Montrose Local Energy Project

Executive Summary

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1.0 INTRODUCTION

Rosemount Farms secured grant funding through the Local Energy Challenge Fund (LECF) to advance the Montrose Local Energy Project (LEP). The project aims to assess the feasibility of drying used animal bedding and processing it to produce pellets for combustion in multi-fuel biomass boilers to generate renewable heat to provide space heating and/or domestic hot water heating for use by Rosemount farms as well as other businesses and individuals in the local community.

SLR Consulting Ltd. (SLR) was commissioned to act as Project Manager, Technical Advisor and to offer general project support. This Executive Summary provides a record of the observations and lessons learned during the project; and also presents the key findings and conclusions on the project as a whole.

1.1 Project Partners

The core members of the Project Team were:

Alex Sanger – Rosemount Farms, who operates Pettycur cattle farm in Montrose, Angus where the fuel production project would potentially be based;

Merlyn Dunn – Angus Council Sector Office for Green Energy providing support for the LECF project (previously Gordon Ogilvie);

Iain Todd – Independent Environmental Consultant;

Colin Robertson – Scottish Biofuels Programme; and

Euan Munro and Duncan Coombs – SLR Consulting providing project management and technical advisory support.

There was also further support from other SLR employees to support document writing and review, and monitor the trials documented in Section 0, namely Diarmid Jamieson, Munashe Musarurwa and Raymond Park.

1.2 Concept

The idea of using waste animal bedding as a fuel was a concept initially proposed by Alex Sanger who was aware of the widespread use of naturally dried animal dung as a fuel in arid parts of the world, showing that this material could potentially be a sustainable source of biofuel with a suitable calorific value. The concept also takes account of the growing use of biomass in Scotland as a fuel source and the increasing demand for sustainable and affordable biomass fuel for use in multi-fuel boilers at a local / regional level.

The concept has several benefits including creating a product from a waste and displacing scarce woody biomass fuels – and the associated demand from forest resources therein. Potential multi-fuel boiler end-users in the local area include entities such as Forfar Golf Club and the Ranger Station in Crombie Country, Monikie, as well as domestic customers.

1.3 External Support

The project has been supported by Angus Council who place a high priority on promoting the development of innovative agricultural projects. Their energy department identified a candidate site for the installation of a multi-fuel boiler to demonstrate the operational viability of the new agricultural fuel.

Regulation of the project has been conducted by SEPA on a pilot basis. Prior notice of key stages was provided to officials. The approach of both SEPA policy and operations to the project has been supportive.

During the project, contact was made with the local Community Council on several occasions. They expressed their support-in-principle for the project

1.4 Location

The project centres on Pettycur Farm which is located in Hillside near Montrose, Angus. The farm is managed by Alex and his team and is used for both arable and livestock farming. There are c.450 Aberdeen Angus beef cattle on the farm, and these cattle are housed in a barn between October and May. For welfare reasons, bedding is required in the cattle shed – primarily straw which is a by-product from the arable farming.

Currently there is approximately 1,500 tonnes of this used bedding produced at Pettycur Farm each year. As a method of disposal it is removed from the shed and spread on fields. While this provides some form of fertiliser, these fields do not require these nutrients.

2.0 TRIALS

2.1 Drying Trials

Drying of the waste bedding is necessary in order to reduce the moisture content (MC) of the fuel to a point where it can combust efficiently. This also prevents aerobic decomposition of the organic components in the fuel, allowing it to be stored. The aim was to reduce the moisture content to c.15% – similar to that of wood pellets.

Between the 2nd and 7th of August 2016, the Project carried out trials to assess the drying of the waste bedding. This was done on Kinknockie Farm using a continuous dryer that removed moisture using heated air. The waste bedding is pushed through the dryer by oscillating arms and has a variable residence time depending on the speed of these arms. For our trials this was c.22 hours for the first pass and 72 hours for the second pass. The moisture reduction following the first pass was not as effective as had been anticipated, hence the need to pass the material through the dryer a second time at a slower rate. The hot air was provided by a CHP unit which was fuelled by biogas produced at the anaerobic digestion plant at Kinknockie Farm.

