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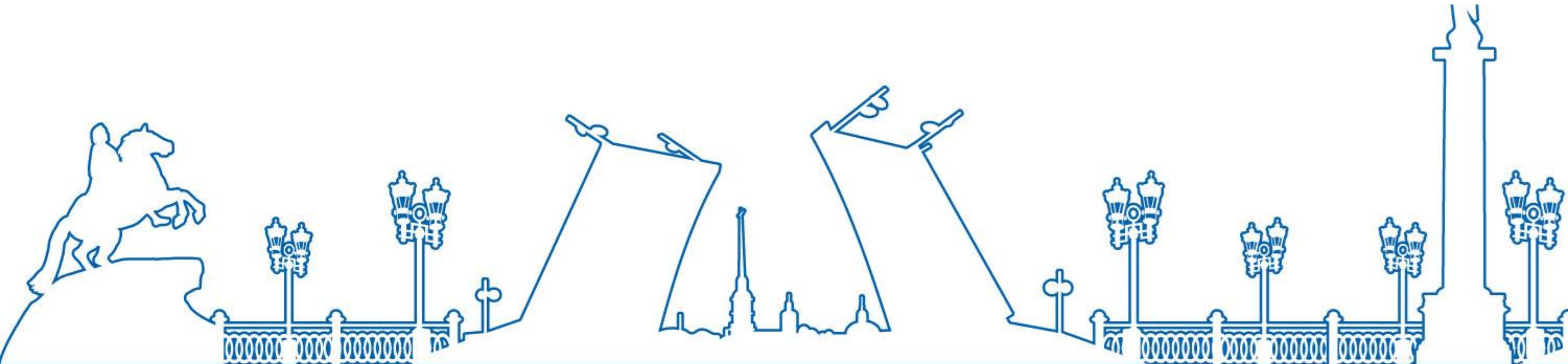
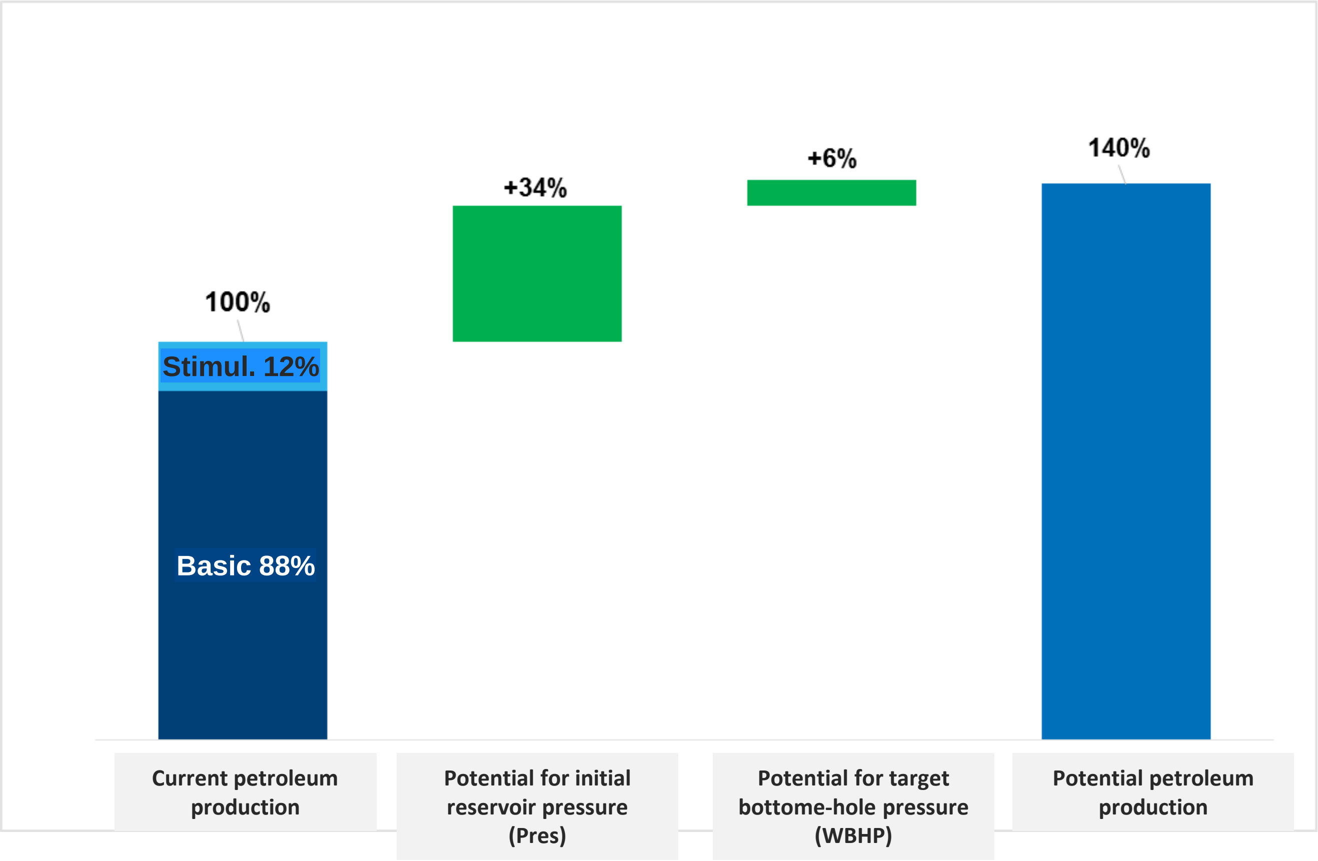
II STRATEGIC CONGRESS 2017

INTEGRATED MANAGEMENT OF OIL AND GAS CONDENSATE FIELDS’ DEVELOPMENT: BEST PRACTICES



SEPTEMBER 26, 2017, SAINT-PETERSBURG, HOTEL ASTORIA

The Company's production structure requires special attention to be given to basic production



The development management potential is significant and requires an integrated approach

Six-component system to be managed

PRODUCTIVITY FACTOR

RESERVOIR PRESSURE

BOTTOM-HOLE PRESSURE

BASIC WELL STOCK IN OPERATION

$$\mathbf{Q}_{н} = \sum_{i=1}^{12} \text{К}_{экс} \cdot \text{СДФ} \cdot \text{К}_{прод} \cdot (\mathbf{P}_{пл} - \mathbf{P}_{заб}) \cdot (\mathbf{1} - \text{обв})$$

