INSEAD

RecyGen

Forecasting Demand for Insect Protein Meal in UK

Data Science for Business

Group 1

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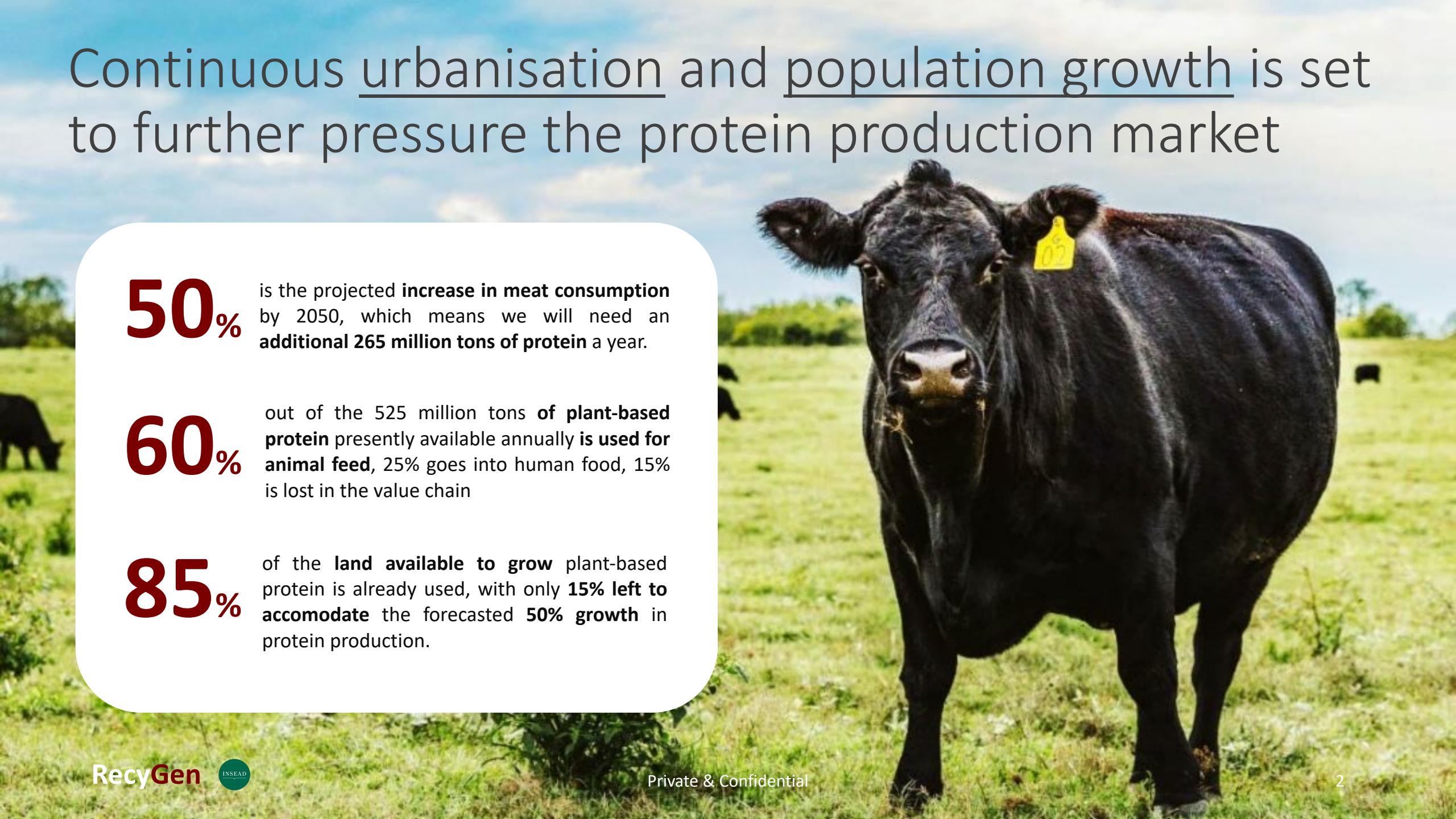
Continuous urbanisation and population growth is set to further pressure the protein production market



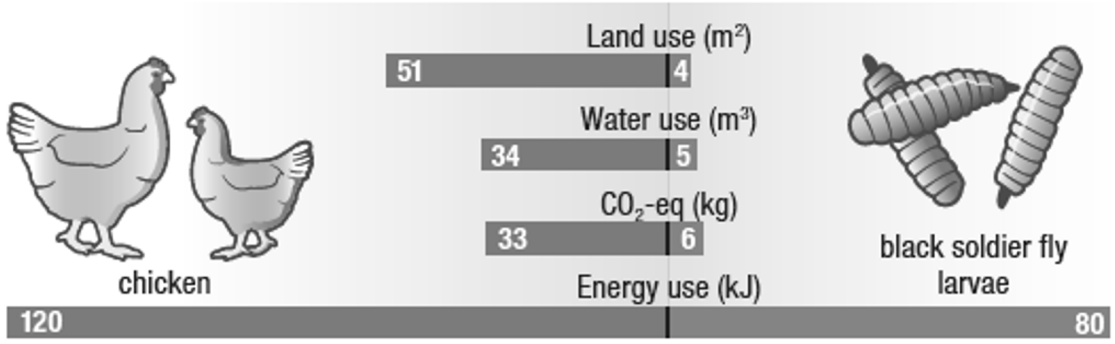
50% is the projected **increase in meat consumption** by 2050, which means we will need an **additional 265 million tons of protein** a year.

60% out of the 525 million tons **of plant-based protein** presently available annually **is used for animal feed**, 25% goes into human food, 15% is lost in the value chain

85% of the **land available to grow** plant-based protein is already used, with only **15% left to accomodate** the forecasted **50% growth** in protein production.

While there are number of ways to increase available protein, insects in animal feed is most developed one

- **Insects are known** as food in about **80%** **of the world's nations**.
- It is anticipated that by 2050 **insects could provide** **15%** **of the additional protein** needed by then.
- Insects are able to **extract** **70%** **of the nutritive value** of their feed.
- In weight-to-weight comparison to traditional farming, **insect farming** requires up to **500x** **less water**, **12x** **less feed**, and **10x** **less land** than beef, while producing **613 times less greenhouse gases.**

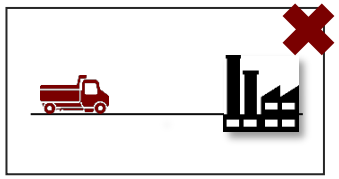


Impact on environment per kg of protein
Source: Bühler

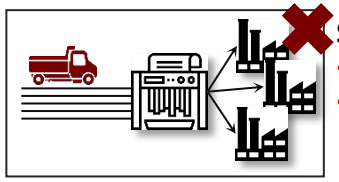
RecyGen placed itself at an intersect of world's two key issues by upcycling waste into insect protein

Waste Management

Large Multi-Stream Plant
- Capital-intensive
- Low sustainability
- Complex operations



