Significant changes in current economical, political and also geological and technological factors influencing the construction costs of oil and gas companies, force them to look for innovative approaches for cost estimation, especially on the early stages of projects development.

Decline of oil prices, decrease of the ruble exchange rate, international sanctions toward Russia as well as difficult reservoirs characteristics making hydrocarbons production more challenging put a pressure on cost estimation and optimization.

Development of cost models or oil and gas construction allows estimating costs with consideration of modeling object technical characteristics and changes in the environment. The paper describes principles, methods and key elements of cost models actively implementing for capital costs evaluation in Russian oil & gas companies.

In the article there are examples of databases used by companies for cost estimation: “smeta” estimate norms, corporate cost data bases on real projects, external data bases.

Authors analyse rules for choosing of the proper analogue, taking into account that the main question is choosing analogue with required characteristics as well as proper implementation of the cost data for the new object. In the article authors suggest to use different types of costs models depending on construction objects type, for example, calculation models for linear objects and structured in a certain way analogues or “flexible” model for areal objects. Considering existing cost data bases and methods for costs analysis, even currently you can get detailed and accurate estimation of the costs.

In recent years, the investment programs of Russian oil and gas companies are affected by numerous competing factors having political, macroeconomic, technical, and technological nature (Fig. 1).

Economic and political trends include:
– Fall in hydrocarbon prices due to supply surpluses on the world oil and gas market;
– Significant depreciation of the ruble, which had a positive effect at the time of sharp decline in oil prices, but could adversely affect future capital investments, for example, in acquiring foreign technologies and equipment;
– Reduction of capital markets for Russian companies;
– International sanctions on imports of technologies and equipment aimed at raising the cost of production and impeding the implementation of new complex projects.

Geological and technical trends are due to objective changes in production conditions in Russia, such as:
– Expansion into new regions, including Eastern Siberia, the Arctic Zone, and projects on sea shelf;
– Increase in the share of difficult-to-recover reserves - according to various estimates, 30 to 60% of the recoverable reserves of the West Siberian fields can now be classified as difficult-to-recover reserves;
– Implementation of new, more efficient technological solutions (multiphase pumps; requirement for 95% utilization of associated gas; stepping up the requirements to energy efficiency of facilities and equipment; use of modern insulating materials; replacement of pipe, fitting, and reinforcement steel gauge, etc.).

The considered competing factors with due regard to long-lived petroleum projects and related need in advanced cost planning have proved to be challenging for the investor.
In the early stages of design (feasibility study, conceptual engineering) in the absence of sufficient information about the project, it is necessary to ensure the following:
– Accuracy of assessment sufficient to make investment decision;
– Continuity of the assessment structure for further plan/actual analysis;
– Iterative calculations.

The optimal combination of reliable data sources and correct evaluation methodologies allow to achieve this goal. In the context of limited information and the need for on-line decision-making, it is more difficult to use the traditional method of estimate calculation. First, zero-base budgeting of facilities requires a fairly large amount of input data and time for evaluation. Second, standards database is incomplete and updated with delays.

That is why Russian companies have to develop methodologies and tools for cost modeling [1]. Ultimately, both database and methods form a single cost assessment tool, namely: cost estimation models, which are increasingly used to estimate costs in Russian oil and gas companies.

**Cost estimation models**

Cost estimation model is generally understood as interrelationship between technical and cost characteristics of an object; they are described basing on information about objects-analogues or other reliable sources, which allows promptly assessing the cost of the required facility construction.

Architecture of cost estimation models is rather universal (Fig. 2). Models typically consist of the following elements:
– Database of physical and cost parameters;
– Methods for objects typification and classification to ensure optimal selection of objects-analogues;
– Description of interrelationships between technical and cost characteristics of the objects, i.e. direct development of models.

In addition, the modeling should take into account external factors that do not directly depend on technical characteristics of the simulated object and cannot be derived from the actual value of the objects-analogues as information on the simulated project and current time period is required:
– Exchange rates affecting the cost of purchasing foreign equipment;
– Availability of imported equipment;
– Application of new technologies;
– Scheme of employees, supplies, and equipment transportation.

**Figure 2. General principles of cost estimation model creation**

![Diagram](image-url)
Taking external factors into account can significantly increase the cost of evaluation, especially in conditions where the external environment changes rapidly, as has been the case in the past three years. However, the impact of some persistent external factors is often overestimated.

For example, the dollar rate, of course, considerably affect costs in the cases there is fairly large share of expensive imported equipment. However, further analysis shows that the share of imported equipment in Russian onshore oil projects is rather low; and in the current context companies prefer to use Russian equipment at the slightest opportunity.

That is why in the fact the dollar rate has only slight effect on objects cost in rubles. The situation is somewhat different in the gas industry, where it is impossible to do without imported compressors, whose value is considerable; here the dollar rate considerations are more important.

**Cost database**

Any assessment is based on estimated or historical data. In real situation, companies have a small choice of accessible bases: these are either databases of costing standards and industry regulatory collections, or in-house historical data, or external databases of the values of representative or actual construction facilities (Fig. 3).