WATER CUT

OPERATION FACTOR

OIL PRODUCTION RATE

FLUID PRODUCTION RATE

- An integrated approach is needed for planning, monitoring and control of each of the six components
- Each component is eligible for potential-based planning

Target model for production management

Basic production management

WELL STOCK

Equipment

$P_{bottom\text{-}hole}$ | K_{ex}

Reservoir potential

$P_{reservoir}$ | Prod Index

Methodology and tools

- Reviewing of well stock in operation cost efficiency
- System of working with inactive production well stock
- Well stock planning

- A system of selecting an optimum bottom-hole pressure in producing wells
- Analysis and planning of K_{ex}

- Automated monitoring of current development status
- Factor analysis of basic production deviation
- Parameter planning

Processes and activities

- Activation of inactive well stock
- Shut down of some of the well stock

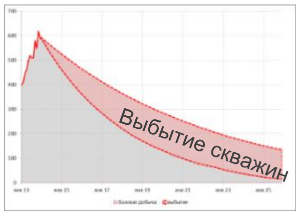
optimization
- Well down time reduction

- Reservoir pressure maintenance system optimization (incl. re-engineering, remedial cementing)
- Restoration of the productivity indexes including accidizing

Goals:

- Make wells, underground equipment and surface infrastructure operate more efficiently
- Reduce per-unit costs
- Realize end-to-end rating of actions to reach the potential

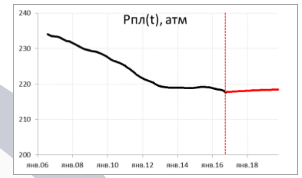
Closed self-consistent parameters calculation



Well stock changes
Production wells are shutting down due to low cost efficiency / high water cut
Conversion to injectors (selected, or specified number))

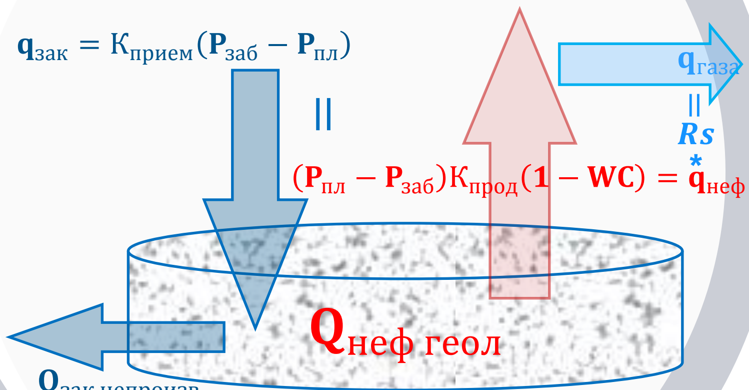
$$\mathbf{Q}_{\text{неф}} = \text{СДФ}_{\text{неф}}\mathbf{q}_{\text{неф}}$$

$$\mathbf{Q}_{\text{зак}} = \text{СДФ}_{\text{наг}}\mathbf{q}_{\text{зак}}$$



reservoir pressure forecast
Material balance equation solving
Self-coordinated indicators of production/injection and reservoir pressure

$$\text{P}_{\text{пл}} = \frac{-Q_{ж.пл.усл.} + W_{зак} + W_{акв}}{c_{эфф} K_{прод}}$$



$$\mathbf{q}_{\text{зак}} = \text{К}_{\text{прием}}(\mathbf{P}_{\text{заб}} - \mathbf{P}_{\text{пл}})$$

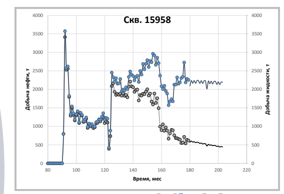
$$\| $$

$$(\mathbf{P}_{\text{пл}} - \mathbf{P}_{\text{заб}})\text{К}_{\text{прод}}(\mathbf{1} - \mathbf{WC}) = \mathbf{q}_{\text{неф}}$$

$$\mathbf{q}_{\text{газа}} = \boldsymbol{Rs} * \mathbf{q}_{\text{неф}}$$

$$\mathbf{Q}_{\text{неф геол}}$$

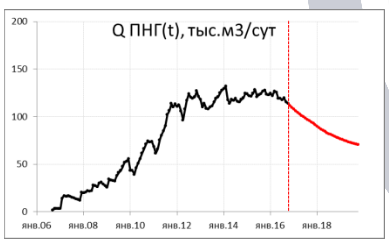
$$\mathbf{Q}_{\text{зак непроизв}}$$



Forecast of fluid production and injection
Calculation of production rates of fluid /injection based on productivity factors
bottom-hole pressure is assumed to be constant

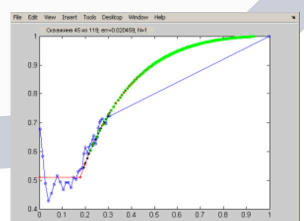
$$\mathbf{q}_{\text{ждк}} = \text{К}_{\text{прод}}(\mathbf{P}_{\text{пл}} - \mathbf{P}_{\text{заб}})$$

$$\mathbf{q}_{\text{зак}} = \text{К}_{\text{прием}}(\mathbf{P}_{\text{заб}} - \mathbf{P}_{\text{пл}})$$



Associated gas production calculation
Using PVT model at the designed reservoir pressure

$$\mathbf{q}_{\text{ПНГ}} = \mathbf{q}_{\text{неф}}\boldsymbol{R_s}(\text{Рпл; ОИЗ})$$