Single-Stream Plant
- No economies of scale
- Low profitability



Sorting Facility
- Need of recycling plants
- High transportation costs and CO2 emissions

Illegal Landfills
- Dramatic health hazard
- Air & soil contamination

RecyGen

Holistic

Affordable

Sustainable

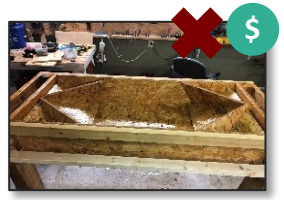
Versatile

Localised

Profitable

Insect Farming

Single-Species Plant
- Enormous CAPEX (up to €150m per plant)
- Significant OPEX (insect feed)

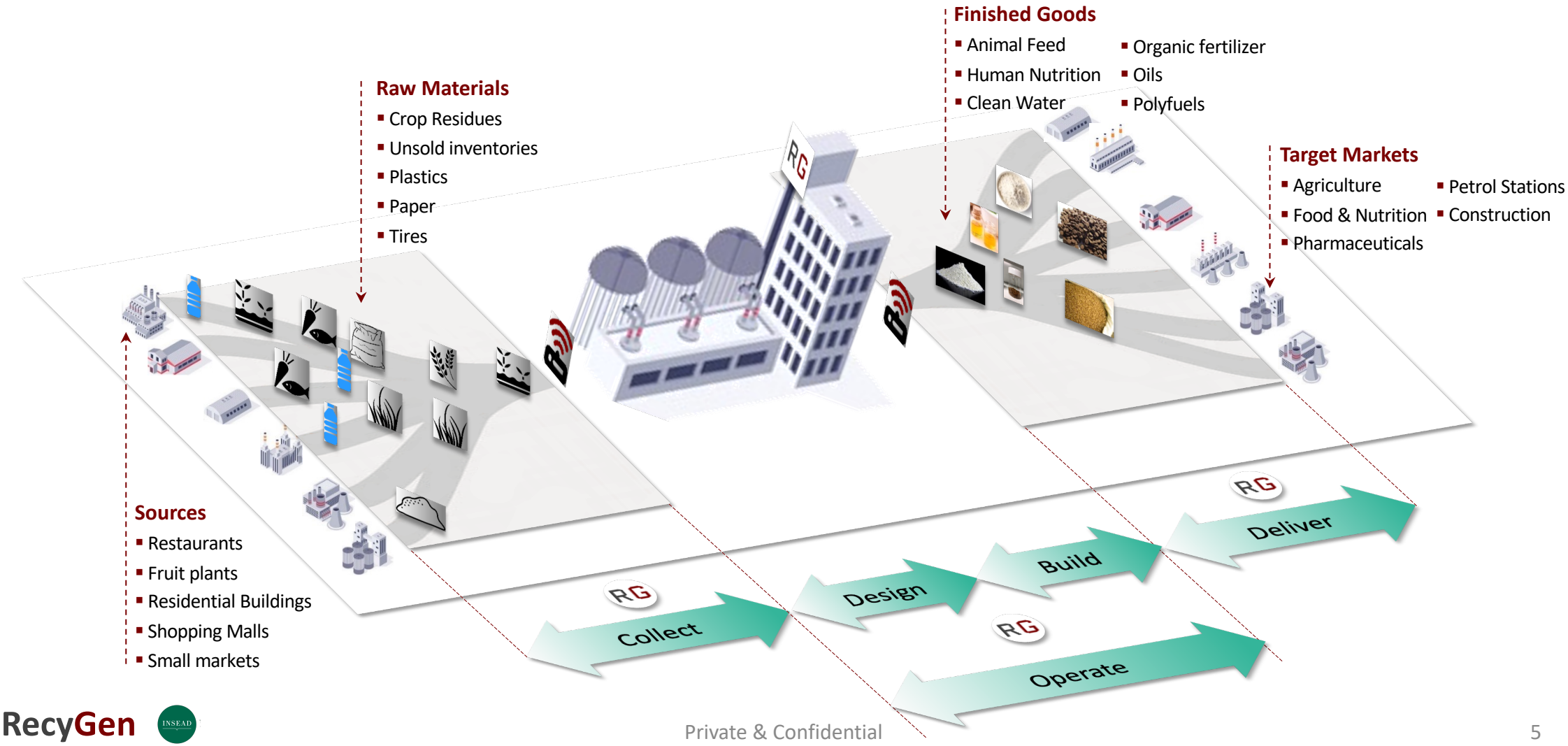


Small-Scale Insect Unit
- No economies of scale
- Low profitability

Single-Species Plant
- Need to be close to both a by-products producer & a power plant

Small-Scale Composting
- No economies of scale
- Low profitability
- 6 months to process

Our value chain allows recycling 15+ types of raw materials & producing 15+ types of outputs



Project Overview

What

Forecasting **cattle, pig and poultry feed production in UK** over the next 30 years

Why

To **estimate demand for insect protein meal** and RecyGen profits to **justify to development of the first insect plant** in the country

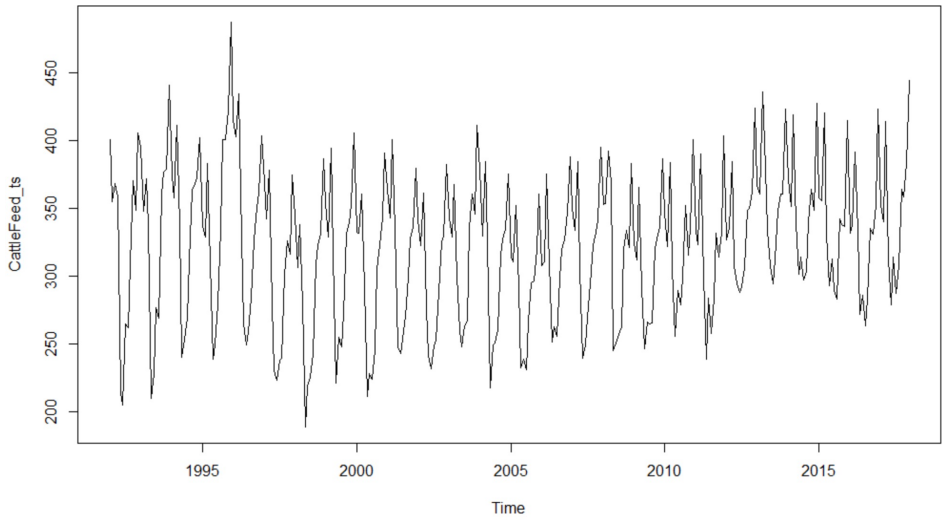
Hypothesis

With **decreasing meat consumption and limited land for pastures** in UK, the animal feed production will display **flattening or decreasing trend.** New protein alternatives like **insect-based meals will become a necessity.**

