ID no.	**Version**	**Security**		**Page**
REC-16-175	2	Internal		**1(11)**
Issued by	**Date**	**Reviewed by**	**Approved by**	
Olle Lindén	2016-10-07	Thomas Davidsson	**Thomas Davidsson**	
		Annika Andersson	**Annika Andersson**	

Vegafish status report 2

VINNOVA/RePro

Vegafish status report 2

Contents

1 Introduction

In accordance to the VINNOVA RePro project coordinated by Findus (Christoffer Schönbeck) and managed by WA3RM (Thomas Parker) Vega fish is responsible to perform calculations and estimations to determine the fish production plant investment cost, building time plan and production cost for status report number 2 due in 2016-10-28. Since the project is focused on recirculation of water through both the fish production plant but also the greenhouse, Wallenius Water´s engineers has been involved to make production planning, engineering estimations and cost evaluations.

2 Abstract

The work done since status report 1 has been comprehensive and resource demanding. The most resource demanding parts have been production planning and layout design.

3 Definitions

RAS – Recirculating Aquaculture System

SAT – Site Acceptance Test

KDP – Key Design Parameters

4 Pre study work

4.1 Work flow

- Finalize market analysis for species to be farmed
- Key design parameters based on a yearly production of 500 ton per year
- Building and construction works – cost estimations
- Complete the investment calculation including operational costs
- Denitrification needs and cost
- Installation cost
- Costs for all necessary permits to build and start production for such a facility
- Complete 2D plant design
- Calculate energy needs

4.2 Market analysis and species

After thorough investigations during the summer, Vegafish and Wallenius water came up with the conclusion to go on with two different species as just looking at one was considered too risky. The idea is to present investment costs, operational costs and layouts for both species. This would give a potential investor options for risk management.

The chosen species was Pike Perch (Gös) and Rainbow Trout (Regnbågslax). These two fish species have slightly different characters in terms of farming risks and market price. The Pike is a higher value fish which could of course yield a higher margin but also have severe problems with cannibalism and deformities during the young age. The Trout is considerable easier to farm but would not yield the same margin. Both species have feed available in Scandinavia and fish eggs and juveniles are easy to purchase.

4.3 Key design parameters

The calculations are done with the base production of 500 metric tons per year for both species. Both farm layouts are quite similar in terms of equipment but differ slightly in how the fishes are farmed. Pike Perch needs slightly warmer water (21°C) versus the Trout (Approx. 19°C). This makes the Pike easier to manage in terms of temperature control as the water doesn't need to be cooled much during summer.

Both farm types would be divided into three individual RAS systems for easier management of water parameters, diseases and operation. This means that the fish needs to be counted, graded and transferred at least three times in a production cycle. Probably more.

Below is two tables which describes the different systems basic properties and recirculation needs.

Pike Perch, 21°C, 500 ton					
RT 30 min	FEED LOAD	SYSTEM VOLUME	RECIRCULATION DEGREE	DAYLY MAKE UP WATER	PUMP CAPACITY
	kg	m³		m³	m³/h
RAS 1	300	750	90%	75	1 500
RAS 2	650	2 020	90%	202	4 040
RAS 3	1 100	3 360	90%	336	6 720

Table 1. Pike Perch plant properties

Rainbow Trout, 19°C, 500 ton					
RT 30 min	FEED LOAD	SYSTEM VOLUME	RECIRCULATION DEGREE	DAILY MAKE UP WATER	PUMP CAPACITY
	kg	m³		m³	m³/h
RAS 1	1 400	1 125	90%	113	2 250
RAS 2	1 000	1 960	90%	196	3 920
RAS 3	1 000	2 800	90%	280	5 600

Table 2. Rainbow Trout plant properties

As can be seen above, the total daily need for intake water is approx. 600 m³ per day regardless of fish species. This is needed as a result of the accumulation of Nitrate. Corresponding to this intake volume, the plant also needs to release the same amount. Therefore, the permissions to release water and the availability of make-up water is essential for this project. The municipal requirements on the effluent water is also key in the feasibility of this project.