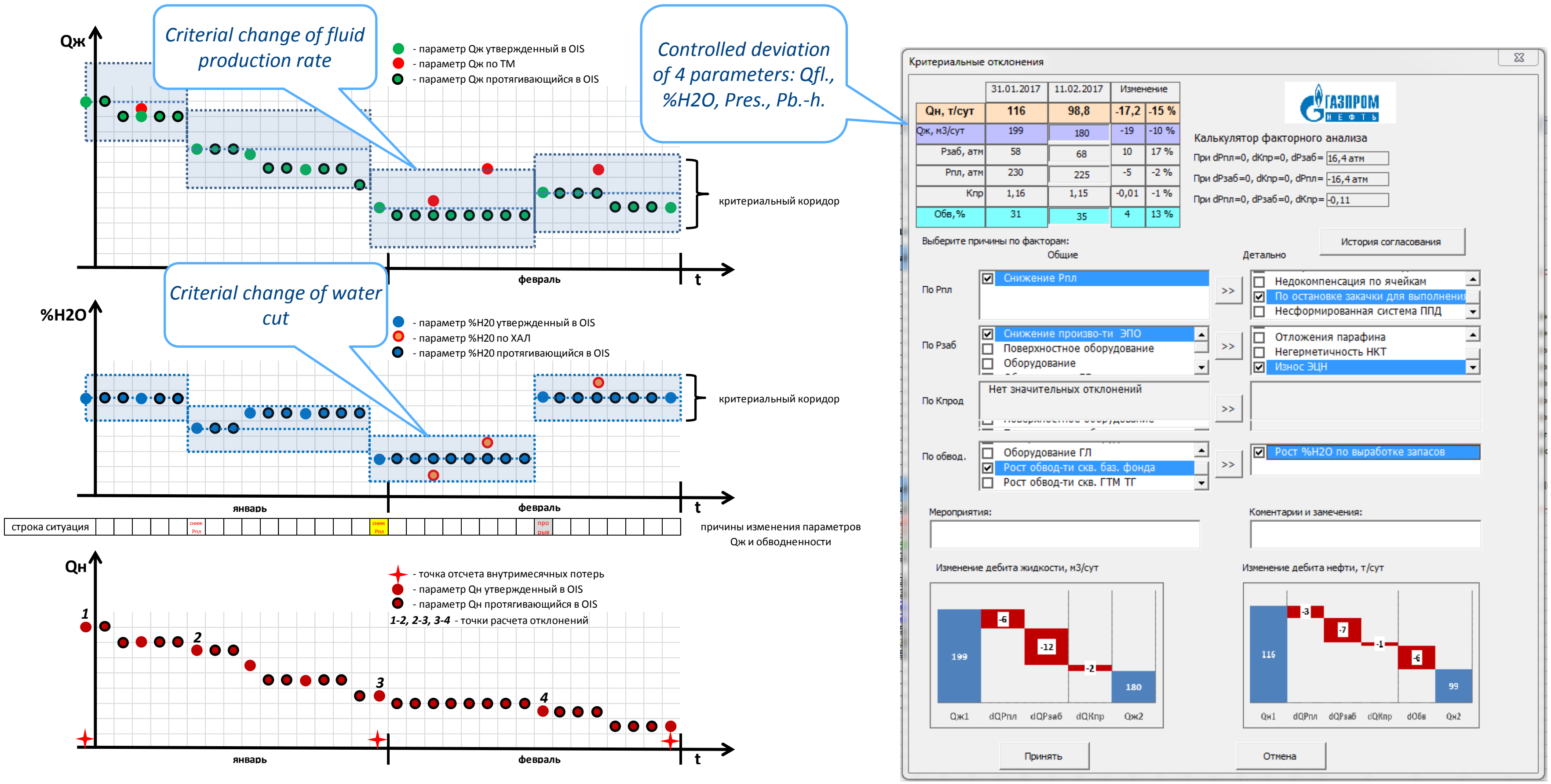


Oil production calculation
Using displacement efficiency, production rate of fluid and current recoverable reserves

$$\mathbf{q}_{\text{неф}} = \mathbf{q}_{\text{ждк}}(\mathbf{1} - \boldsymbol{WC})$$

$$\boldsymbol{WC} = f(\text{ОИЗ})$$

Verification and data QC during initial data loading



During data loading into OIS system it is necessary to specify the reason of change if the loaded value is out of given range

Digitalization.
Data science for verification of geology and well performance data

Project goal: automatization of uploading, verification and analysis of large data arrays using machine learning algorithms to make production decisions quicker and more efficient

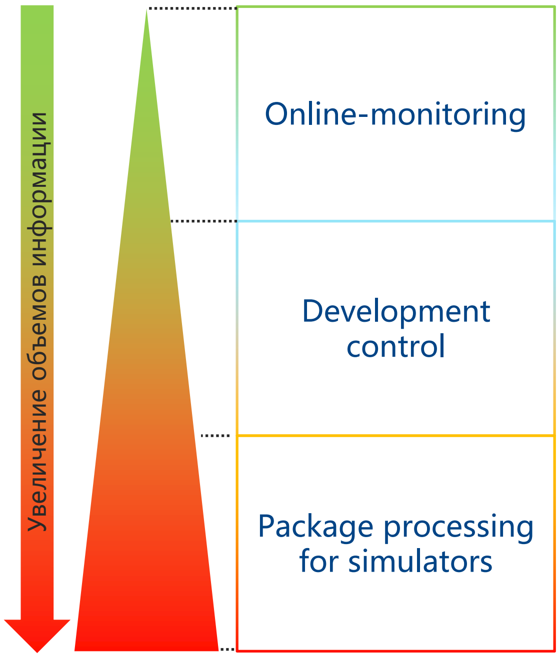
Data for analysis

- Production history
- Telemetry
- Porosity and permeability properties of the reservoir
- Logging
- Field research
- Geological maps

Data analysis module

Data filtering	machine learning	Mutual influence maps

Data refinement based on deterministic models



Main (expected) effects

- Labor to be reduced by more than 20 man-years
- Deterministic models to become of a higher quality

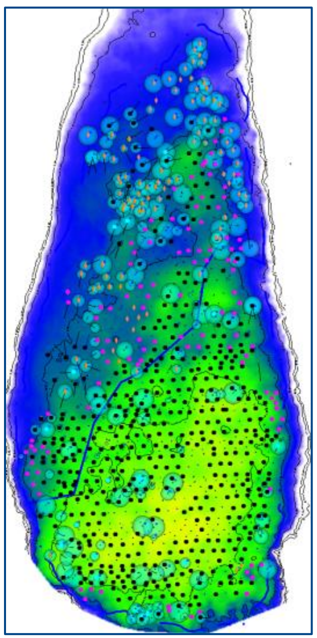
Technology partners

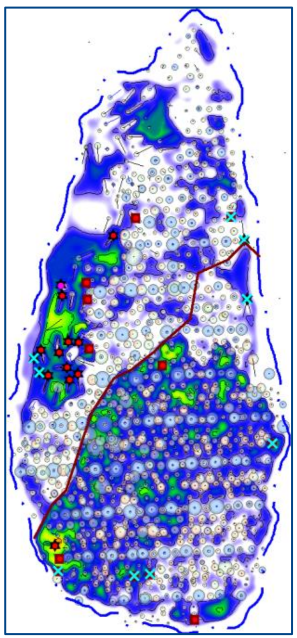
MIPT CENTER FOR ENGINEERING AND TECHNOLOGY

Reserves verification example

Stage 1:

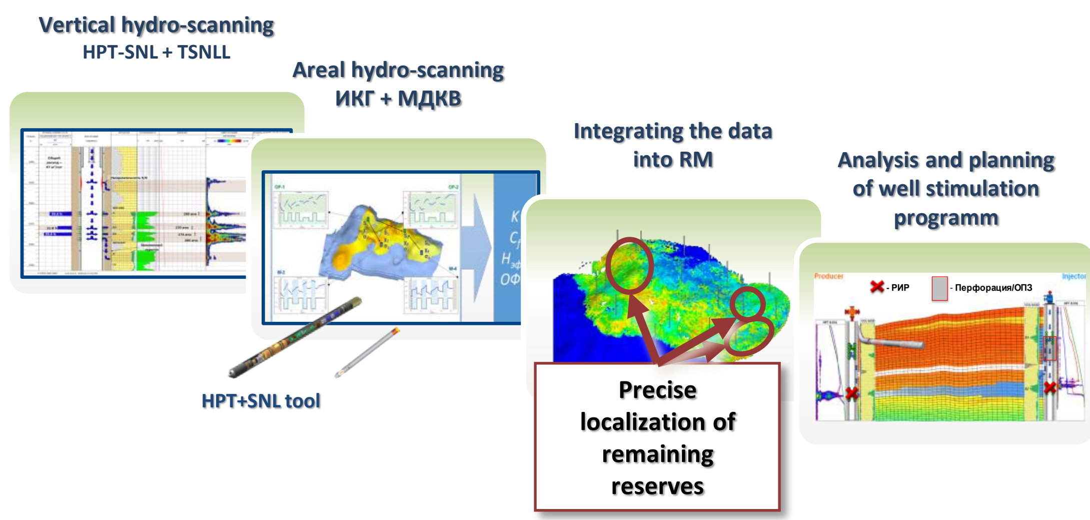
- STOIIP verification, estimation of the sweep efficiency
- Risk maps construction
- Preparation and realization of the activities in order to prove localized remaining recoverable reserves





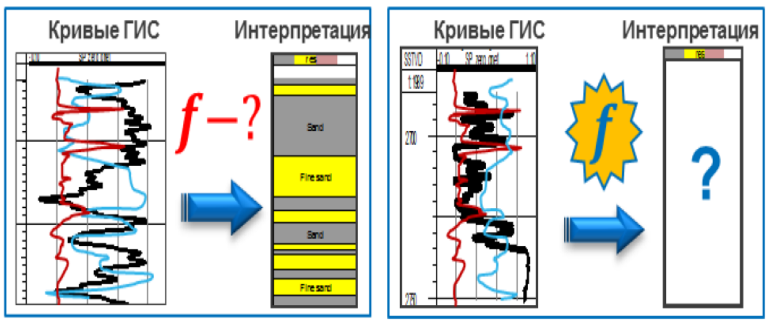
Stage 2:

- Vertical and areal hydroscanning using reference well grid
- Integration of collected data into the reservoir model and precise localization of remaining recoverable reserves
- Planning and implementation of well stimulation programm



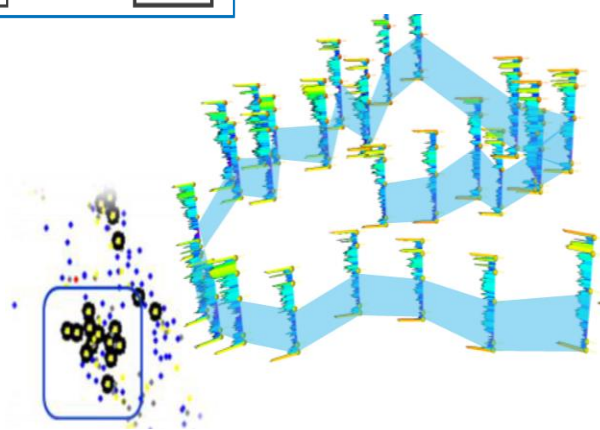
Digitalization.
The search for missed reservoir intervals

Project goal: missed reservoir intervals localization in the cross-section by using modern machine learning algorithms to analyze results of geological and geophysical studies and field production data



Analysis of well logging data and search for productive intervals

Reservoir prediction



Main (expected) effects

- Increase of reserves in the assets of production
- Up to 1 million tons of extra production by 2025

Technology partners

IBM

Models hierarchy for automated development control

Development element

- Shakhmatka-Tekhrezhim / Mekhfond information systemS
- Factor analysis
- AvtoControl Razrabotki information system

Waterflooding element

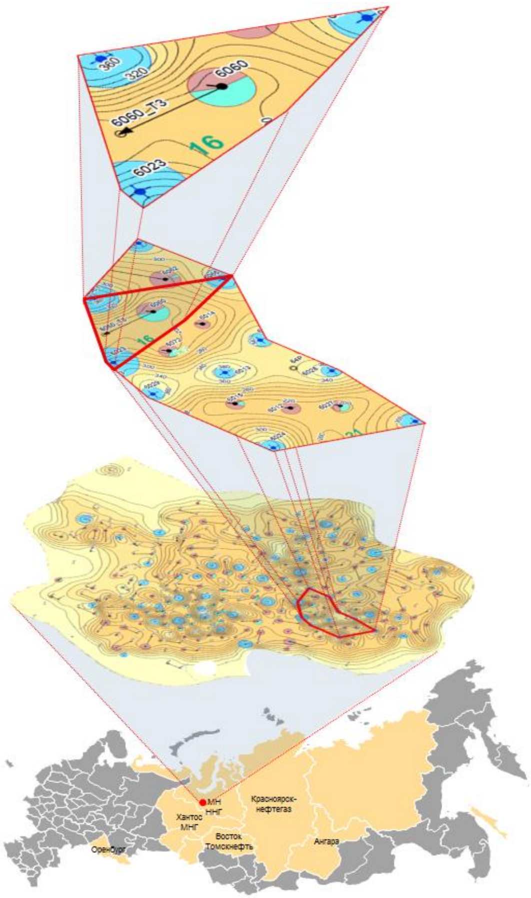
- Block-factor analysis
- Sector 3D hydrodynamic models