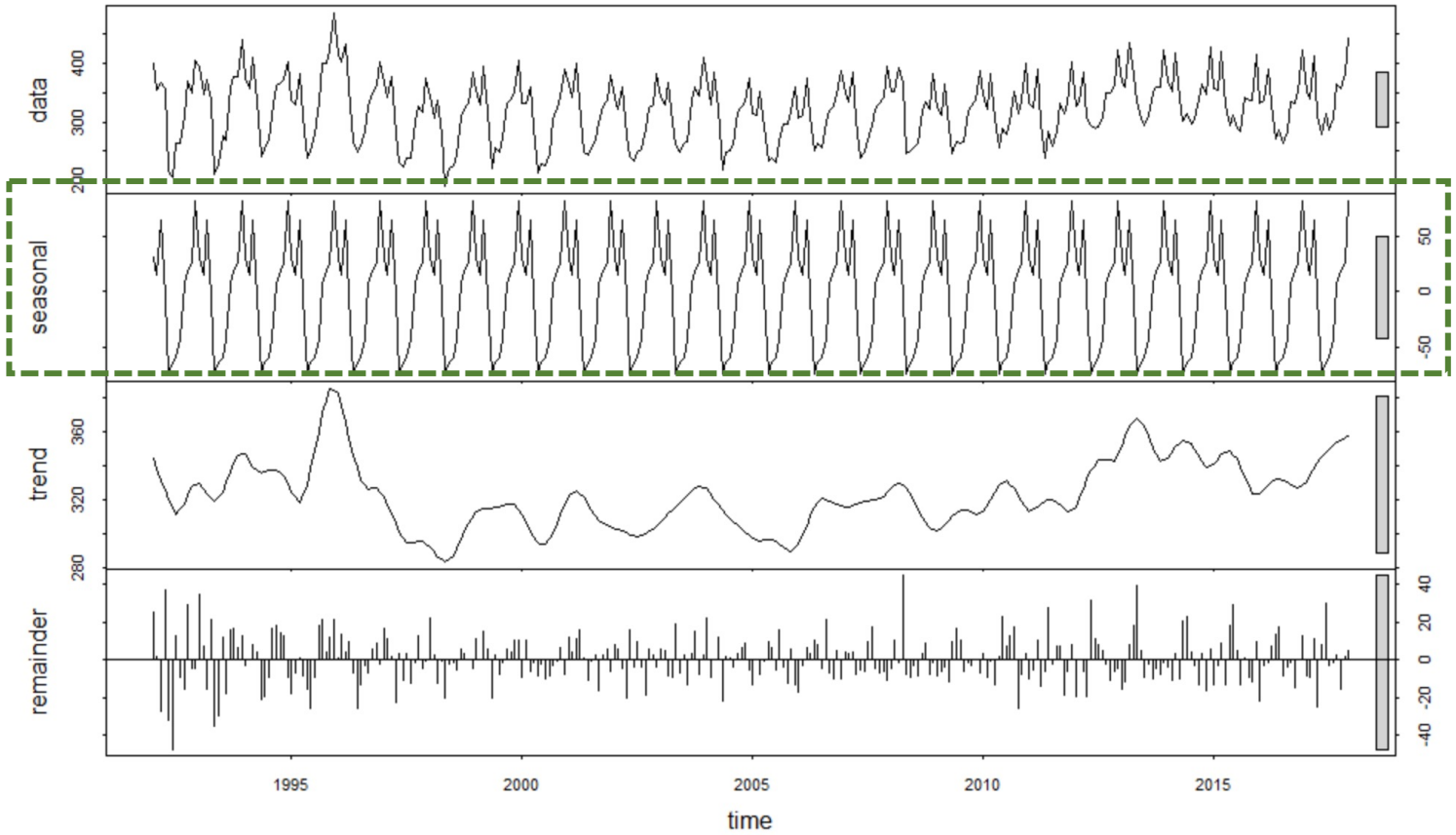
Cattle Feed Model Summary I.

- **Data Set:** monthly cattle feed production in thousands tonnes
- **STL Decomposition:** shows seasonality but no significant trend (large standard error)

