Integrated Production Modelling in function of Full Field Optimization Programme

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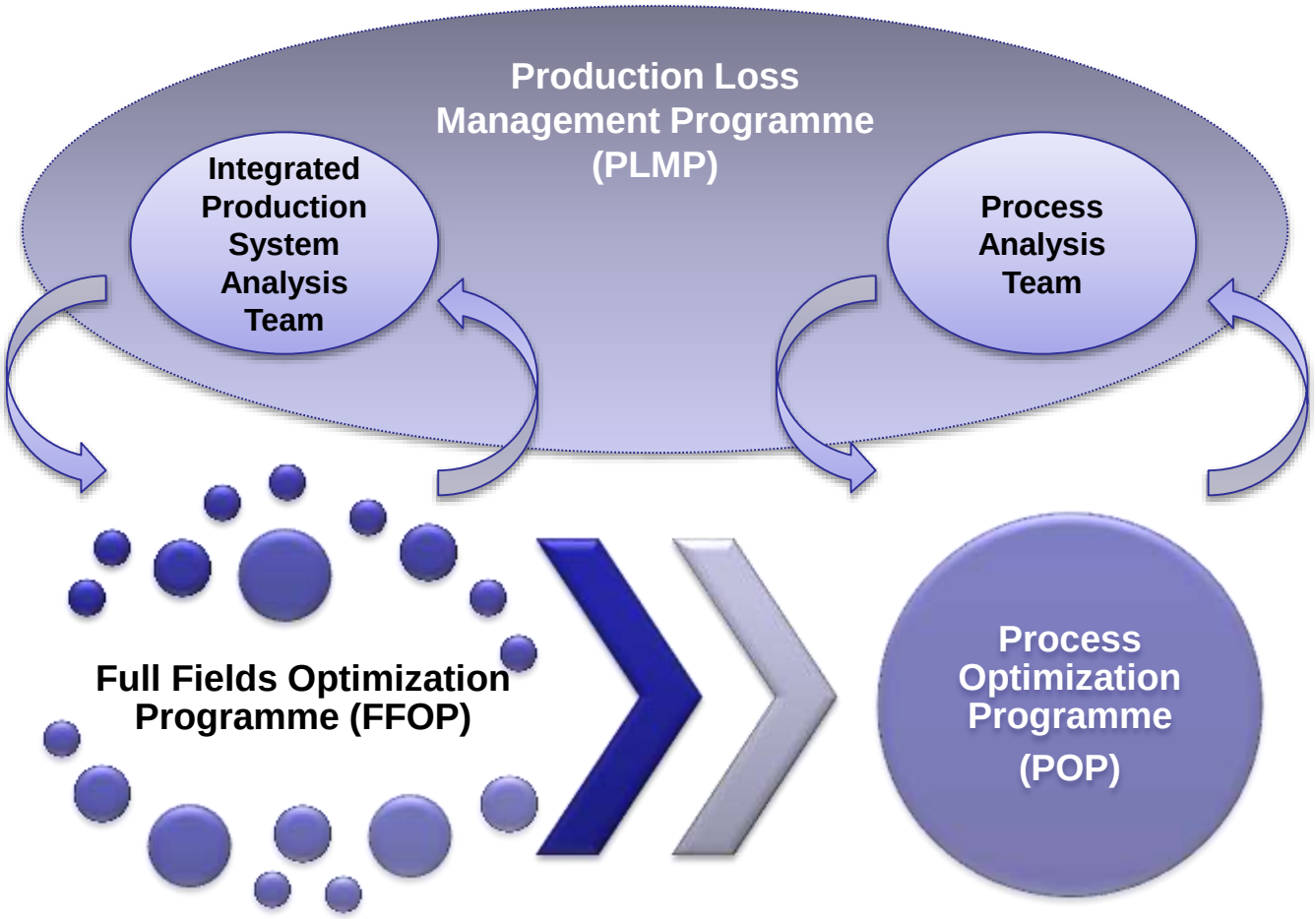
INA Production Optimization Concept



