal-content/summary/eu-waste-management-law.html. [Zugriff am 2023 August 2023].

[3] Bundesministerium für Klimaschutz Umwelt Energie Mobilität Innovation und Technologie, *Abfallwirtschaftsgesetz 2002 BGBI I. Nr. 102/2002,* Wien: Bundesministerium Klimaschutz Umwelt Energie Mobilität Innovation und Technologie, 2023.

[4] A. Westermayer und R. Rosenberger, „Baurestmassen Verwertung und Entsorgung," Geschäftsstelle Bau, Wien, 2018.

[5] Tiris Maps, „mapsmobile.tirol," [Online]. Available: https://mapsmobile.tirol.gv.at/synserver?project=mobile_kataster&client=flexjs&language=de&view=nurHintergrund&basemapview=OEK&x=63066.92384218092&y=230177.8797307592&scale=64000. [Zugriff am 15 August 2023].

[6] HTB Baugeselleschaft m.b.H., *Firmeninterne Projektunterlagen KW Sellrain,* Arzl im Pitztal: HTB Baugesellschaft m.b.H..

[7] WKO Bau, „Nachweispflicht Nachhaltigkeitsaspekte," 12 Dezember 2022. [Online]. Available: https://www.wko.at/service/umwelt-energie/Informationspflicht-ueber-Nachhaltigkeitsaspekte.html. [Zugriff am 01 August 2023].