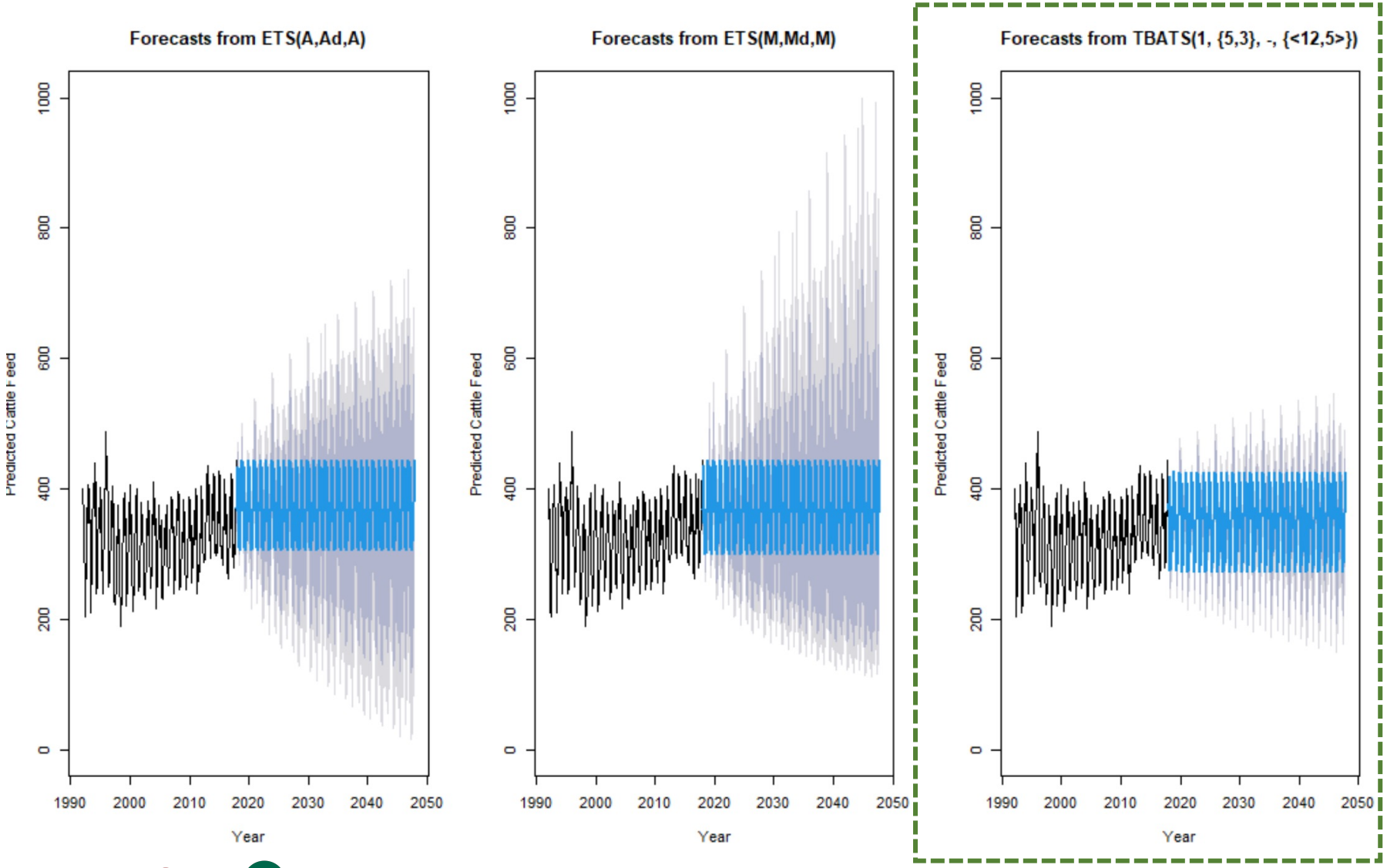
Cattle Feed Production Timeseries Chart



Cattle Feed Production Timeseries Decomposition



Cattle Feed Model Summary II.



- **Models:** AAN, MMN, AAZ, MMZ (all damped), TBATS
- **Projection**: 30 years
- **Confidence Levels:**

  0.8 to 0.95
- **Results:**

Model	AIC	Mean Error
AAZ	3603	3.94
MMZ	3578	3.79
TBATS	3542	3.78

- **Conclusion:** from the models run **TBATS performed best** - its forecasts are used for profit calculations

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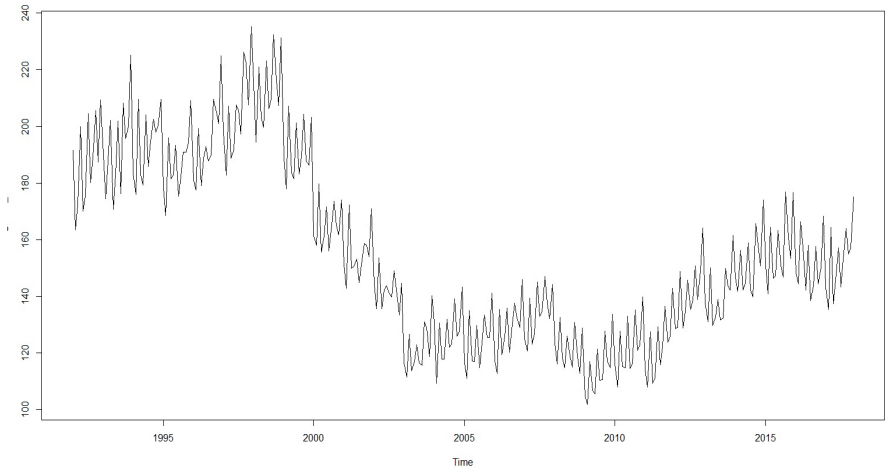
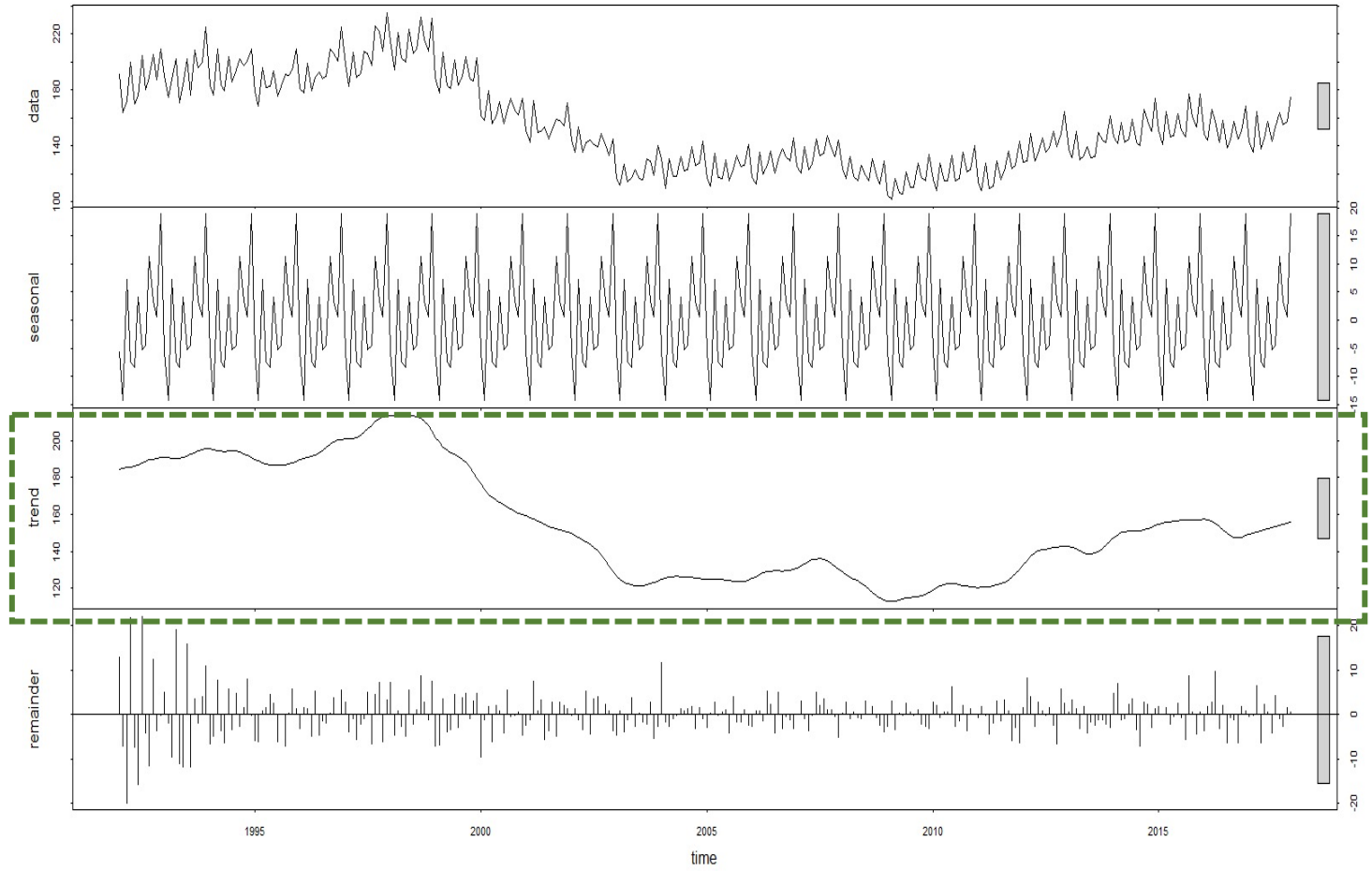
Pig Feed Model Summary I.