![Costing standards, Enterprise databases, External databases](image)

**Figure 3.** Sources of data for cost estimation: GESN: state itemized cost estimate standards; FSSC: federal book of estimate prices; TER, FER: territorial and federal unit costs, respectively.

Each of these sources has advantages and disadvantages. For example, when using the costing standards, it is impossible to take into account some new technologies. Cost estimates also lack reference books on equipment prices. GESN-2001 does not contain standards for drilling wells, so oil and gas and oilfield service companies had to establish their own simulation models to estimate the cost of wells. This practice is currently being carried over to other oil and gas facilities.

Corporate database naturally carries the greatest credibility for oil and gas companies, but it may lack suitable objects-analogues or data on the required regions. At the same time, any corporate database of costs involve the use of technologies and procedures of one company, which are needed to be checked for optimality (i.e., a certain benchmarking with other producers should be conducted), and does not take into account the body of knowledge accumulated by other market participants.

Databases of software systems or external databases are widely used in evaluation of foreign projects. There are no public databases of oil and gas fields development and facilities construction; so when assessing, companies often have to rely on their own resources, even if there are no similar objects in the company’s database. It is known from experience, that creation of costs database is a complicated process, often too expensive for independent players. In Ingenix Group Company, it took about four years of active teamwork of multidisciplinary experts to create a full-fledged database of model oil and gas facilities [2].
Thus, when evaluating Russian projects, oil and gas companies are mainly obliged to use the internal sources of information, which are available to them, and do not always have a basis for comparative analysis and selection of the best project.

In the current situation of uncertainty, it seems rational to use all available sources of information, including external databases. The cost of applying them to vertically integrated companies will not be considerable, but the effect of improving the estimation accuracy may be significant. Moreover, further developments and techniques can greatly save time of creation and implementation of company’s costs database [3].

Analogue selection, objects typification

In practice, estimates based on objects already constructed and having similar technical characteristics are considered most reliable. However, this method has limitations: a key problem is in the fact that usually a perfectly suitable object-analogue does not exist.

This is particularly evident when it comes to areal objects such as Oil Treatment Plant (OTP), Booster Pump Stations (BPS), or Gas Treatment Units (GTU). For example, OTP has three throughput capacity characteristics (for liquid, oil, and gas) responding to fluid characteristics in the specific filed. Even Oil Treatment Plants of equal capacity (e.g., 3.5 MM tons per year) will have a differing set of processing units; and correct assessment can be made only at this level.

The same applies to linear facilities as the cost of a pipeline or road of a certain length can only be the basis for assessing a similar facility. Cost of construction per 1 km decreases when the facility extends; thus, a simple scaling can cause considerable errors (Table 1).

### Table 1

<table>
<thead>
<tr>
<th>Areal and linear analogue objects</th>
<th>Length, km</th>
<th>Capacity, MM tons per year</th>
<th>Cost, mln. RUB</th>
<th>CAW and materials</th>
<th>Equipment</th>
<th>Other works</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPF</td>
<td>-</td>
<td>2.5</td>
<td>1258.8</td>
<td>843.1</td>
<td>357.7</td>
<td>58.0</td>
</tr>
<tr>
<td>Gas pipeline 530x10</td>
<td>165</td>
<td>-</td>
<td>5056.9</td>
<td>4017.9</td>
<td>182.8</td>
<td>856.2</td>
</tr>
<tr>
<td>V Category road</td>
<td>54</td>
<td>-</td>
<td>793.7</td>
<td>654.2</td>
<td>0.0</td>
<td>139.5</td>
</tr>
</tbody>
</table>

Note: 1. Construction and assembly works. 2. Metrics for OTP the figures are in 2014 prices, for gas pipeline and road in 2015 prices.

It is the authors’ opinion that it should not be feared to use for assessments the available "non-perfectly" matching objects-analogues; especially if it is done consciously and correctly. Selection and creation of a model object already imply the use of certain evaluation techniques adopted by the company, although these methods are often not formally prescribed. Anyway, creation and evaluation of a new facility, based on a similar one, involve the systematization of information and application of modeling. The better the information is collated and the more complete the data about model object and the object-analogue, the more accurate the assessment. This is achieved by using the cost modeling at the level of individual technological units, both for areal and linear objects.

Description of interrelationships: different models for different types of object

Two groups of objects can be distinguished (areal and linear) with different approaches to cost modeling (Table 2).