Development target

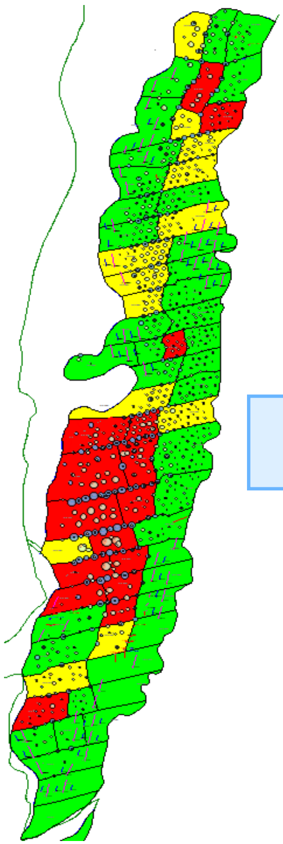
- Proxy-model
- 3D simulation model

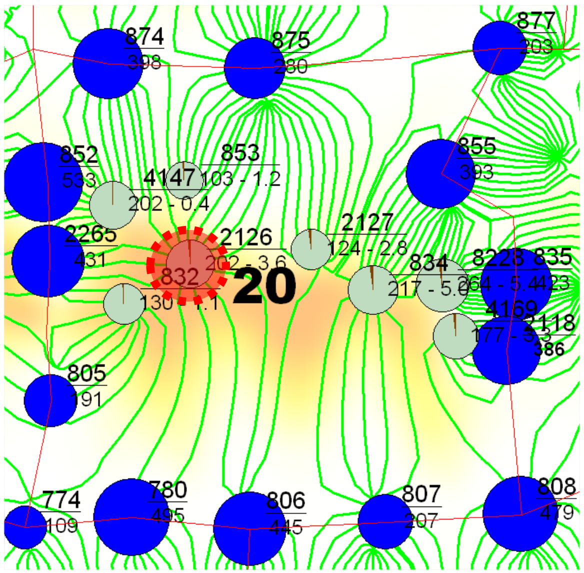
Assets / fields

- Benchmarking tools

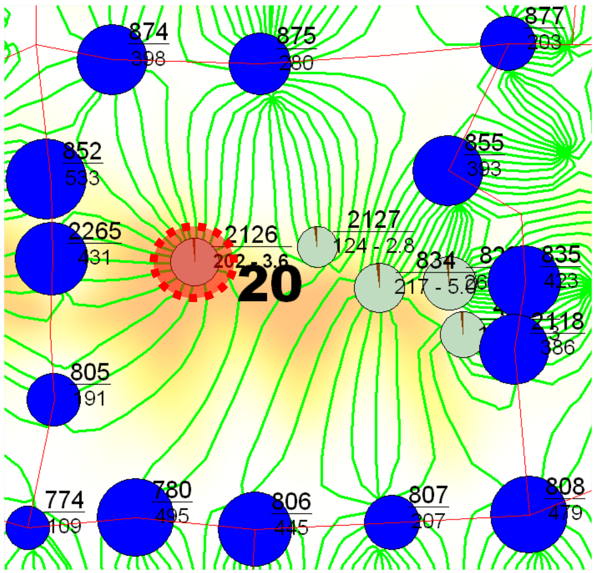


Waterflooding management modeling example





Wells with high water cut # 853, # 4147 и # 832 do not allow displacement front to move towards well #2126

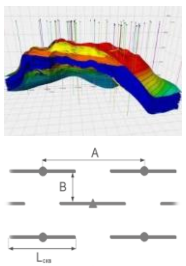


Wells # 853, # 4147 and # 832 are shut down. Oil production level stabilized, and fluid production and injection volumes reduced in the element of developement

Results

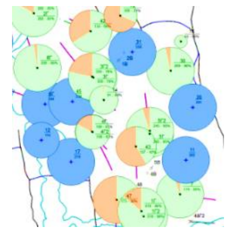
- Oil production increment: **1,800 t**
- Water injection volumes reduction: **255,000 m³**

Reservoir management tools developement
Creation of optimization algotithms



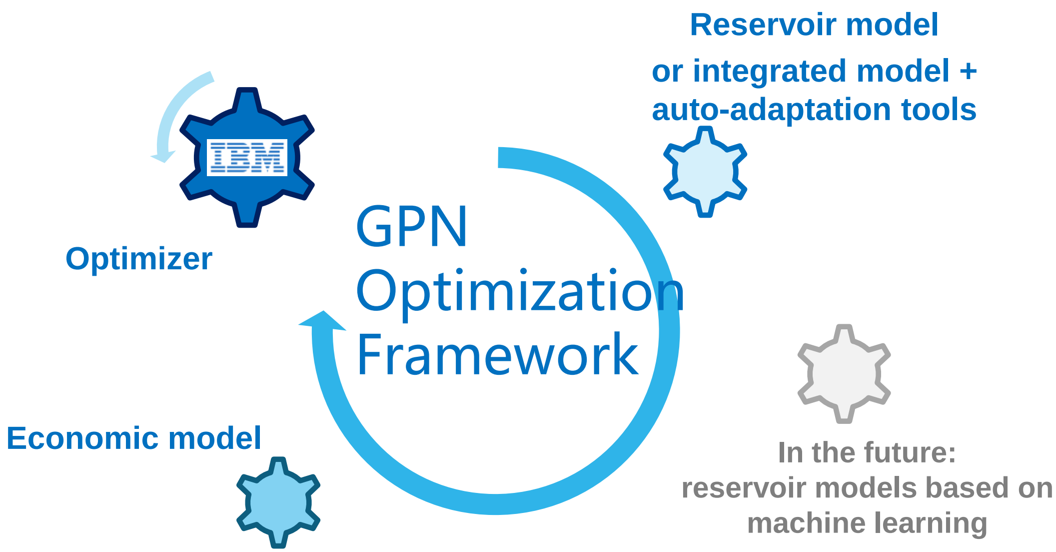
New assets

Selection of the optimal development system



Mature assets

Waterflooding management



+10 % NPV

+1 % RF

Effect from implementation in new assets

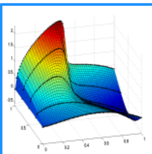
+1 %

Production increment for current assets within 3-5 years future

Digitalization.
Metamodelling of the well inflow in the development element

Project goal: Optimization of the development system with a help of reservoir inflows modeling in the development element using machine learning methods, numeric modeling for operational control tasks and reservoir management

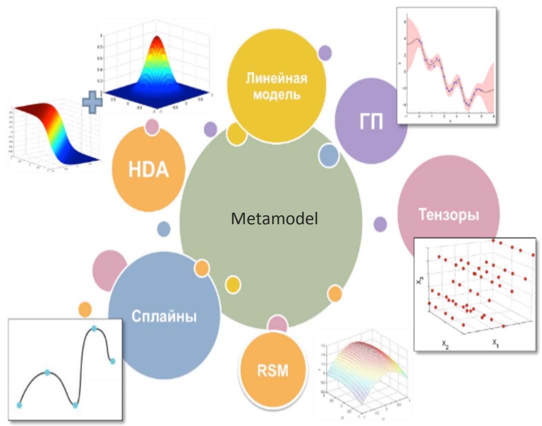
Data for analysis
- PVT-properties
- Relative permeability
- Capillary pressure curves
- Porosity and permeability distribution
- Initial distribution of pressure, water, oil and gas saturations



