Production Forecasting in the Age of Big Data in Oil & Gas industry

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Technical Potential Forecasting

National Production Portfolio Management and why is TP important?

1. Currently not transparent
2. TP reporting to MPM not consistent across PAC’s
3. Production system bottlenecks
4. Sustained production

- Ideally, this is the rate at which we should be producing.
- However the production at sale point is significantly lower.
- This gap is created by efficiency of various processes through which the crude passes from wellhead to sale point and uptime of the system.
- The balance between maintaining peak efficiency of production system and uptime is directly proportional to delivery of technical potential.

Ensuring standardization on TP definition allows systematic & focused review of existing key constraints.
## Technical Potential Forecasting

### Value of improving the TP forecasting accuracy

<table>
<thead>
<tr>
<th>Existing Thinking</th>
<th>Opportunities</th>
<th>Business Outcome</th>
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<tbody>
<tr>
<td>• Oil Forecast are still done using Decline Curve Analysis, A theory proposed by JJ Arps (1944).</td>
<td>• Understanding the overall technical characteristics / patterns of Fields/Well with the Application of Analytics</td>
<td>• Major Oil &amp; Gas Operators, especially NOCs face decision that involve billions of dollars and thousands of lives essentially based on the production profiles.</td>
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<tr>
<td>• Forecasting adopted was Complex, dependent upon interaction of multiple variables</td>
<td>• Adopt a system that shall automate the process of Short Term, Medium Term and Long Term Forecasting</td>
<td>• When it comes to short term (1-2 years) the accuracy of forecast is paramount since it could mean saving on a huge unnecessary investment.</td>
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<td>• Normal interpolation techniques applied did not plug gaps in Well Test data</td>
<td>• Forecasts &amp; its Upside/Downside with Accuracy measurement an integral part of forecasting process</td>
<td>• Downtimes can be preempted or delayed based on the overall production requirement</td>
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<tr>
<td>• Measurement of Forecasting accuracy not a practice</td>
<td>• Forecasting Process was not automated</td>
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National Production Portfolio Management and why is TP important?
Technical Potential Forecasting

National Production Portfolio Management and why is TP important?

Note: Numbers are indicative only and do not reflect the actual/forecast figures.
Forecasting

Science and Art
Technical Potential Forecasting

Considerations

- What is technical potential data?
- How do we build the time-series data?
- Understanding the time-series patterns?
- What do we want out of a production forecast? Long-term or short-term?
- Do we want to measure effect of X on Y? (scenario forecasting)
- What methods are out there to forecast/analyze them?
- How do we decide which method is best?
- How can we use SAS for all this?
Forecasting
Building the Technical Potential

No Well Test Data

Comparing with Production

Removing Outlier

Technical Potential

Applying Heuristic
Forecasting
Building the Technical Potential

Technical Potential @ various Field Levels

Country
  - Region 1
  - Region 2
    - Operator 1
    - Operator 2
      - Field 1
      - Field 2
      - Field 9
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Time Series Patterns

- **Trend + Cyclic**
- **Trend + Outliers**
- **Trend + Ramp Up**
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Time series Patterns

Data Quality

Very Short History

Long history + Different Start Dates

Short History + Different Start Dates
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Time series modelling

ARIMA

• Analyzes and forecasts equally spaced univariate time series data, transfer function data and intervention data

• Using the Autoregressive integrated moving average or autoregressive moving average model

• Predicts a value in a response time series as a linear combination of its own past values, past errors (shocks or innovations) and current and past values of the other time series (ARIMAX Model)

• Divided into three stages – *identification, estimation & diagnostic checking and forecasting stage*

UCM

• Model decomposes into trends, cycles, and the regression effects of explanatory variables

• Provides variety of diagnostic tools to assess the fitted model and to suggest possible extensions or modifications

• Components of UCM provide the a succinct description of the underlying mechanism governing the timeseries

• Similar to the Dynamic Models, popular in Bayesian time series, captures the versatility of ARIMA and interpretability of Smoothing Models
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Challenges and Integrating DCA

• Very Short History Modelling
• Benchmarking the results of ARIMA, UCM
• Time series with Large errors in ARIMA, UCM
• Lifecycle behaviour of fields

Decline Curve Analysis
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Overall Framework

1. **Reconstruct Technical Potential (TP)**
   - Extract Raw TP from OFM and recalculate the series by applying heuristics.

2. **Outlier Pre-Treatment**
   - Smoothen outliers from the time-series example – gas production data mixed with oil production data.

3. **Classification of fields**
   - Break into groups based on history available / start dates, short history, # of wells in field, % contribution.

4. **Generate Baseline Timeseries Forecast**
   - Apply time-series modelling technique – ARIMA, UCM, Combined Modeling and evaluate out of sample MAPE.

5. **Integrate Decline Curve Analysis**
   - Benchmark results with DCA and undertake DCA forecasts for short time series and integrate the results.

6. **Schedule monthly forecast / Re-diagnose**
   - Pareto analysis of MAPE, trend of forecast accuracy improvement / deterioration after each cycle of forecast, re-diagnose where required.
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Forecast Evaluation Method and Observed Accuracy

1. Define a holdout period for model selection
2. Diagnose training history
3. Construct competing models
   - Model 1: ARIMA, $f(\text{History, Outliers, etc...})$
   - Model 2: ARIMAX, $f(\text{History, Trends, Outliers, Predicting variables})$
   - Model 3: UCM, $f(\text{History, Outliers, Trends, Cyclicity, Events, etc...})$
4. Forecast & evaluate model performance over holdout period
5. Select champion model and refit over entire history
6. Produce forecast with events and correction for moving development

Error
- Model 1: 13.64%
- Model 2: 11.05%
- Model 3: 8.58%

$M = \frac{100}{n} \sum_{t=1}^{n} \frac{|A_t - F_t|}{A_t}$
where $A_t$ is the actual value and $F_t$ is the forecast value.
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Forecast Evaluation Method and Observed Accuracy

80% of the fields we achieved < 20% error in MAPE

Top 30 fields contributing 80% of production we achieved average < 10% error in MAPE