The drying trial took c.22 tonnes of used bedding at 69% MC and fed it into the dryer. It required two passes through the dryer in order to achieve 20% MC. A challenge faced during the drying trials was clumping of the bedding into lumps which prevented the efficient drying of the material, particularly in the middle of these lumps.

From these trials SLR estimated the moisture loss per unit of heat energy input to be between 1.32×10^{-3} and 1.4×10^{-4} t/kWh. Using these values, the calorific content of the final fuel and information supplied by dryer manufacturers it was possible to estimate the amount of fuel required to provide the energy for drying. This was expressed as a percentage of the total fuel pellets made and was projected as being between 17% and 34% of the total fuel production.

Before commencement of the pelleting trials, further drying was required to ensure the waste bedding was at c.15% MC. This was done in a similar continuous dryer to that mentioned above, at Harpers Wood Recycling Centre, Insch. The lower moisture content is important to ensure ease of conveying and prevent decomposition of the fuel pellets while in storage.

2.2 Pelleting Trials

The main body of the pelleting trials took place at Harpers Wood Recycling Centre in Insch between the 22nd and 27th of August 2016.

Conversion of dried bedding into pellets is required to facilitate efficient handling, storage and end-use of the fuel. Creation of pellets, while requiring energy and equipment, increases the density of the fuel, thus reducing the transport costs and providing a homogeneous boiler feed.

Prior to pelleting, it was necessary to remove hard contaminants from the dried bedding feedstock and pulverise it to render it suitable for the pelleting process.

First, the small amounts of stones and tramp metal were removed using an Air Density Separator (ADS). Then the bedding was pulverised into a consistent size using a Hammer Mill. Finally, the dried bedding was converted into a pellet by extruding it through a die in a Pellet Mill. The pelleting process generates a lot of heat, therefore the pellets required cooling prior to storage. This cooling was facilitated by blowing cold air over the output conveyor enroute from the pellet mill to the storage hopper.

SLR identified that in order to increase the viability of the pellets as a fuel, mixing of the bedding with sawdust was required. Trial mixes of fuel with 0%, 25%, 50% and 75% sawdust were produced. Each of these was successfully processed through the Pellet Mill and the project generated c.2 tonnes of each fuel type. Each fuel type was sent for laboratory analysis, including assessment for net calorific value (i.e. without water). The results of these tests are shown in Table 2-1.

Table 2-1
Calorific Values of Fuel Types

Fuel Type	Net Calorific Value (MJ/kg)
0% Sawdust	14.38
25% Sawdust	14.38
50% Sawdust	15.45
75% Sawdust	16.04

Further trials were then carried out at Mormond Engineering, Fraserburgh using a small scale pellet mill. This allowed the Project Team to ascertain how a facility on the size of a farm scale processing plant would perform. Two tonnes of used animal bedding were processed into pellets 100% muck pellets without issue. It was noted during these trials that the power requirement of the pellet mill motor was lower than in normally is when processing sawdust.

2.3 Boiler Trials

The next step for the Project Team was to test the viability of the pellets produced as a fuel source. Of the biomass boiler suppliers that came forward and provided costs for hosting the trials, Heitechnik (HT) were selected to carry out the trials at their test centre near Gdansk, Poland. These trials were carried out between the 21st and 23rd of October 2016 using an HT multi-fuel pellet boiler. Not only was it important for the team to assess the performance of the pellets for potential customers, but it was also important that information on the thermal performance was established in order to inform the heat and fuel requirement for drying.

The first fuels tested were the 0% and 25% sawdust pellets. Unfortunately it was not possible to get these fuels to burn continuously in the multi-fuel pellet boiler supplied without the addition of A1 Grade Wood pellets to increase the calorific value. There were also issues with the fuel causing blockages in the screw conveyor that fed the boiler burner. These issues ruled out these fuel mixes for future use.

When testing the 50% and 75% sawdust pellets, steady state combustion was achieved, but the same issues occurred with the fuel blocking the feed system. The HT technicians noted the relative hardness of the pellets as the most likely cause. It was not possible to rectify this feeding issue, even with remedial work carried out on the feed conveyor.