Surrogate model

Data filtering	Target function	Machine learning

Optimization of the development system



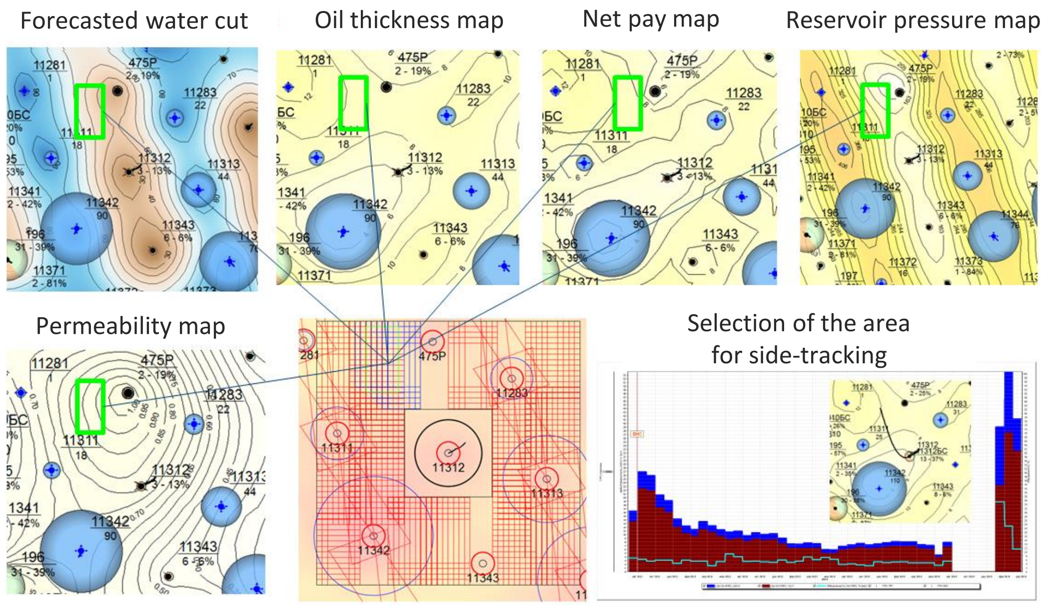
Synonyms: surrogate model, proxy model, hybrid model

Main (expected) effects
- Reduction of errors in identifying reservoir problems by 2%
- Making hydrodynamic calculation faster 10 times and more

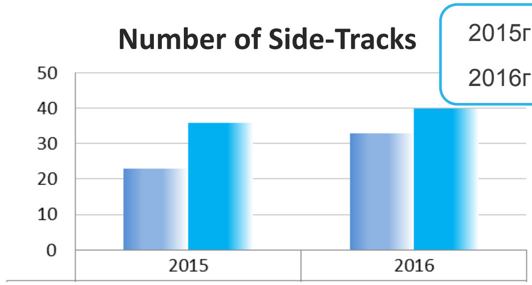
Technology partners
SkTECH
SKOLKOVO INSTITUTE OF SCIENCE AND TECHNOLOGY