- **Data Set:** monthly pig feed production in thousands tonnes
- **STL Decomposition:** no clear seasonality on the data but the trend is significant (low standard error)

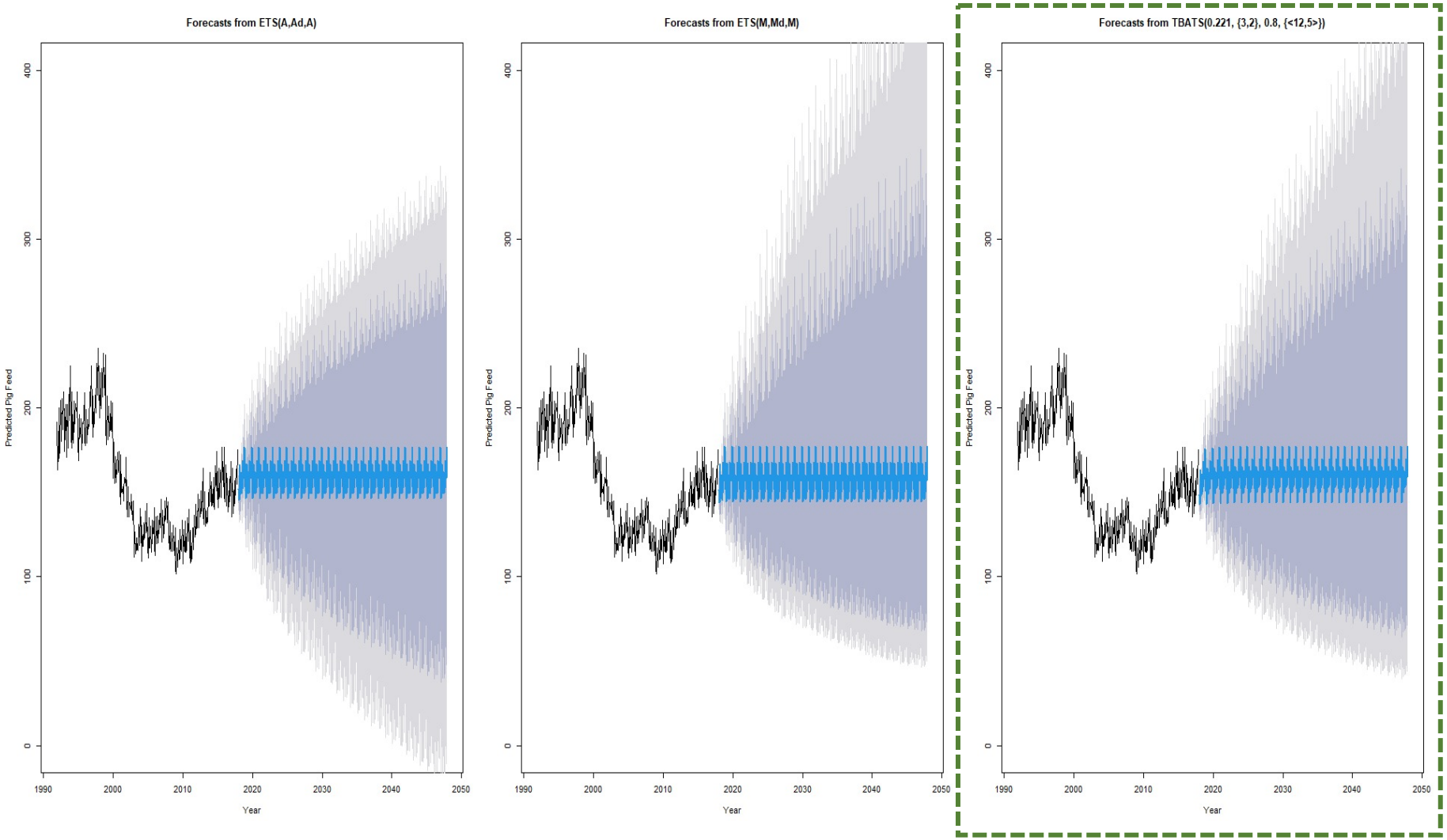
Pig Feed Production Timeseries Chart



Pig Feed Production Timeseries Decomposition



Pig Feed Model Summary II.



- **Models:** AAN, MMN, AAZ, MMZ (all damped), TBATS
- **Projection**: 30 years
- **Confidence Levels:**

  0.8 to 0.95
- **Results:**

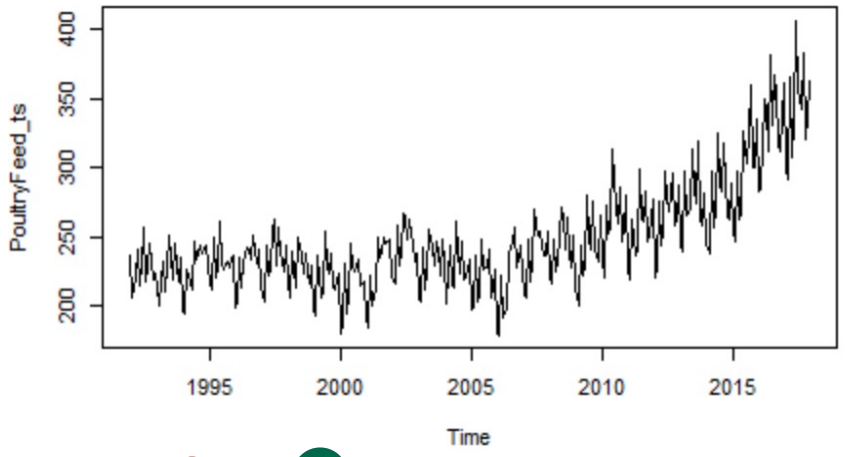
Model	AIC	Mean Error
AAZ	2977	2.97
MMZ	2915	2.78
TBATS	2863	2.97

- **Conclusion:** from the models run **TBATS performed best -** its forecasts are used for profit calculations