INA Production Optimization Concept

Full Field Optimization Programme

- Reservoir Performance Improvement
- Well Performance Improvement
  - Inflow Performance (Stimulations, Sand Control)
  - Vertical Lift Performance (Artificial Lift Optimization, Velocity String installation, WH Pressure manipulation)
  - Flow Assurance (Wax, Scale, Corrosion inhibition improvement)
- Pipeline Network Performance Improvement
  - Flow Assurance (Smart Pig, Wax, Scale, Corrosion inhibition improvement)
  - Reconstruction due to performance improvement
- Facility Performance Improvement
- Integrated Production System Computer Models - Maximum system production potential determination

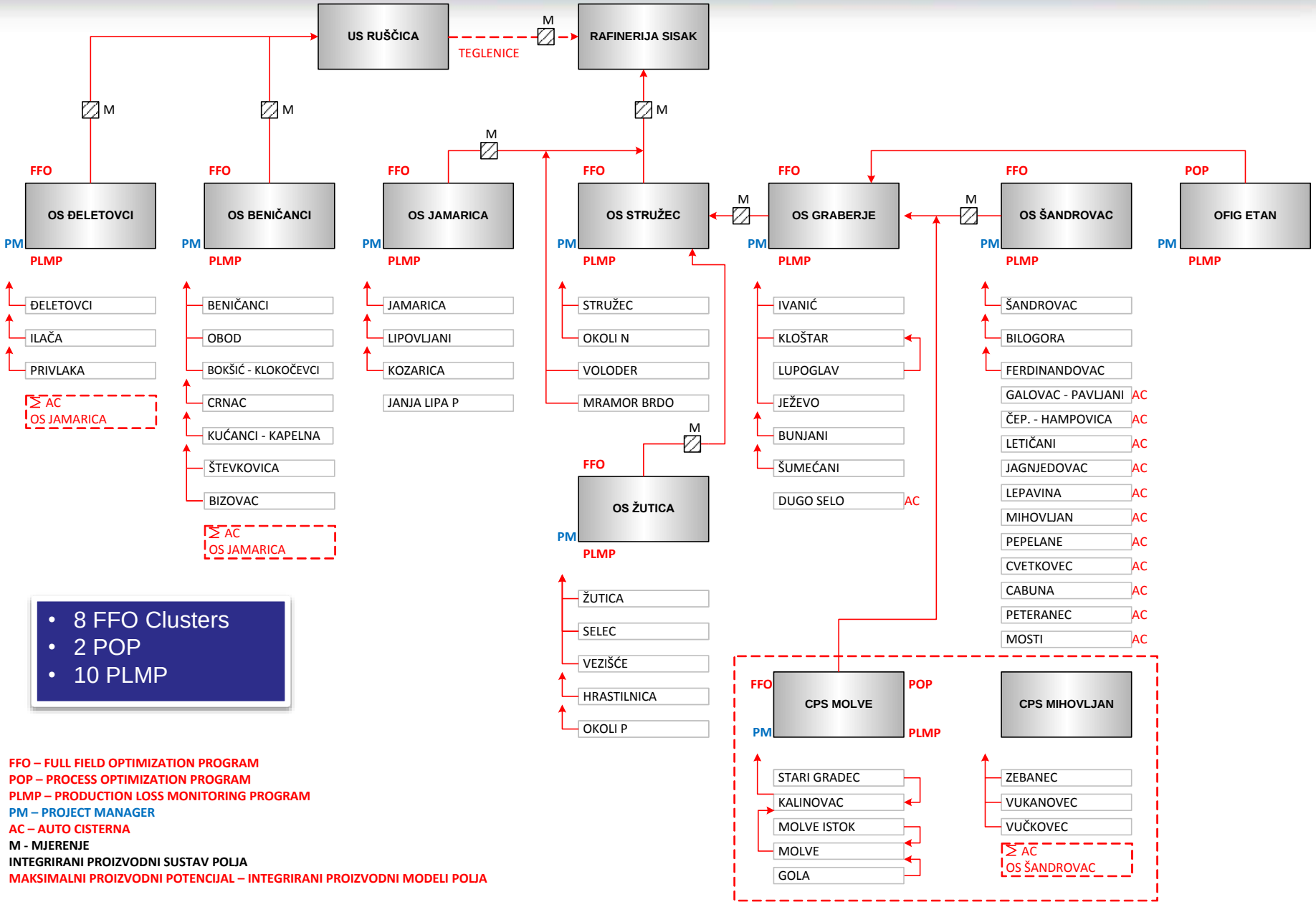
Process Optimization Programme

- During the oil/gas field lifecycle, all parameters in the produced wellstream change; composition, flow, pressure, temperature….
- Process plants require constant modificationd in order to meet the new characterics of the feed.
- Inlet separation – review of the plant metallurgy/corriosion performance, separator sizing, pressure/temperature of operation.
- Gas compression – constant adjustment of compression plant capacity. Intention to build the compressors only when needed, not too much in advance. Use of existing compressor machines. Relocation from a depleted field to a new location. Re-use and re-engineering of the existing equipment.