However, in order to save more water and also utilize the nutrients in the waste water, the effluent water can be circulated into the greenhouse and then be spread onto tomato plants. This would add "free" nutrients to the greenhouse and approximately half of the water could be circulated back to the fish farm, therefore lowering the make-up water need to about 300 m³ per day.

4.4 Investment cost

The investment cost is calculated through detailed equipment lists, ground work estimations, installation complexity, man hours, staff facilities, consultants and building permits amongst others. These costs will not be specified separately in this report as it is considered to be internal and confidential material.

Below is a cost estimation table showing investment costs and running costs for both species. Big uncertainties have been seen in the estimations around building works and fish tanks. A qualified guess is that these cost drivers could be lowered significantly for each species if existing facilities are available.

Investment Pike Perch		
Investment cost	131 200 000	SEK
Yearly operational costs	34 660 000	SEK
Production	500	ton
Price per kg farm gate	125	SEK
Total income	62 500 000	SEK
Net income yearly	27 840 000	SEK

Table 3. Investment Pike Perch

Investment Rainbow Trout		
Investment cost	132 300 000	SEK
Yearly operational costs	40 130 000	SEK
Production	500	ton
Price per kg farm gate	125	SEK
Total income	62 500 000	SEK
Net income yearly	22 370 000	SEK

Table 4. Investment Rainbow Trout

As can be seen above, the total investment is around 130 MSEK. This figure also corresponds well to other RAS-plants built in Europe the resent time. The operational costs for the Trout is considerably higher than the ones for the Pike as it requires more feed.

The sales price is set to 125 SEK/kg for both Pike Perch and Rainbow Trout. Whether this is possible or not, needs to be decided together with a possible customer/investor and is highly dependent on sale channels etc.

4.5 Production plan

Important to know is that the Pike Perch production would yield a full batch after 24 month whereas the Rainbow Trout would take 30 month to produce a full batch. The production schedule for each species can be seen below.

PIKE PERCH																	
STOCKING		S		S		S		S		S		S		S		S	
FIRST STEP		6,1		6,2		6,3											
SECOND STEP				12,1		12,2		12,3									
THIRD STEP						18,1		18,2		18,3		18,4		18,5		18,6	
MONTHS	0		6		12		18		24		30		36		42		48
HARVEST 250 TONS							H		H		H		H		H		H

Table 1. Pike Perch production plan

TROUT									
STOCKING	S	S	S	S	S	S	S	S	
FIRST STEP		6,1	6,2	6,3	6,4				
SECOND STEP			12,1	12,2	12,3	12,4			
THIRD STEP				18,1	18,2	18,3	18,4		
FOURTH STEP					24,1	24,2	24,3	24,4	24,5
MONTHS	0	6	12	18	24	30	36	42	48
HARVEST 250 TONS					H	H	H	H	H

Table 2. Rainbow Trout production plan

In this plan, the Pike Perch are stocked every 6 month and requires three cycles before the first harvest can be done, 18 months. For the Trout, this takes 24 month. This is the first income that the production would generate.

The production plan can be altered to suit the market need better which means that stocking could be done more often but in smaller quantities. This set up also has some limits as to how few juveniles can be ordered at the same time.

4.6 Denitrification

As the plant is recirculating the water, eventually the levels of Nitrate reaches toxic levels for the fish. The common solution to this problem is to change approx. 10% of the system volume per day. However, such a water exchange rate would mean considerable costs for make-up water long term. It would also put strain on the municipal water treatment plant. A denitrification step is therefore required to lower the exchange rate to around 1-5%. Denitrification steps are normally quite energy intensive and requires additional operational resources. The work so far has not included dimensioning or calculations for such a treatment step. The estimated budget for such a treatment step is estimated to roughly 10 MSEK.