The emissions values for all of the fuel mixes were also not favourable. Emissions testing for Renewable Heat Incentive (RHI) approval requires 5 hours of monitoring; however, the team were only able to achieve continuous combustion for c.30 minutes. This may have improved over time, but the trials were halted before this could be ascertained. As expected, the emissions recorded exceeded those from A1 Grade wood pellets, but were also above what would be required for an RHI approved installation burning waste wood – the most applicable standard that could be found for our potential installation[1]. See table below for

[1] BS EN 303-5:2012, Heating Boilers Part 5, Table C11, Page 75, BSI 2012

emissions noted during the trials for our fuel, an A1 Grade wood pellet and the emissions limits.

Table 2-2
Emissions recorded and limits for waste wood

Pellet Fuel	CO	NO_x
0% Sawdust	3333ppm	59ppm
25% Sawdust	>4000ppm	89ppm
50% Sawdust	1095ppm	176ppm
75% Sawdust	419ppm	156ppm
A1 grade wood pellet	80 – 130ppm	120 – 160ppm
Waste wood emissions limits	250 mg/m3	400mg/m3

After amendments to the project budget, further trials were planned for the end of March 2017. The team were hopeful that a different type of boiler could demonstrate the viability of the fuel. The trials were to be conducted using an AgTec Boiler at the Kiwa Test Centre in Gloucester. Unfortunately, delays to the delivery of the boiler to Kiwa meant that the trials could not be completed during the 2016/17 financial year and therefore fell outside of the funding cycle of this phase of the project.

3.0 ENGINEERING SPECIFICATION

Using the information gathered during the trials phase, it was possible to make approximations of the mass and energy balance of a potential waste bedding plant. From the findings of the boiler trials, it was deemed necessary to mix at least 50% sawdust with the dried animal bedding for viable and efficient combustion.

The impacts of the potential operating regime were explored during this report, comparing running the plant 24 hours 7 days a week to just running the plant 12 hours a day 5 days a week (i.e. Monday to Friday). A plant running on a 24/7 regime would be around 33% smaller than one operating on a Mon-Fri regime and it was considered that this would lead to a potentially prohibitive increase in the capital cost for the plant. However, it was necessary to process all of the bedding in the time that the cattle are housed during the winter since the storage required to spread the production across 12 months would also result in significant additional costs and also lead to potential decomposition of the used bedding before drying. Hence the potential processing plant would only operate between October and May, when the cattle are housed.

The details of the individual plant item sizes for a facility running 24 hours a day 7 days a week producing either 50% or 75% sawdust pellets is shown in below.

Table 3-1
Specification for Farm Scale Pellets Plant (24/7)

Specification	Unit	Value
Dryer input	t/h	0.26
Dryer heat	kW	428.65
Milling in	t/h	0.12
Milling out	t/h	0.11
Pelleting out 50% Sawdust	t/h	0.21

Specification	Unit	Value
Pelleting out 75% Sawdust	t/h	0.31
Customer Storage 50% Sawdust	t	50
Customer Storage 75% Sawdust	t	75
Combustion Storage 50% Sawdust	t	5
Combustion Storage 75% Sawdust	t	7
Boiler Power	kW	564
Boiler Pellet Use 50% Sawdust	t/h	0.07
Boiler Pellet Use 75% Sawdust	t/h	0.15

An overview of the plant operation is shown as a Process Flow Diagram in Figure 3-1 below.