- Gas sweetening. Update of the sweetening technology, plant revamps in order to achieve lower energy consumption and other benefits of the change of sweetening technology. Meeting the new feed requirements - general trend of increase of sour gasses content in the produced gas.
- NGL recovery and fractionation. Rereview of NGL plant operation modes and maximizing the profit from NGL.
- Utilities – optimization of cogeneration plants' operation; balancing the production of el. power and heat.

Production Loss Management Programme

- Maximum system production potential determination from Integrated System Computer Models
- Actual production is to be monitored and any gap between actual production and the potential becomes loss (Production data monitoring, capturing and recording to be improved for better system surveillance)
- Losses must be recorded, classified and losses also must be allocated back to wells as it is done for production allocation.
- Production efficiency & Operational efficiency determination
- Management process : a) Capture loss event, b) Validate, Quantify & Classify event, c) Investigate the loss event, d) Review and Action
- To facilitate the prioritization of action list, it is necessary to evaluate the loss in terms of HSE impact, financial / commercial impact, volume impact and any cost in performing maintenance /work-over operations
- Daily Loss report, Weekly Loss status report, Weekly Loss KPI report
- Repeated maximum system production potential determination (System Analysis)

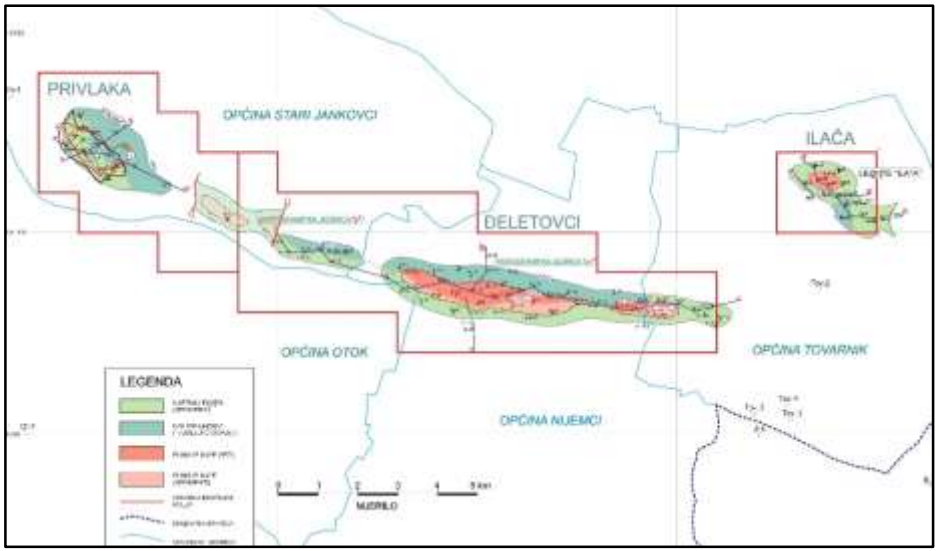
INA Cluster (Technological Unit) Schematics