Another solution to the problem would be to circulate the effluent water (sludge water) into the greenhouse and utilize the nutrients for the tomato plants, collect the excess water and circulate it back to the RAS-plant. The water would be denitrified by the plants and would therefore lower the overall content of Nitrate. The volume treated each day would be around 600 m^3, corresponding to 25 m^3/h. This solution will require more investigation together with the greenhouse Engineers (Royal Pride Sweden).

4.7 2D-design

The general 2D-designs are based on the production planning needs, RAS area and accommodation for make-up water tanks, feed room, storage room, cooling room and staff facilities. A detailed design will be done in a later stage where investors are secured.

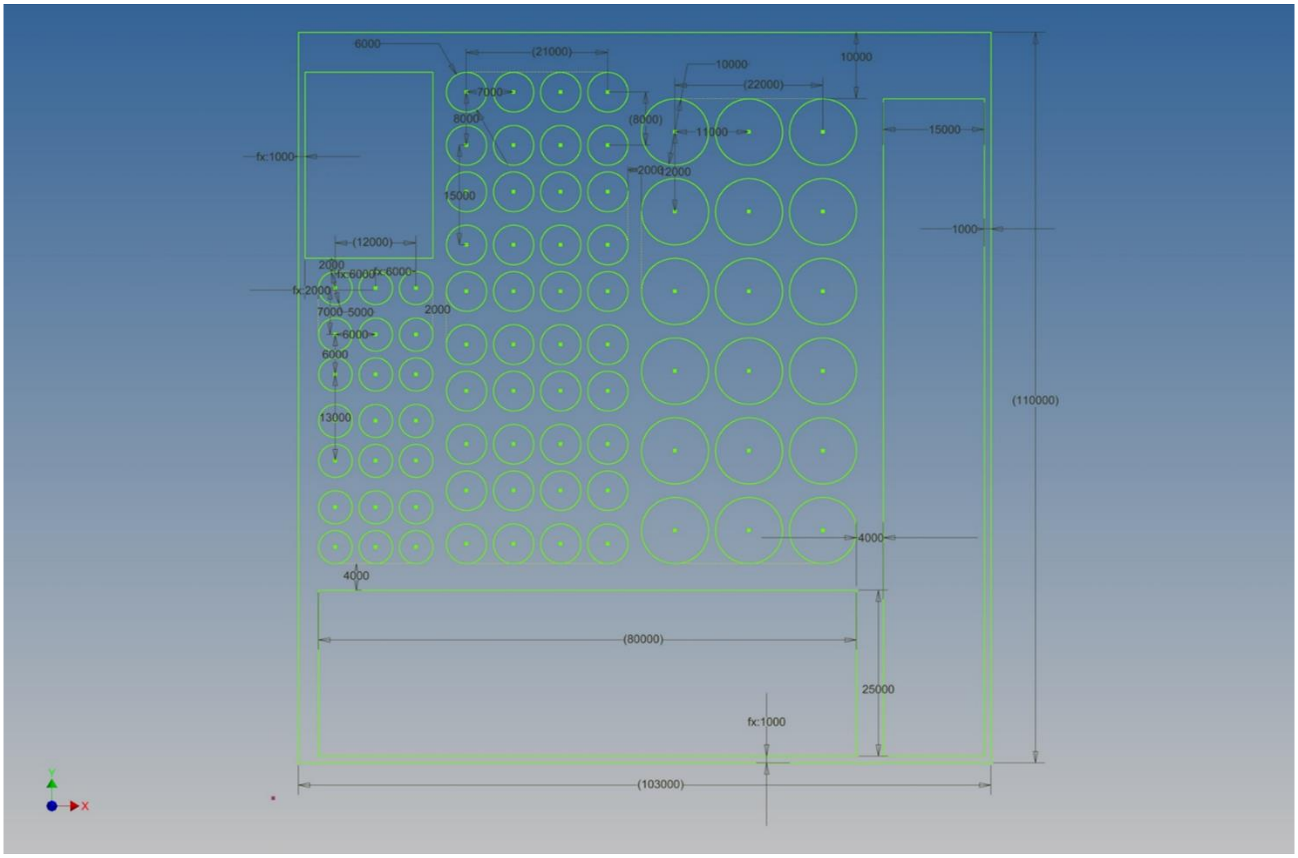


Figure 1. Basic 2D-layout for the Pike Perch plant (mm)

NOTE: the width of the plant is expected to increase from 103 m to 120 m.