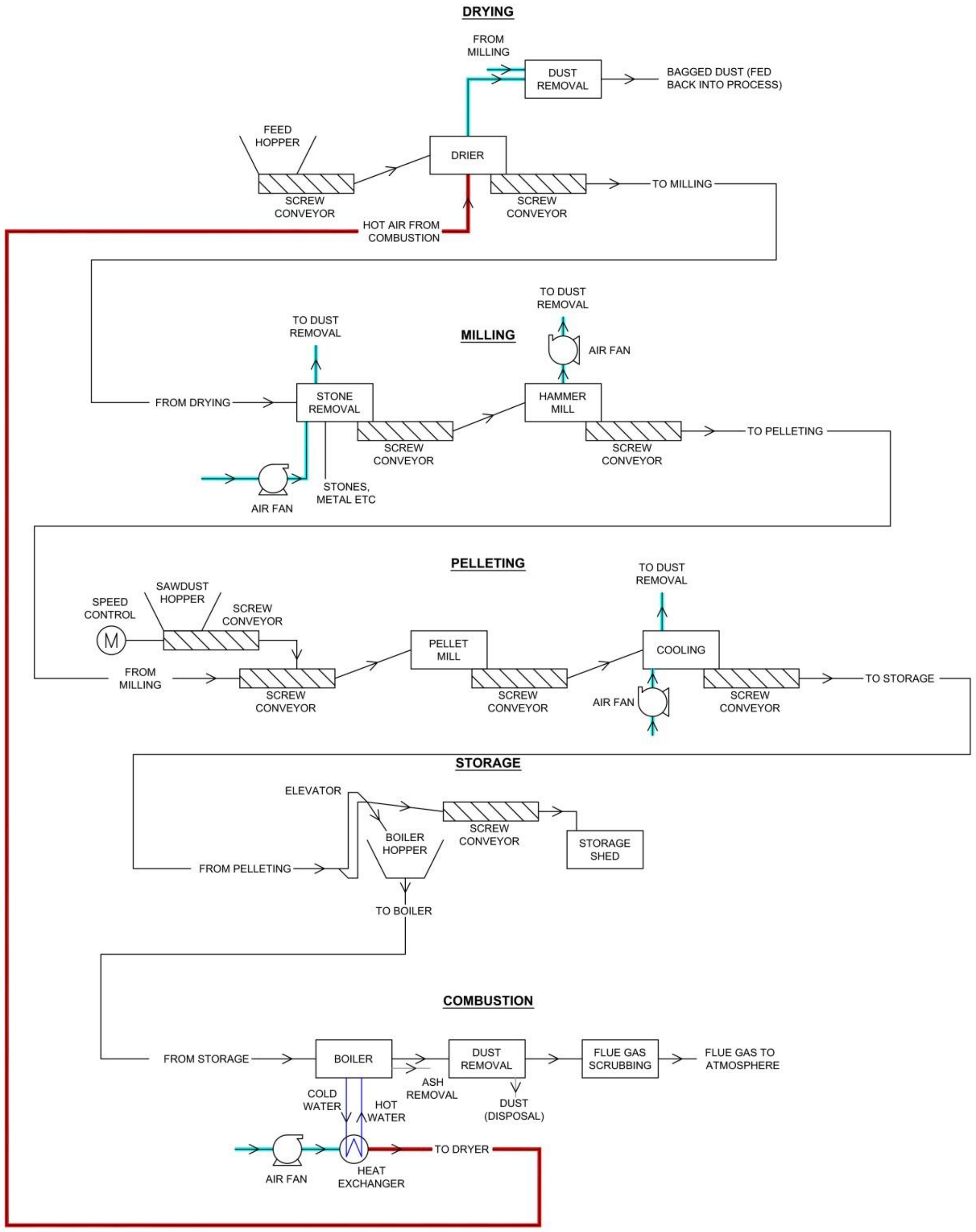

Figure 3-1
Process Flow Diagram for Waste Bedding Plant

4.0 FINANCIAL MODEL

Of the options considered, SLR has produced a shortlist of cost scenarios based on a number of factors including the sawdust composition of the pellet produced as well as the throughput and operational regime of the proposed facility. This results in a set of facility scenarios that capture the extremities of various parameter combinations which are then subject to detailed cost analysis in this section. The 4 cost scenarios considered further are identified in Table 4-1.