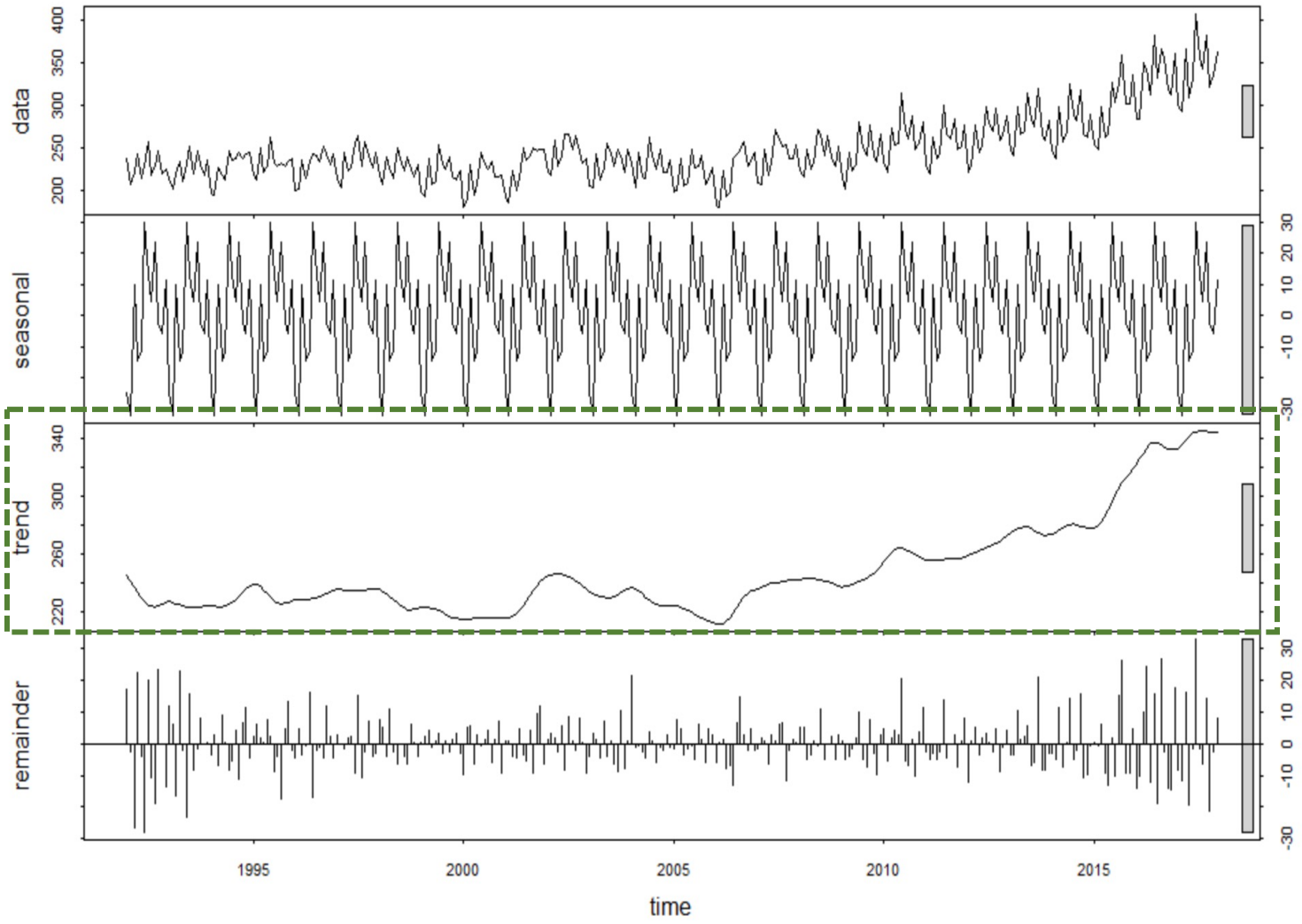
Poultry Feed Model Summary I.

- **Data Set:** monthly poultry feed production in thousands tonnes
- **STL Decomposition:** no clear seasonality on the data but significant upwards, accelerating trend

Poultry Feed Production Timeseries Chart



Poultry Feed Production Timeseries Decomposition



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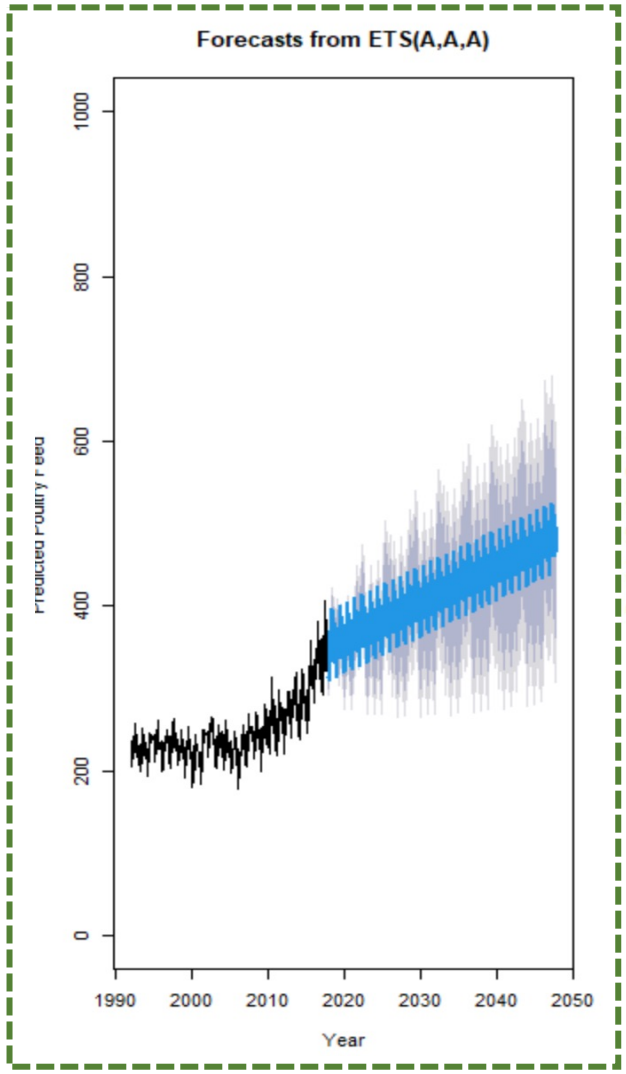
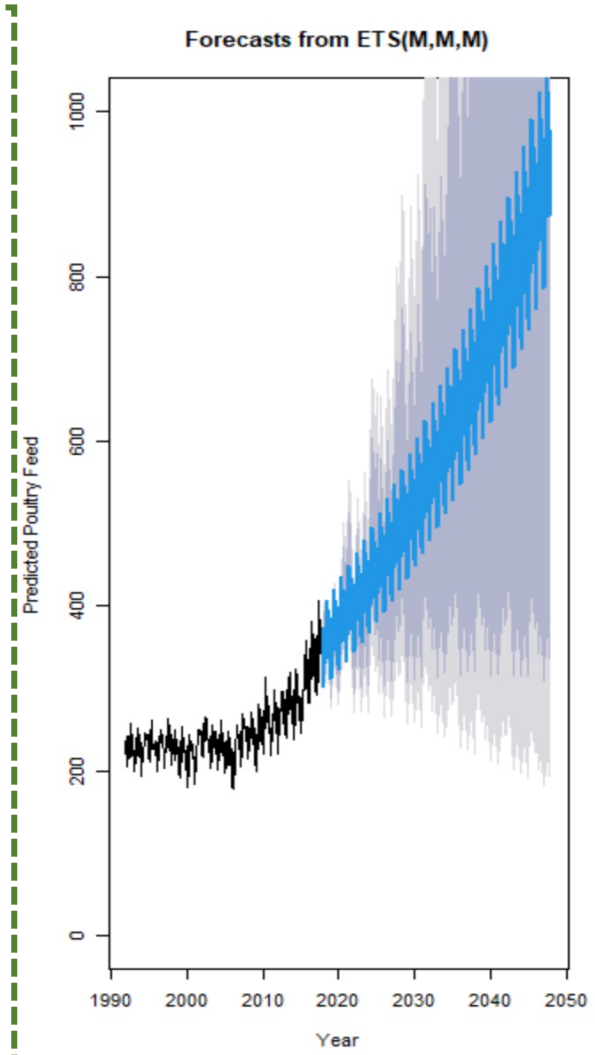
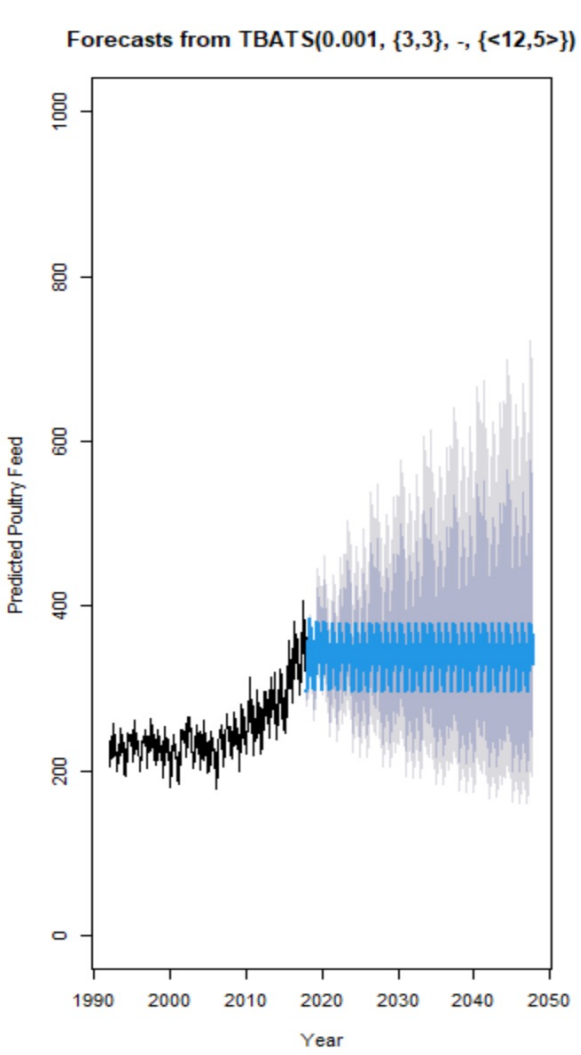
Poultry Feed Model Summary II.