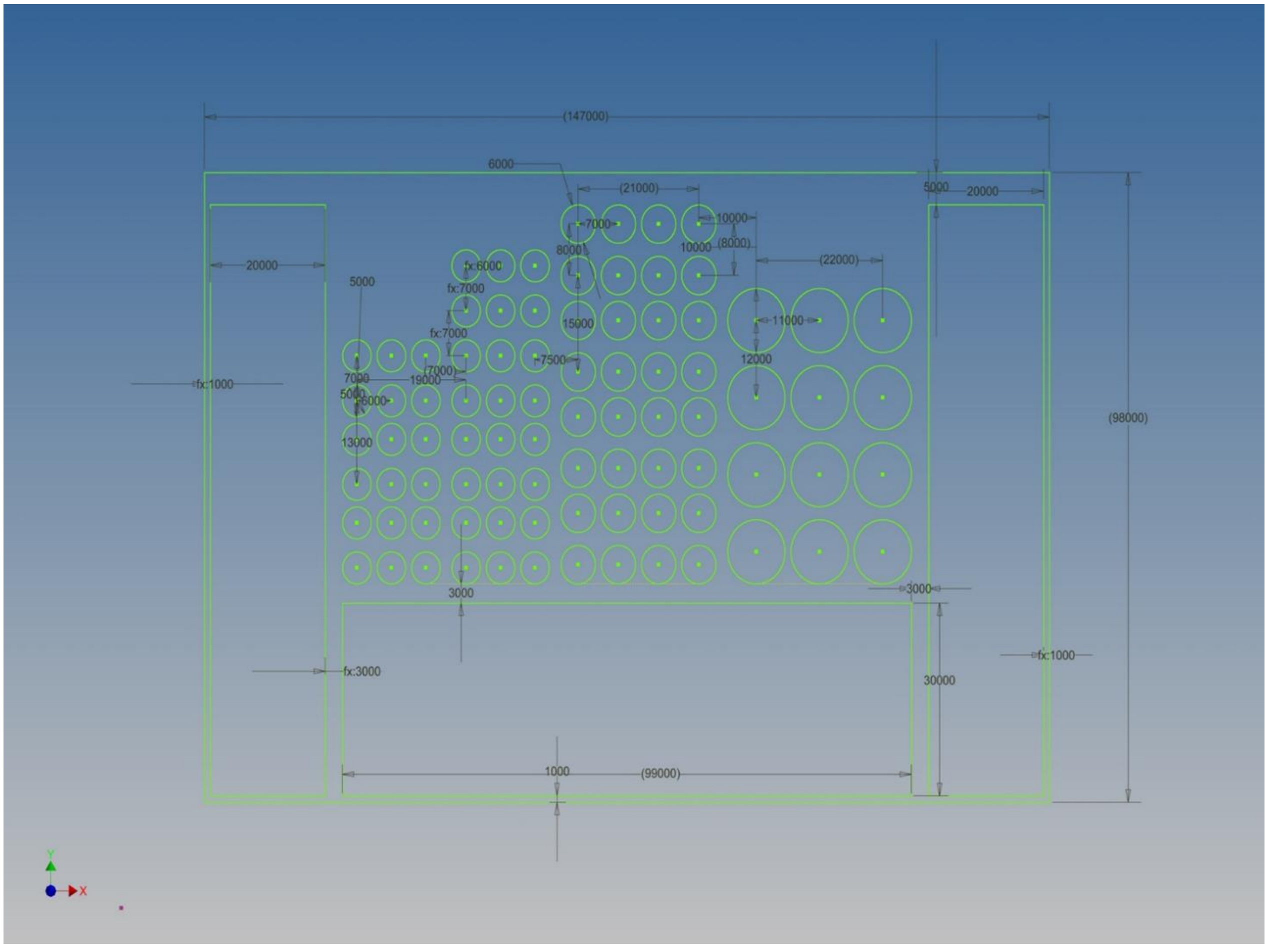


Figure 2. Basic 2D-layout for the Rainbow Trout plant (mm)