Table 4-1 Options Summary

Option	Description	Details
1	Continued spreading	Current practice of removing c. 1.5ktpa of used animal bedding from cattle sheds at Pettycur Farm and using mobile plant to spread material on fields to biodegrade naturally.
2a	Farm scale facility with 50% hybrid pellet	Amassing of used animal bedding from Pettycur Farm, drying material and blending with sawdust to produce hybrid fuel pellets comprised of 50% sawdust. - Circa 1.5kt of material collected and processed over a period of approximately 8 months between October and May; - 24 hour operation 7 days a week; - Use of dedicated boiler to provide heat for drying; and - Circa 1.7kt of pellets produced with surplus pellets sold to third party customers.
2b	Farm scale facility with 75% hybrid pellet	Amassing and processing of used animal bedding as above to produce hybrid fuel pellets comprised of 75% sawdust. - Circa 1.5kt of material collected and processed over a period of approximately 8 months between October and May; - 24 hour operation 7 days a week; - Use of dedicated boiler to provide heat for drying; and - Circa 2.5kt of pellets produced with surplus pellets sold to third party customers.
3	Large scale facility in Tayside with 50% hybrid pellet	Amassing of used animal bedding from a quarter of cattle farms in the Tayside area, drying material and blending with sawdust to produce hybrid fuel pellets comprised of 50% sawdust. - Circa 150kt of material collected and processed over a period of approximately 8 months between October and May; - 24 hour operation 7 days a week; - Use of dedicated boiler to provide heat for drying; and - Circa 167kt of pellets produced with surplus pellets sold to third party customers.

4.1 Capital Costs

The capital costs for development of a new pellet production facility covering the 3 options presented above include the following key cost elements:

- ***Civils and building:*** for provision of a building with foundations, utility connections and all necessary ancillary works (access road, yards, drainage) roads, weighbridge, yard, drainage, lighting etc. The hardstanding area allocated would be sufficient to accommodate the tipping area, M&E process equipment and buffer storage for deliveries and exports.
- ***Process mechanical & electrical (M&E) plant:*** with the necessary technical equipment and specifications to process the material into fuel and usable heat (drying, milling, screening, pelleting, storage, combustion and, where required, conveying);
- ***Mobile plant:*** typically a front end loader (FEL) with a bucket attachment to load and a fork attachment to handle packaged output materials;
- ***Project delivery fees and contingency:*** these comprise costs for planning, permitting, technical adviser support, contractor margin and a project contingency of 5% of overall CAPEX costs.

It is envisaged that the CAPEX for Options 2a and 2b will be broadly comparable as the plants will be similarly sized. The CAPEX for Option 3 is considerably greater as a larger plant and process equipment capable of processing a greater throughput of material will be required.

A high level breakdown of the CAPEX for each of the shortlisted options is presented in Table 4-2. While indicative only, these costs are based on the proposed facility being adequately sized to achieve an optimum throughput[2].

Table 4-2 Breakdown of Facility Capital Costs (£000's) for Options Considered

	Option 1	Option 2a	Option 2b	Option 3
Civils	0	169	169	1,440
M&E Plant	0	799	938	15,984
Mobile Plant	0	130	130	260
Fees + Contingency	0	81	88	1,298
Total (£000's)	**0**	**1,179**	**1,325**	**18,982**

4.2 Operating Costs

Operating costs for the proposed facility include those associated with labour, plant hire, maintenance, sawdust, utilities and consumables such as flue gas treatment, disposal costs, fees and associated contingency costs. For each of the options considered, the facility will operate 24 hours a day 7 days a week on a double shift. Therefore, it is expected that staffing costs will be a considerable proportion of the overall operating costs.

A summary breakdown of the annual operating costs forecast for the shortlisted options modelled is presented in Table 4-3.

[2] Note that the capital cost estimates developed for the proposed facility do not include costs associated with site acquisition

Table 4-3 Breakdown of Facility Operating Costs (£000's) for Options Considered

	Option 1	Option 2a	Option 2b	Option 3
Labour and plant hire	10	110	110	658
Maintenance	0	37	44	734
Sawdust	0	92	205	9,183
Utilities	0	8	8	662
Flue gas treatment and ash disposal	0	5	6	467
Fees and contingency	0	21	27	591
Total (£000's)	**10**	**271**	**397**	**12,294**

4.3 Revenue

It is expected that some of the pellets produced will be combusted in an onsite boiler to generate heat required to dry the animal bedding – this is referred to as sacrificial pellet use. In assessing the financial viability of these options, it is expected that revenue will be generated from the sale of surplus pellets produced, i.e. total pellets produced, less the sacrificial pellet use.