- **Models:** AAN, MMN, AAZ, MMZ (not damped), TBATS
- **Projection**: 30 years
- **Confidence Levels:** 0.8 to 0.95
- **Results:**

Model	AIC	Mean Error
AAZ	3281	3.02
MMZ	3249	2.88
TBATS	3209	2.91

- **Conclusion:** despite TBATS having best AIC and error from the models run, based on the curve shape **we selected AAZ model for the forecasts** used in profit calculations

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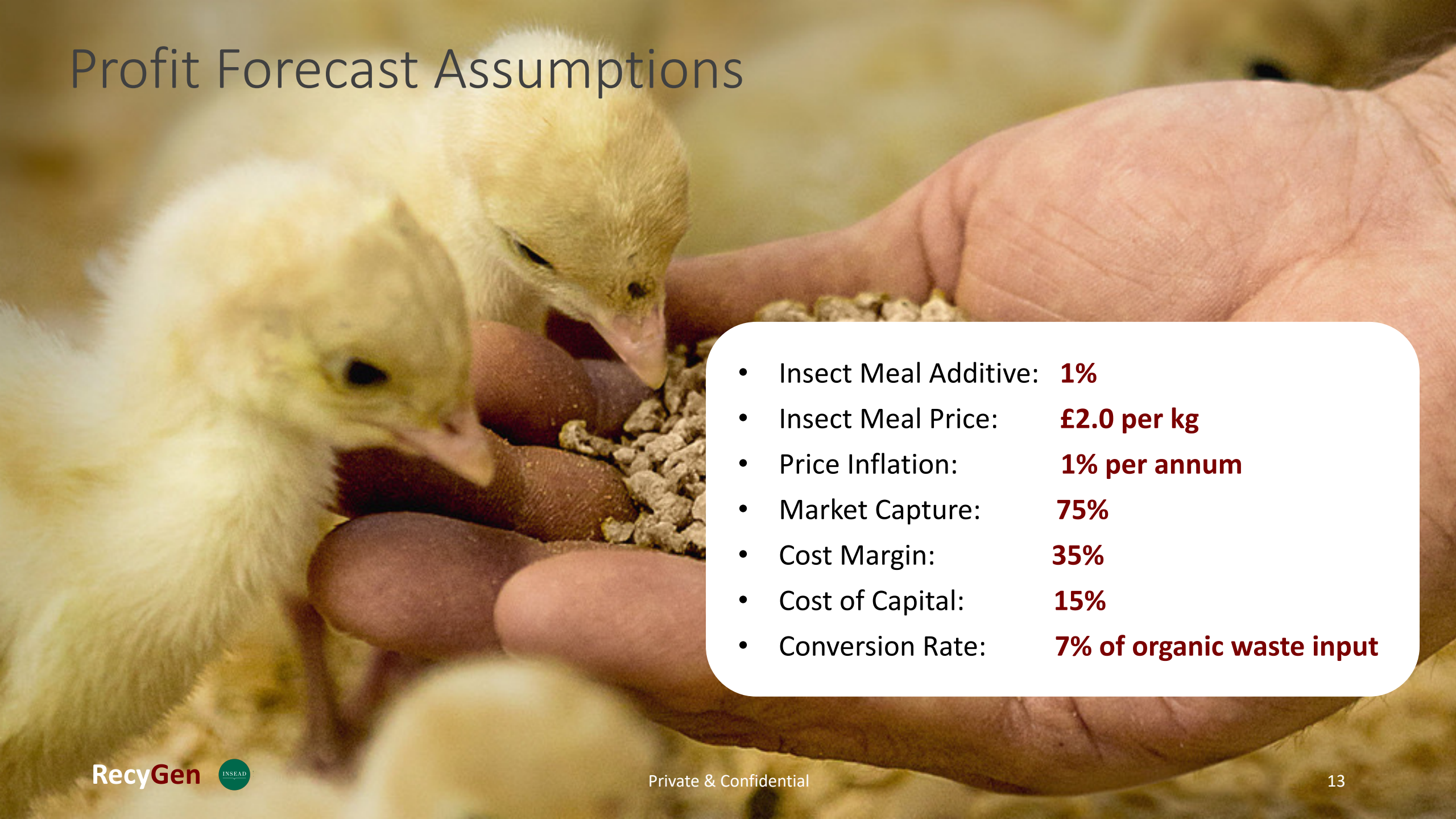
Profit Forecast Assumptions