Introduction of the Automated Selection of Well Interventions information system

Algorithms for calculation and selection of candidates for hydraulic fracturing

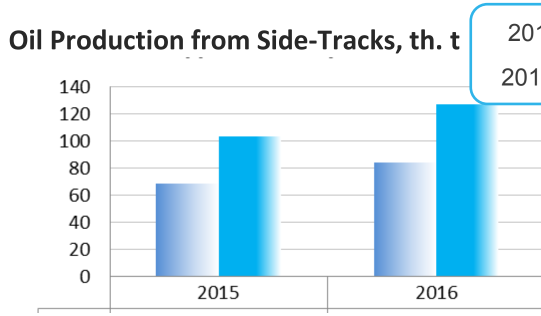


Business effect



2015г +56% to 2014

2016г +11% to 2015



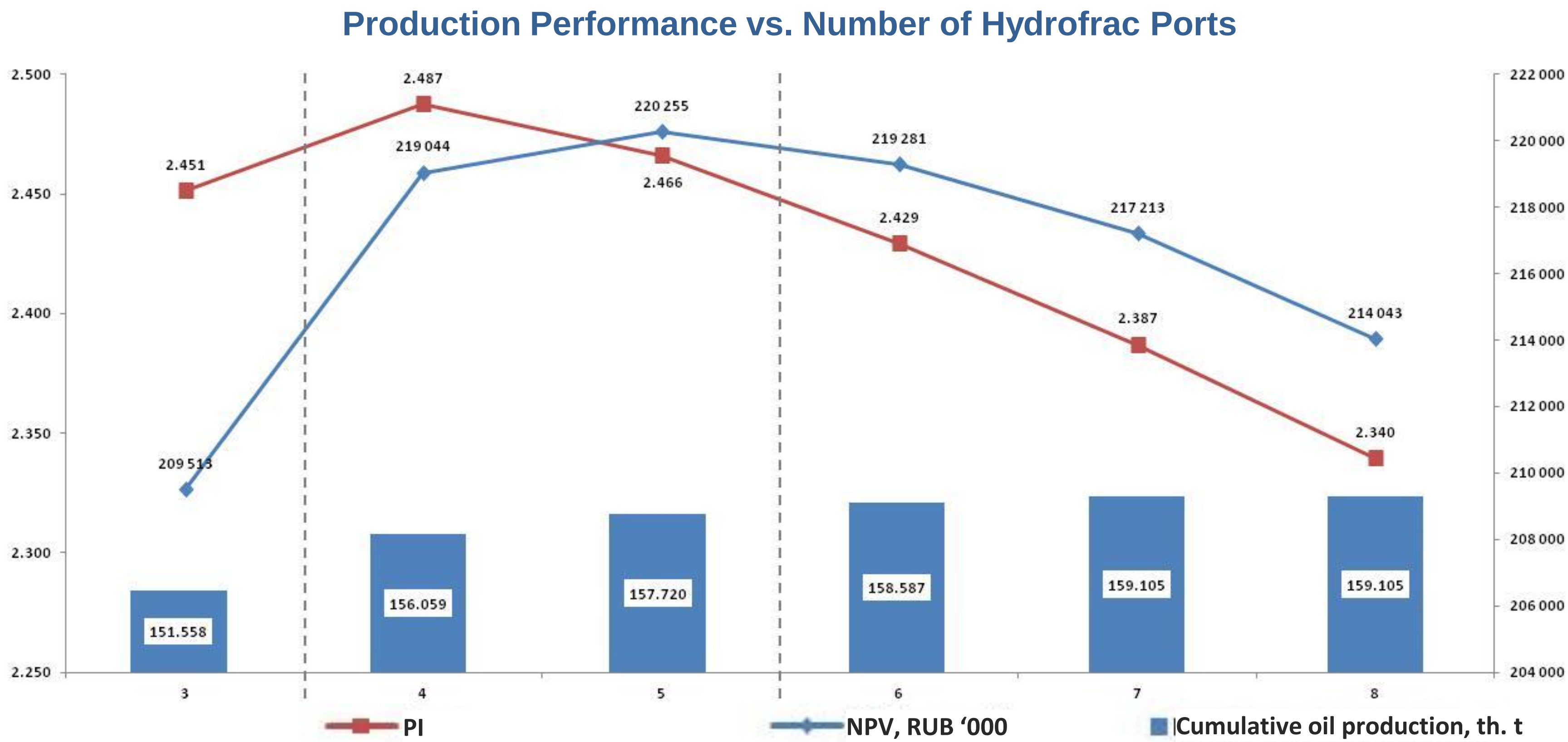
2015г +52% to 2014

2016г +22% to 2015

Result of implementation the Well Stimulation Selection tool:

- ✓ Estimation of the well potential and increasing of well stimulations operations
- ✓ Stimulation candidates rating: selection of the best candidates for the well stimulation program

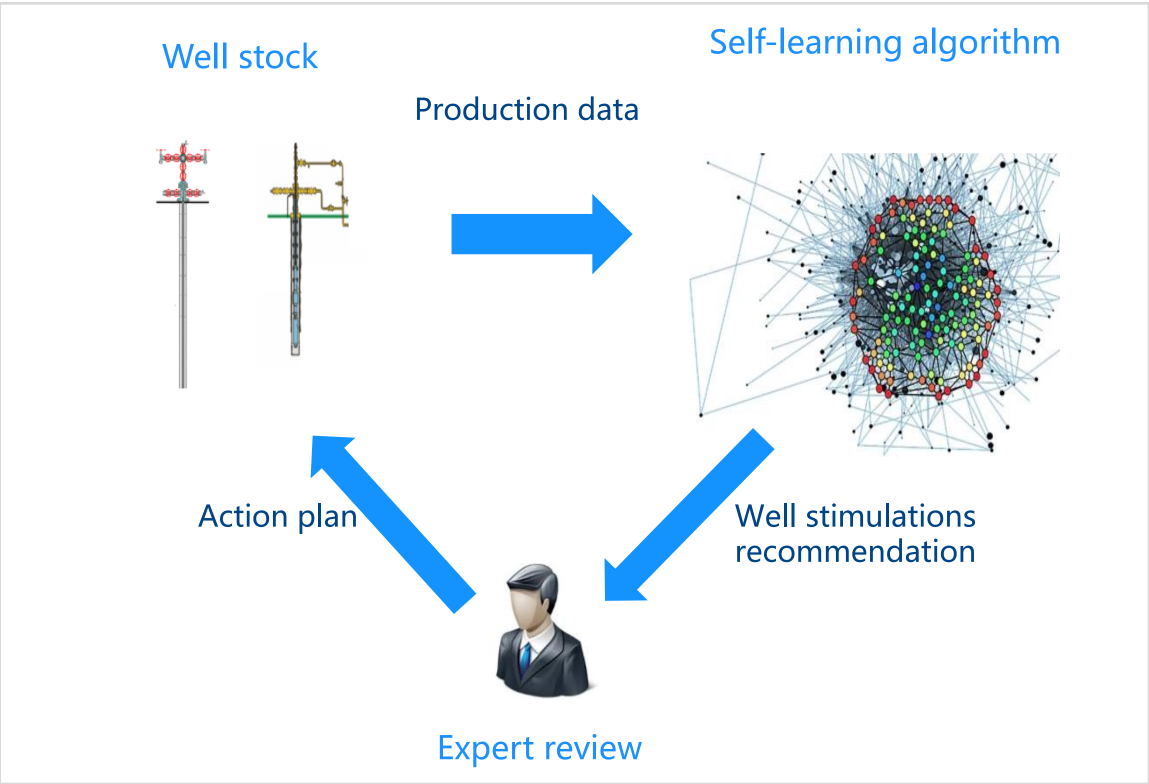
The example of multi-stage hydrofracturing horizontal well design optimization



Optimal design for the low permeable reservoirs
3mD – 150 m/frac, 1mD – 100 m/frac

Machine learning in interpretation of the study results

Project goal: decreasing of well downtime and increasing of geotechnical operations efficiency due to automatization of well data analysis based on self-learning algorithm and fewer number of active experiments