Sawdust currently costs in the region of £110/tonne. Revenue assumptions used in the model are based on an indicative pellet price of £165 / tonne in Y1. This is based on the typical range currently experienced for sawdust pellets, pro-rated on the basis of net calorific value (NCV).

Where the annual revenue from pellet sales is greater than the annual plant operating costs, the facility is considered to be commercially viable. Based on the costs and anticipated revenues, it is considered unlikely that a farm scale facility processing only 1.5ktpa of used animal bedding would be economically viable. In contrast, the development and operation of a larger scale facility processing 150ktpa of used animal bedding could offer a commercially attractive alternative provided the scheme could be accommodated on land already owned by the developer.

The estimated revenue generation from pellet sales in Y1 of each of the options modelled is as follows:

- Circa £188,800 / annum for Option 2a.
- Circa £301,600 / annum for Option 2b. This is because as the proportion of used animal bedding in the pellets is reduced, more pellets can be produced.
- Circa £18.7 million / annum for Option 3.

The indicative revenues presented above demonstrate the potential profitability of a larger facility when compared to that developed at a farm scale.

4.4 Sensitivity Analysis

In order to assess the impact of certain parameters on the unit costs presented in Section 4.3, a sensitivity analysis has been carried out based on the following:

- CAPEX +/- 10%;
- OPEX +/- 10%;
- Sawdust cost +/- 10%;
- Pellet sale price +/- 10%; and
- Sawdust cost vs pellet sale price.

None of the variables considered have a bearing on the economic viability of the options considered. Options 2a and 2b continue to be unviable. For Option 3, the payback period for the modelled scenario is c. 3 years. All the variables considered with the exception of pellet price have any significant bearing on the overall payback period – an increase of 10% in the pellet sale price reduces the payback period to just 2 years, while a decrease of 10% in the pellet sale price increases the payback period to 4 years.

5.0 DISCUSSION AND CONCLUSIONS

While the concept of turning waste animal bedding into a fuel has many attractive aspects, it also offered up significant challenges for the Project Team. The team were able to overcome the main technical issues with clumping in the dryer and subsequently produced c.10 tonnes of fuel pellets without major issue.

For the boiler trials, there were however some issues encountered in conveying of all the fuel mixes, the emissions recorded for all the fuel mixes and achieving steady state combustion of the 0% and 25% sawdust pellets. The team sought to organise further boiler trials to see if these issues could be resolved, however this was not possible due to time constraints.

With the 50% and 75% sawdust pellets being the only combustible fuels, this informed the mass and energy balance as well as the financial model. The higher sawdust content leads to a high operating cost for a potential plant, but did not significantly reduce the amount of sacrificial pellets being reused to provide heat for drying. Considering the relatively small difference between the sawdust purchased and the sale price of biomass pellets, it does not appear possible for a waste bedding processing plant to create an operating profit – particularly for the options pertaining to a farm scale facility.

In order for that situation to change, there would need to be an increase in the difference between the sawdust and pellet price. Alternatively, if the heat requirement for the dryer came from another source e.g. waste heat from an AD plant, this would increase the viability of the plant by making more pellets available for sale.

The commercial modelling assumes availability of capital and therefore no annualised cost of borrowing. Where the annual revenue from pellet sales is greater than the annual plant operating costs, the facility is considered to be commercially viable. Based on the costs and anticipated revenues, it is considered unlikely that a farm scale facility processing only 1.5ktpa of used animal bedding would be economically viable. In contrast, the development and operation of a larger scale facility processing 150ktpa of used animal bedding could potentially offer a commercially attractive alternative, subject to securing access to land already owned by the developer and certainty over long-term feedstock supply (including sawdust, pellet end use market and price).

There is an inherent assumption that the quantity of sawdust required each year will be readily available; however, the increase in demand could potentially result in an increase in the price of sawdust locally.

6.0 CLOSURE

This report has been prepared by SLR Consulting Limited with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

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SLR disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.

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