### Table 2

<table>
<thead>
<tr>
<th>Expenditures</th>
<th>Full cost simulation models for linear objects</th>
<th>Object-analogue or “flexible” models of areal objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAW calculation, including wages</td>
<td>For the entire facility</td>
<td>For technological units</td>
</tr>
<tr>
<td>Supplies</td>
<td>For the entire facility</td>
<td>For technological units</td>
</tr>
<tr>
<td>MEM</td>
<td>For the entire facility</td>
<td>For technological units</td>
</tr>
<tr>
<td><strong>Equipment:</strong></td>
<td><strong>Model includes predefined list of equipment:</strong></td>
<td><strong>Equipment from the object-analogue; shipping cost can be specified</strong></td>
</tr>
</tbody>
</table>
Russian shipping cost is recalculated automatically

<table>
<thead>
<tr>
<th>Imported</th>
<th>Automated recalculation according to the specified dollar rate</th>
<th>Recalculation is possible in accordance with the specified dollar rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other:</td>
<td>Percentage of CAW cost (can be modified)</td>
<td>Percentage of CAW cost for the object-analogue; with the DEW coefficient for the object-analogue</td>
</tr>
<tr>
<td>DEW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>excl. DEW</td>
<td>Percentage of CAW cost</td>
<td>Percentage of CAW cost</td>
</tr>
</tbody>
</table>

**Note:** MEM is Mathematical Economic Model; DEW is Design and Exploration Works.

Cost for linear objects depends considerably on the length, which at first glance make them easier to model. However, even if a technically simple construction like a road is taken, it will be necessary to take into account at least three types of laying conditions (bogs, normal ground, permafrost) for correct assessment, not to mention 18 influencing parameters of the road itself (Fig. 4). Here, it is important to strike a balance between accuracy and number of parameters defined: in the case there are too many parameters, the model will no longer be easy-to-use.

When creating cost estimation models of linear objects, a multi-level approach was applied in Ingenix Group Company. For example, there is only five-item main menu for a road, and additional menu that the user fills in if he has specific information about the object. In the case the user is in the early stage of modeling, most of the parameters can be taken by default since he does not have information about this object. If the object is evaluated at a later stage, the user can enter all the additional parameters (Fig. 4). Practice shows good convergence of data simulated for linear objects and actual cost of the objects constructed. Ingenix Group Company has already created cost estimation models and developed a software solution for cost calculation modules for pipelines, roads, and power lines.

![Image of road model](https://via.placeholder.com/150)

**Figure 4.** Main and additional menus in road modeling.

Simulation models for areal objects should be based on the other principles. In this case, the number of influencing parameters increases many times, and there is a risk to get stuck in details. Based on the experience, the
authors do not suggest building “classical” simulation models using the areas objects-analogues, since this requires recalculation of complicated, non-obvious, and often non-existent dependencies.

In the stage of conceptual design, it may be sufficient to use a capacity-equivalent object-analogue (e.g., OTP having a capacity of 3 million tons), but only in the case the detailed breakdown up to the level of technological units, and equipment list are available for it [2, 4]. Relationship between the levels of the database, cost and physical parameters of the object would be a “flexible” model that allows taking into account modifications at the level of the technological units. As more detailed technical information is obtained, it is possible to update their structure: for example, number of hectares of pad works, length of service networks, and equipment configuration. However, the main condition for modeling the facility is the availability of a standardized database and a convenient tool for such analysis.

In the case database structure is adequate (Table 3), a correct analysis of the facility construction cost can be carried out in several ways:

– Accounting for the fraction of the technological units cost in the total cost of the facility (e.g., cost of the service networks can make up to 30% of the cost of the facility, which is nearly equal to the cost of the technological site);

Table 3

<table>
<thead>
<tr>
<th>Process facility</th>
<th>Overall value, min. RUB</th>
<th>Unit cost index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Machinry operation</td>
<td>Measure of unit cost</td>
</tr>
<tr>
<td></td>
<td>Total CAW</td>
<td>Wages</td>
</tr>
<tr>
<td>Vertical leveling (amount V = 115295.4 m$^3$)</td>
<td>19.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Service networks (length L = 5679 m)</td>
<td>33.7</td>
<td>2.1</td>
</tr>
<tr>
<td>Complete Transformer Substation with Low-voltage Complete Indoor Switch Gear (2Complete Transformer Substation for Outdoor Installation-1000/6/0,4)</td>
<td>0.8</td>
<td>0.1</td>
</tr>
<tr>
<td>Oil and Gas Processing Facility (OGS-I-1.0-3000-2-I; OGS-II-1.6-3000-2-I; EPP-40 m$^3$)</td>
<td>1.8</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Note: 1. OGS is Oil-Gas Separator. 2. Cost of OTP technological units construction is shown in 2001 prices.

– With the easily verifiable Unit Cost Indices (e.g., pad works per 1 m$^3$; man-hour rate; metal cost per 1 ton);
– According to the cost composition of technological unit (e.g., the bulk of network cost will come from supplies; the bulk of oil treatment facility will come from equipment).

It may be noted that Russian oil and gas companies are actively implementing and applying cost modeling yet. Most of the companies in one form or another already have standardized cost estimation models [5] and tools [1].

Conclusions

1. Significant changes in the economic, political and geotechnological factors affecting costs encourage oil and gas companies to seek innovative valuation approaches to cost assessment, since the efficiency of estimate calculations is not sufficient.
2. Cost models help to carry out a prompt cost estimate for oil and gas facilities construction taking into account features of a model object and changes in the external environment.

3. Currently, every company is trying to compile and configure a corporate database on its own facilities construction cost; but this does not facilitate comparative analysis and communications with the other oil and gas industry insiders.

4. Thanks to flexibility and efficiency, cost modeling is gaining ground.

References