- 8 FFO Clusters
- 2 POP
- 10 PLMP

FFO – FULL FIELD OPTIMIZATION PROGRAM
POP – PROCESS OPTIMIZATION PROGRAM
PLMP – PRODUCTION LOSS MONITORING PROGRAM
PM – PROJECT MANAGER
AC – AUTO CISTERNA
M - MJERENJE
INTEGRIRANI PROIZVODNI SUSTAV POLJA
MAKSIMALNI PROIZVODNI POTENCIJAL – INTEGRIRANI PROIZVODNI MODELI POLJA

Scope of FFO Programme Đeletovci Cluster

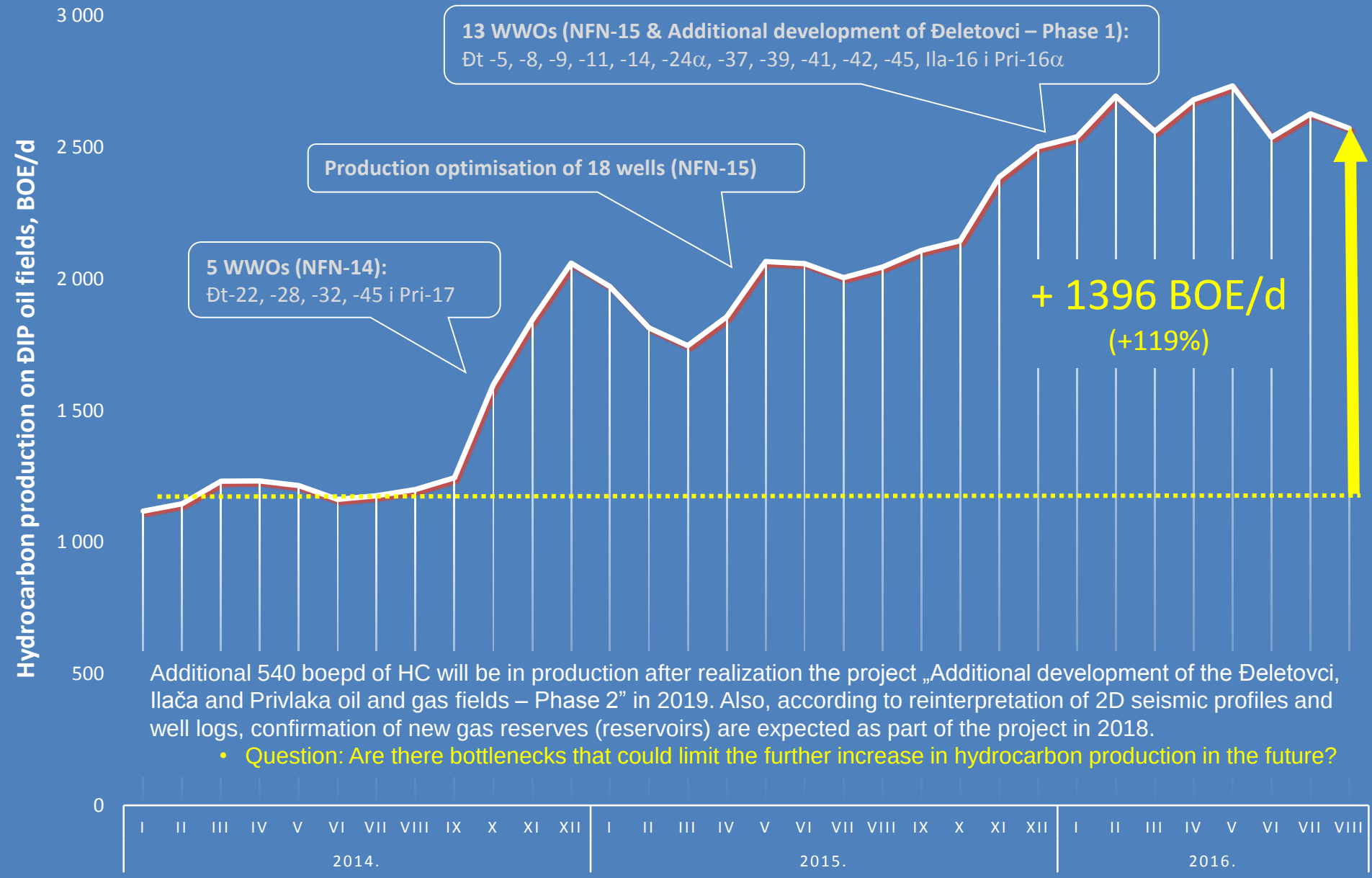


Oil field Ilača	
Number of hydrodynamic units	2 (1 depleted)
Start of production	1984.
Number of producing wells	5 (93 boepd)
OOIP / RFc	1 Mm3 / 26%
Initial / current reservoir pressure	110 bar / 53 bar
Current WC & GOR	38% & 168 m3/m3
Artificial Lift	Sucker-rod lift
Dominant drive mechanism/s	Gas cap + depletion

Oil field Privlaka	
Number of hydrodynamic units	5 (2 inactive)
Start of production	1984.
Number of producing wells	11 (579 boepd)
OOIP / RFc	3,8 Mm3 / 27,3%
Initial / current reservoir pressure	76-101 bar / 76-96 bar
Current WC & GOR	61% & 57 m3/m3
Artificial Lift	Sucker-rod lift
Dominant drive mechanism/s	Bottom or edge water

Oil field Đeletovci	
Number of hydrodynamic units	2 (1 depleted)
Start of production	1984.
Number of producing wells	26 (1900 boepd)
OOIP / RFc	6,2 Mm3 / 46,6%
Initial / current reservoir pressure	103 bar / 88 bar
Current WC & GOR	32% & 53 m3/m3
Artificial Lift	Sucker-rod lift
Dominant drive mechanism/s	Bottom water

Goal of Programme Đeletovci Cluster

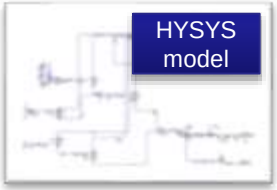


Additional 540 boepd of HC will be in production after realization the project „Additional development of the Đeletovci, Ilača and Privlaka oil and gas fields – Phase 2" in 2019. Also, according to reinterpretation of 2D seismic profiles and well logs, confirmation of new gas reserves (reservoirs) are expected as part of the project in 2018.

- Question: Are there bottlenecks that could limit the further increase in hydrocarbon production in the future?

Integrated Production System Model – Đeletovci Cluster

FFOP - Integrated approach based on fields cluster (technological units) nodal analysis



- Production System Potential Determination present / future
- Production Optimization – Bottlenecks Shooting;
- Production Allocation (Production Loss Mng. P.);