The layout is by no means set and can be changed once the engineering starts. There are several aspects of the layout that needs to be considered. The RAS-systems will most likely be placed together with walls between. Some of the rooms inside the building will have special demands on air quality since feed will be stored there.

The plants are divided into three RAS-systems as the fish requires slightly different handling, feed and supervision throughout its production cycle.

4.8 Energy need

Based on the building size, insulation, water temperature, ventilation need, inlet water temperature etc. the calculated heating energy need would be 3 179 520 kW/year. This is therefore the total amount of heating energy needed and <u>not</u> the electricity consumption.

4.8.1 Energy need breakdown

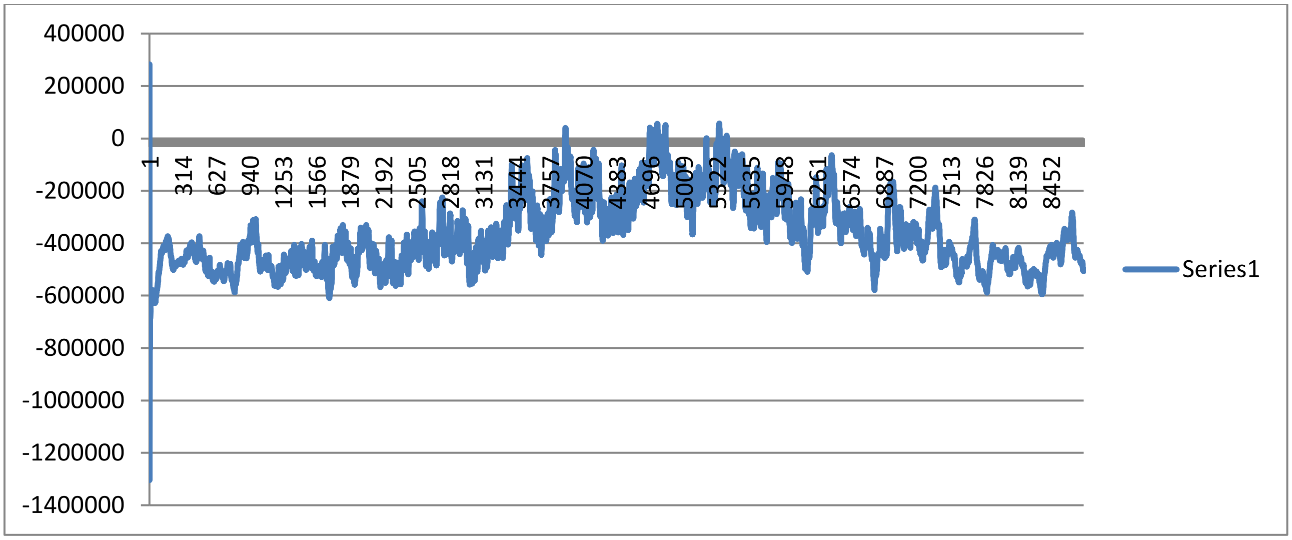
The total energy need will come from heat leakage from the building, heating of inlet water, ventilation and CO2-stripping. The maximum heating energy need during the winter period is approx. 803 kW of continuous heating power.

The biggest energy consumer is the inlet water. During winter, the inlet water will need approx. 480 kW in continuous heating power. This is based on an inlet water temperature of 5°C.

The energy need is based on Stockholm weather data and two scenarios. Winter and summer.

Summer parameters: Intake water temperature 10°C

Winter parameters: Intake water temperature 5°C



Graph 1. System energy need over the year based on Stockholm weather data. X-axis is hours, Y-axis is energy expressed in watts.