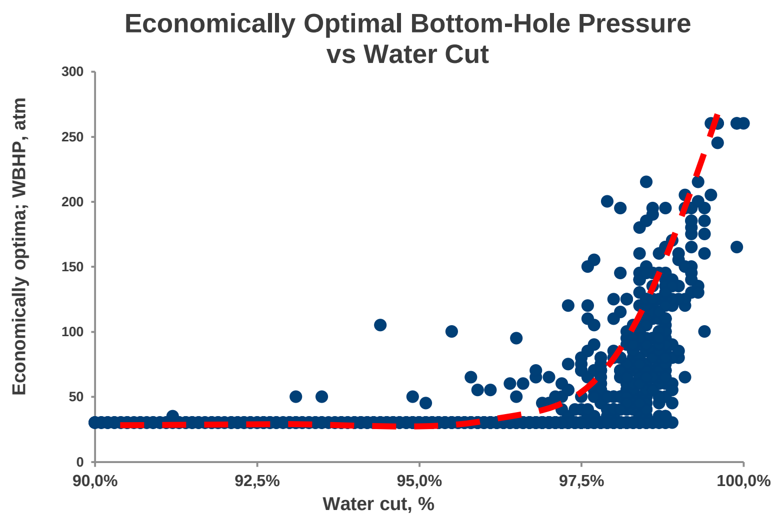
Main (expected) effects

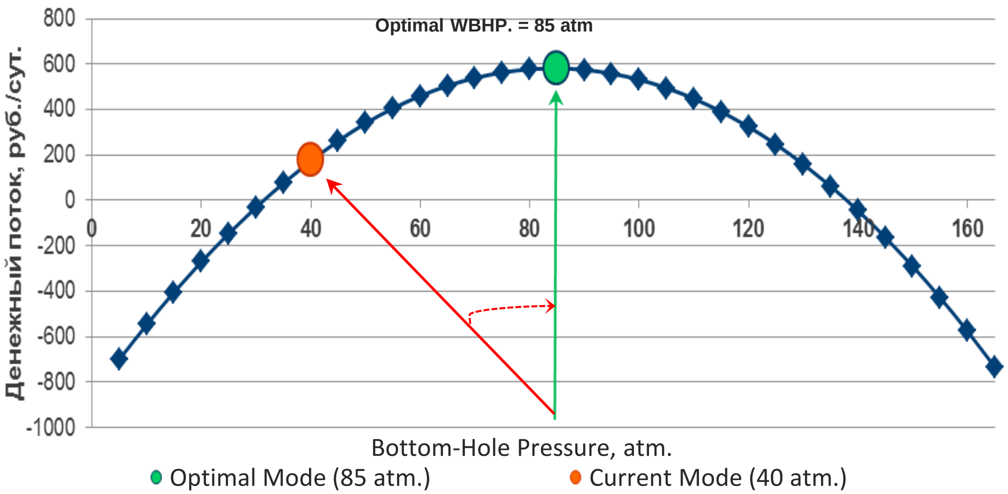
- Savings of RUB 200 mln. per year
- Increasing of well test coverage from 20-30% to 100%

Technology partners

Increasing of the profitability from artificial lift well stock

Well Profitability Assessment for Various Production Modes

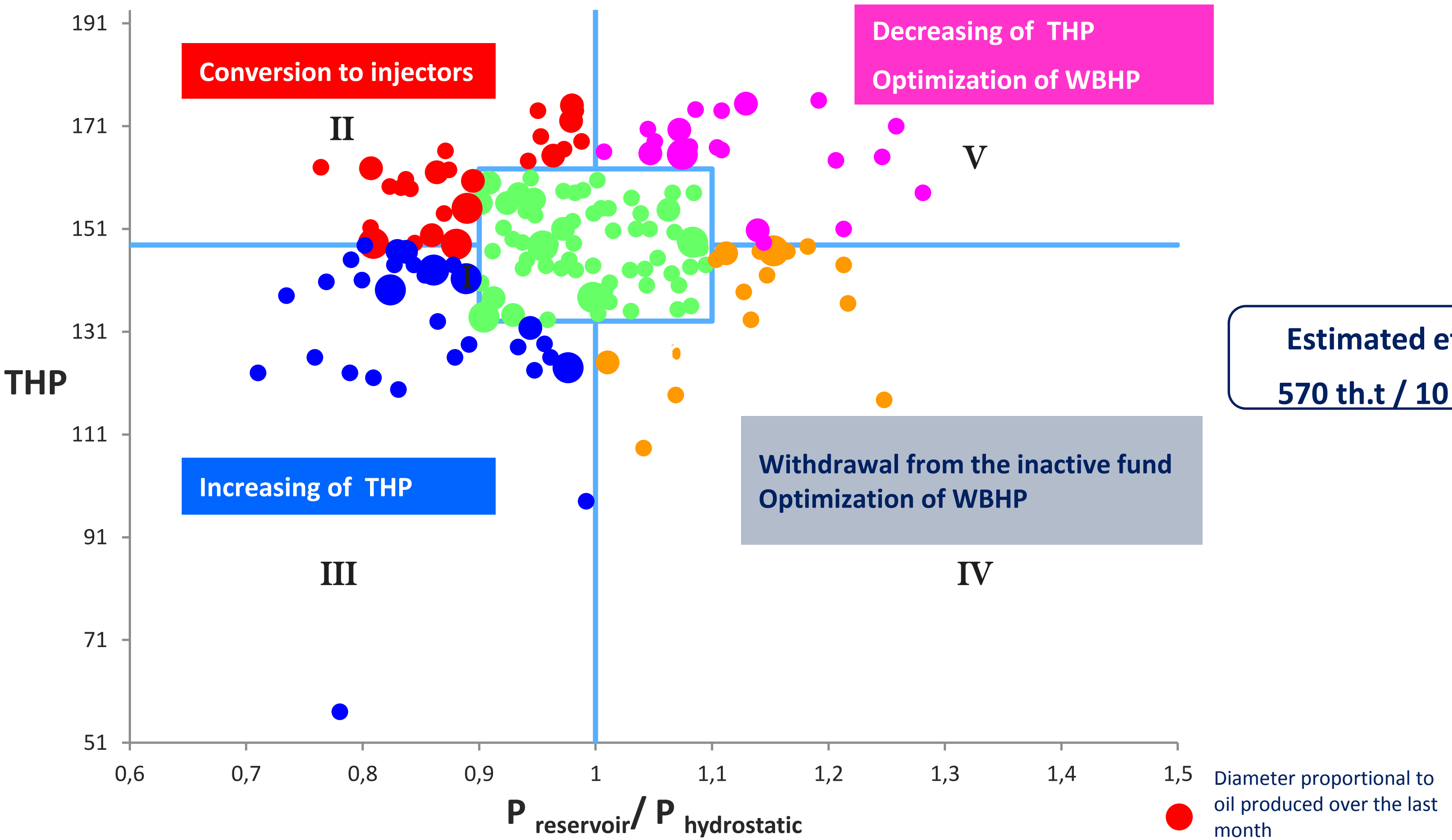




Calculation of the key profitability model parameters is automated :

- ✓ The forecast of oil production, water cut and rates of depletion is dependent on bottom-hole pressure
- ✓ Electric power consumption
- ✓ Anticipated average time before failure
- ✓ ESP selection
- ✓ OPEX, REVEX, CF, NPV

Example of reengineering of the surface facilities system



Estimated effect:

570 th.t / 10 years

Conclusions

1. A sufficient set of tools has been accumulated for the integrated management of the production from mature fields
2. The hierarchy of approaches allows to maintain a balance between the detail of models and the speed of decision-making
3. The existing potential for the production from mature fields is concentrated in the continuation of the integration of the value chain tools
4. A breakthrough in the development of methods and algorithms for integrated development management is concentrated in the areas of usage of machine learning methods and big data science
5. The trend towards digitalization makes new demands on the role of the engineer: from performing usual operations to the system integrator-analyst