- Insect Meal Additive: **1%**
- Insect Meal Price: **£2.0 per kg**
- Price Inflation: **1% per annum**
- Market Capture: **75%**
- Cost Margin: **35%**
- Cost of Capital: **15%**
- Conversion Rate: **7% of organic waste input**

Forecast Cash Flows (20 out of 30 years displayed)

Scenario	*1*	*Point*

Annual Price Inflation	1%																					
in '000s tonnes unless specified		***2018***	***2019***	***2020***	***2021***	***2022***	***2023***	***2024***	***2025***	***2026***	***2027***	***2028***	***2029***	***2030***	***2031***	***2032***	***2033***	***2034***	***2035***	***2036***	***2037***	***2038***
Cattle Feed																						
Point		4,148	4,134	4,135	4,135	4,135	4,135	4,135	4,135	4,135	4,135	4,135	4,135	4,135	4,135	4,135	4,135	4,135	4,135	4,135	4,135	4,135
Low 80		3,806	3,732	3,696	3,664	3,634	3,605	3,578	3,553	3,528	3,504	3,481	3,459	3,437	3,417	3,396	3,377	3,358	3,339	3,321	3,303	3,285
High 80		4,491	4,537	4,573	4,606	4,637	4,665	4,692	4,718	4,743	4,767	4,790	4,812	4,833	4,854	4,874	4,894	4,913	4,932	4,950	4,968	4,985
Pig Feed																						
Point		1,877	1,887	1,892	1,895	1,896	1,897	1,897	1,898	1,898	1,898	1,898	1,898	1,898	1,898	1,898	1,898	1,898	1,898	1,898	1,898	1,898
Low 80		1,742	1,646	1,570	1,506	1,450	1,401	1,357	1,317	1,281	1,248	1,217	1,188	1,161	1,136	1,112	1,089	1,068	1,047	1,027	1,008	990
High 80		2,021	2,155	2,263	2,357	2,442	2,520	2,592	2,660	2,724	2,785	2,844	2,901	2,956	3,009	3,061	3,112	3,162	3,210	3,258	3,305	3,351
Poultry Feed																						
Point		4,189	4,242	4,295	4,348	4,401	4,454	4,507	4,560	4,613	4,666	4,720	4,773	4,826	4,879	4,932	4,985	5,038	5,091	5,144	5,197	5,250
Low 80		3,979	3,941	3,924	3,918	3,919	3,925	3,935	3,947	3,962	3,978	3,996	4,016	4,037	4,058	4,081	4,105	4,129	4,154	4,180	4,207	4,234
High 80		4,399	4,544	4,666	4,778	4,883	4,983	5,080	5,174	5,265	5,355	5,443	5,529	5,615	5,699	5,782	5,865	5,946	6,027	6,108	6,187	6,267
Market Capture	75%																					
Insect Meal Additive	1%	76.61	76.98	77.41	77.84	78.24	78.65	79.05	79.45	79.85	80.25	80.65	81.04	81.44	81.84	82.24	82.64	83.03	83.43	83.83	84.23	84.63
Price per kg	£2.00	£2.00	£2.00	£2.01	£2.01	£2.01	£2.01	£2.01	£2.01	£2.02	£2.02	£2.02	£2.02	£2.02	£2.02	£2.03	£2.03	£2.03	£2.03	£2.03	£2.03	£2.04
Total Revenue (£ million)		**£153.34**	**£154.21**	**£155.22**	**£156.19**	**£157.14**	**£158.09**	**£159.03**	**£159.96**	**£160.90**	**£161.84**	**£162.78**	**£163.72**	**£164.66**	**£165.60**	**£166.54**	**£167.49**	**£168.44**	**£169.38**	**£170.33**	**£171.28**	**£172.24**
Opex Costs	35%	-£53.67	-£53.97	-£54.33	-£54.67	-£55.00	-£55.33	-£55.66	-£55.99	-£56.32	-£56.64	-£56.97	-£57.30	-£57.63	-£57.96	-£58.29	-£58.62	-£58.95	-£59.28	-£59.62	-£59.95	-£60.28
Net Profit (£ million)		**£99.67**	**£100.24**	**£100.89**	**£101.52**	**£102.14**	**£102.76**	**£103.37**	**£103.98**	**£104.59**	**£105.19**	**£105.80**	**£106.42**	**£107.03**	**£107.64**	**£108.25**	**£108.87**	**£109.48**	**£110.10**	**£110.72**	**£111.34**	**£111.95**

Cost of Capital	15%
NPV (£ million)	**£679.44**
Cost of Plant (£ million)	£250.00
Payback Period (years)	2.50
Per Annum Production	82.43
Coversion Rate	7%
Implied Organic Waste Needed	1,178
Food Waste in UK 2019	*3,600*

Conclusions

Aims

Purpose is to estimate the feasibility of setting up a plant of insect-based animal feed in the U.K.

- Predict future animal feed demand in 3 categories (cattle, pig and poultry) in the U.K.
- Predict future supply of crop waste in the U.K.

Findings

- Our findings show that TBATS models performed best for all feed types.
- The models forecasted the amount of animal feed being produced over next 30 years (the anticipated life spam of a plant) and assuming 75% market capture and 1% replacement of traditional raw materials, the **NPV** of the project costing £250 m would be **over £200 m** with plant **payback period of 2.5 years** (point forecast numbers).
- Despite an estimate that the **demand for animal feed would flatten over the next 30 years** in the UK as a result of **land constraints and change in dietary habits**, we are convinced that the demand for alternative proteins, incl. insect will be growing exponentially.

The project is NPV positive and therefore it should be pursued.

Limitations

- For the estimation of demand, we saw very wide margins of error in the model outputs. We believe this is a result of not having more granular data or a longer historical dataset. More specifically, having bi-weekly animal feed data instead of monthly, or an additional 20 years of historical data (before 1990), the models would be far more potent in calibrating the historical flactuations and would forecast values with smaller margins of error
- The supply-side model was weaker due to data size. Despite the same horizon, available data were strictly annual.

Next Steps

The following should be done to strengthen our confidence in pursuing the project:

- ✓ Retrieve bi-weekly data on animal feed product and crop wastes
- ✓ Research market prices of insect protein meal and oils, forecast future prices and conduct NPV sensitivity analysis. This is hard as the industry is nascent and current players are not willing to share proprietary data
- ✓ Conduct primary research to estimate market share penetrations in the early years in conjunction with sensitivity analysis for number of new market entrants
- ✓ RecyGen will be collecting insect protein data from the first pilot plant dependent on the types of raw organic inputs. Dataset can and most likely will be used in machine learning to project best combination of inputs and forecast quality of the protein produced.

Data Sources

Data Sets

Crops Lost	http://www.fao.org/faostat/en/?#data/BC
Animal Feed Production	https://www.gov.uk/government/statistics/animal-feed-production

Other Information

RecyGen	https://www.recygen.com/
Animal Feed Composition & Prices	https://www.allaboutfeed.net/all-about/new-proteins/insect-meal-allowance-expected-in-2020/