The graph above describes the energy need for each hour over the year. A negative number means the plant needs to be heated. A positive number means the plant needs to be cooled.

NOTE: Energy need is <u>NOT</u> the same as electric consumption. This is just the amount of heating power the system needs over a year. Peak continuous heat energy consumption is 803 kW on the coldest winter days.

4.9 Electrical consumption

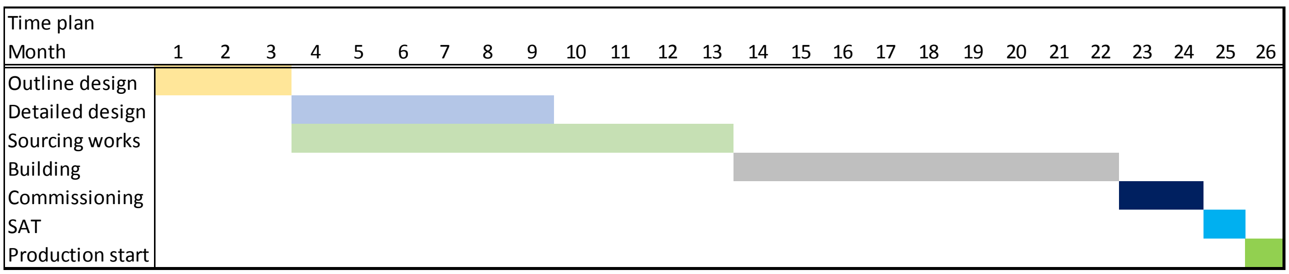
In excess of the heating energy need, the plant will need electricity to drive it´s pumps, control systems, mixers, lamps etc. This figure is quite hard to estimate at this moment before a detailed design is done. However, an estimation of peak consumption is 580 kW/h and will occur when the system is fully occupied and at maximum production.

4.10 Time plan

The total build is expected to take approx. 26 month. The work starts with the outline design where all production technical details are mapped. After that, the detailed design takes place where water levels, detailed dimensioning and drawings are made. The engineering follows by a period of sourcing activities where not only equipment are purchased but also details around the actual build are addressed. Procurement tasks will be ruling for the projects outcome and must be addressed as soon as the outline design is done.

After the plant is built, the commissioning and startup of the bio filters take place. After the commissioning is approved, a SAT-test will be carried out together with the production personnel/plant owner to secure the plant can deliver to specification. Production will start with low densities and slowly ramp up towards expected production targets.

Some engineering work will continue after the detailed design phase is completed.



5 Conclusion

The pre study shows that both Pike Perch and Rainbow Trout are possible species to farm indoors in RAS-systems with a positive yearly yield. However, several issues needs to be addressed before any investment can be done. The main issues are permits to release water, intake water availability, staff, reuse of effluent water and sales price.

The plant would need to denitrify about 600 m³ water per day. This means the same amount would be either treated in a denitrification step or treated by the greenhouse. Expected intake water volume is 300 m³/day if denitrification step works well. If not, the intake water volume would be 600 m³/day.

Total facility area estimated to 15000 m² and estimated energy need 3 179 520 kWh yearly.

Total investment cost is expected to around 130 million SEK but can possibly be lowered if ground and building works can be done in a more cost efficient way or existing buildings can be modified and used.

The net income is estimated to around 28 million SEK for Pike Perch and around 22,5 million SEK for Rainbow Trout after operational costs.

Production time is estimated to 18 and 24 months for Pike Perch and Rainbow Trout respectively. 500 ton output would be reached after 24 and 30 month respectively depending on production planning schedule.

To realize the project, special focus needs to be directed towards production permits, water supply, effluent water treatment regulations, staff, investment and water circulation through greenhouse.

Important to evaluate before investing is the production risks. Pike Perch is much harder to farm since it´s very cannibalistic. On the other hand, Rainbow Trout has fierce competition from the Norwegian farms as well as some pond farms in North of Sweden.