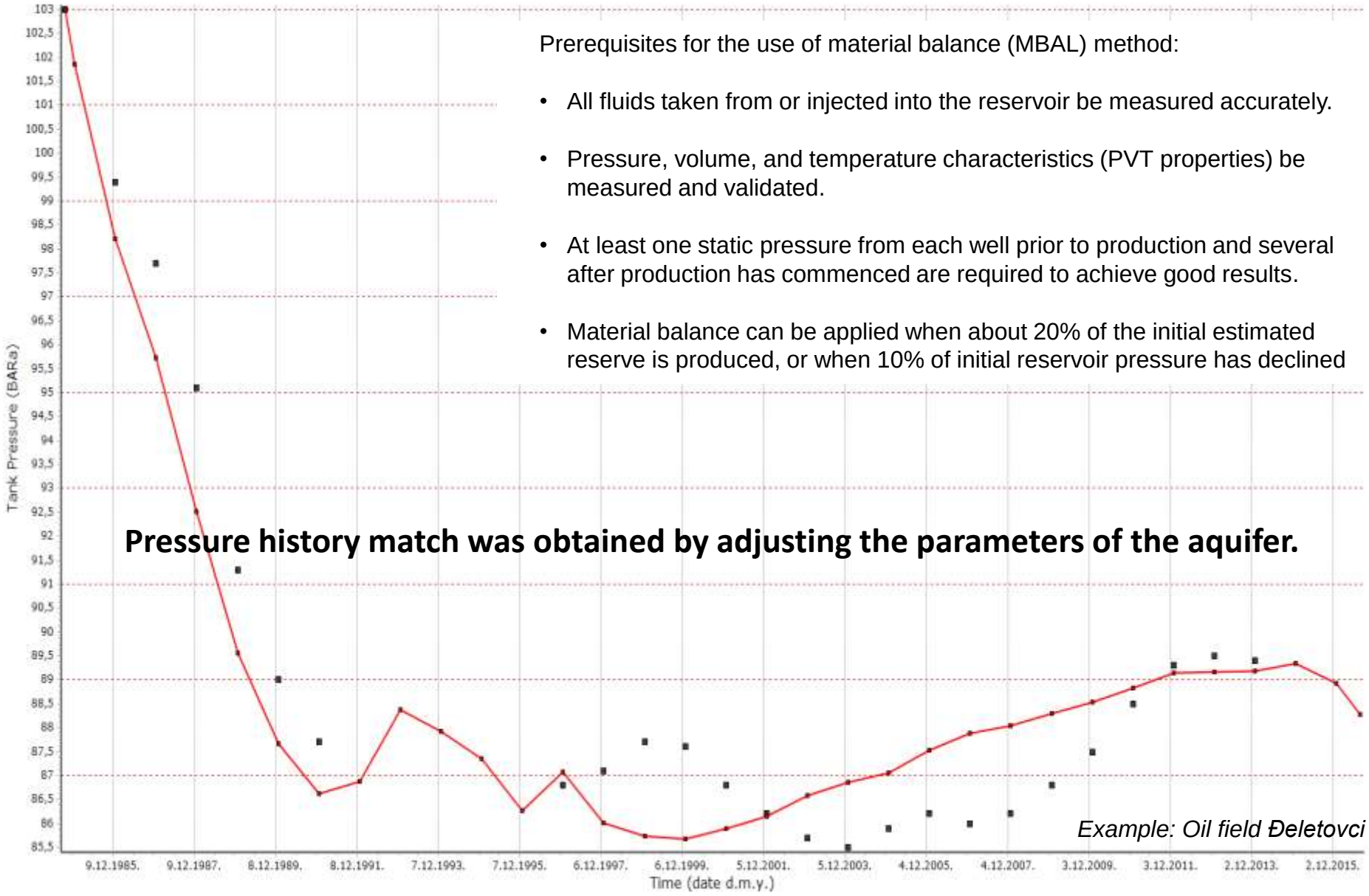
Reservoir - MBAL		HISTORY MATCHED, DECLINE
Wells Prosper	IPR	VOGEL, MULTIRATE JONES/VOGEL
	VLP	PETROLEUM EXPERTS I; II; III
GatheringSys - GAP		PETROLEUM EXPERTS V, Brill (slugs)

Fluid	31.7.2016.	IPM	Diff
Ql (m^3/d)	680,5	692,1	2,7%
Qo (m^3/d)	387,0	400,0	3,2%
Qw (m^3/d)	311,7	292,1	6,7%
Qg (m^3/d)	18 000	18 992	5,3%

Reservoir description

Prerequisites for the use of material balance (MBAL) method:

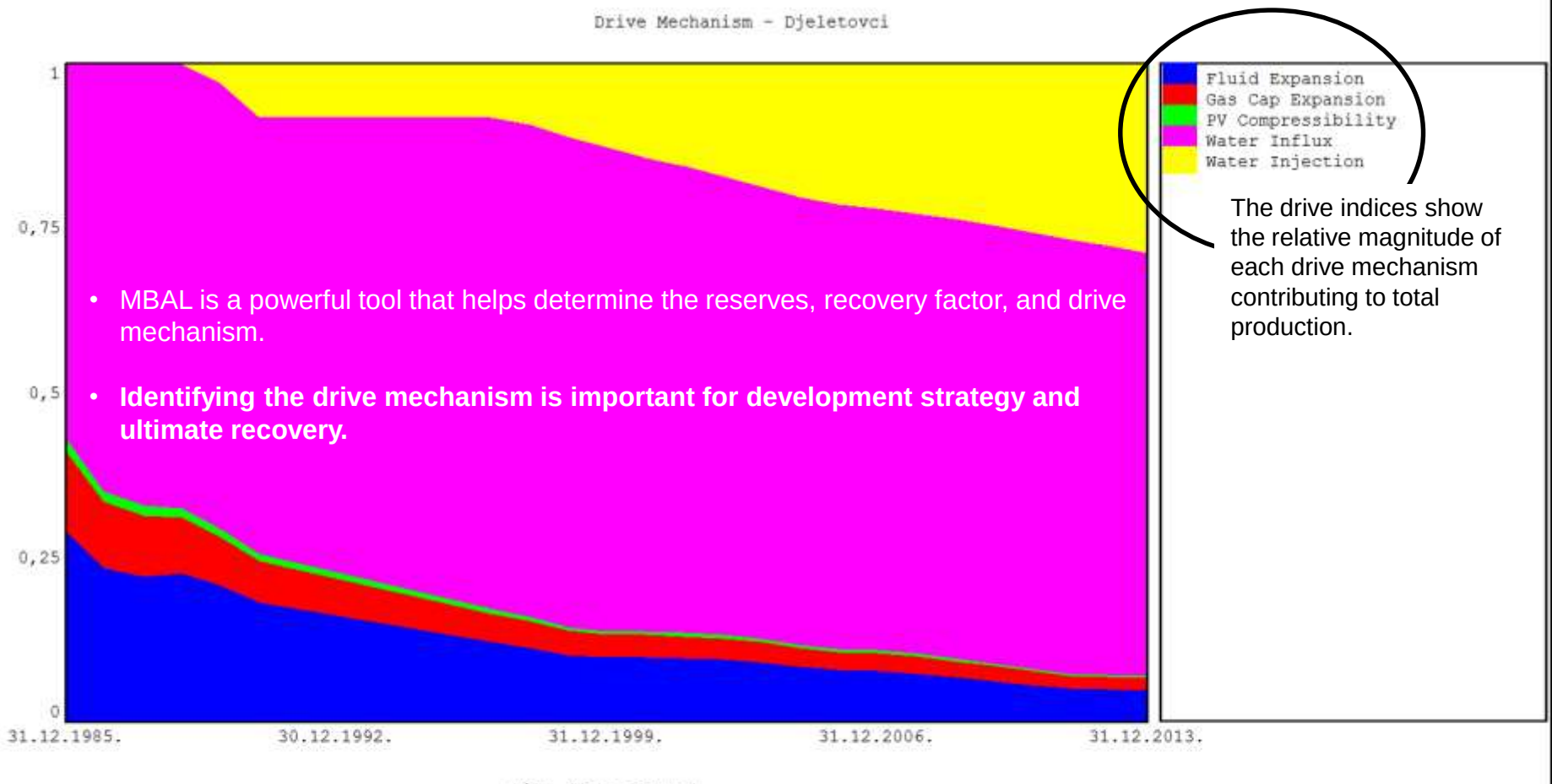
- All fluids taken from or injected into the reservoir be measured accurately.
- Pressure, volume, and temperature characteristics (PVT properties) be measured and validated.
- At least one static pressure from each well prior to production and several after production has commenced are required to achieve good results.
- Material balance can be applied when about 20% of the initial estimated reserve is produced, or when 10% of initial reservoir pressure has declined



Pressure history match was obtained by adjusting the parameters of the aquifer.

Example: Oil field Đeletovci

Reservoir description



- MBAL is a powerful tool that helps determine the reserves, recovery factor, and drive mechanism.
- **Identifying the drive mechanism is important for development strategy and ultimate recovery.**

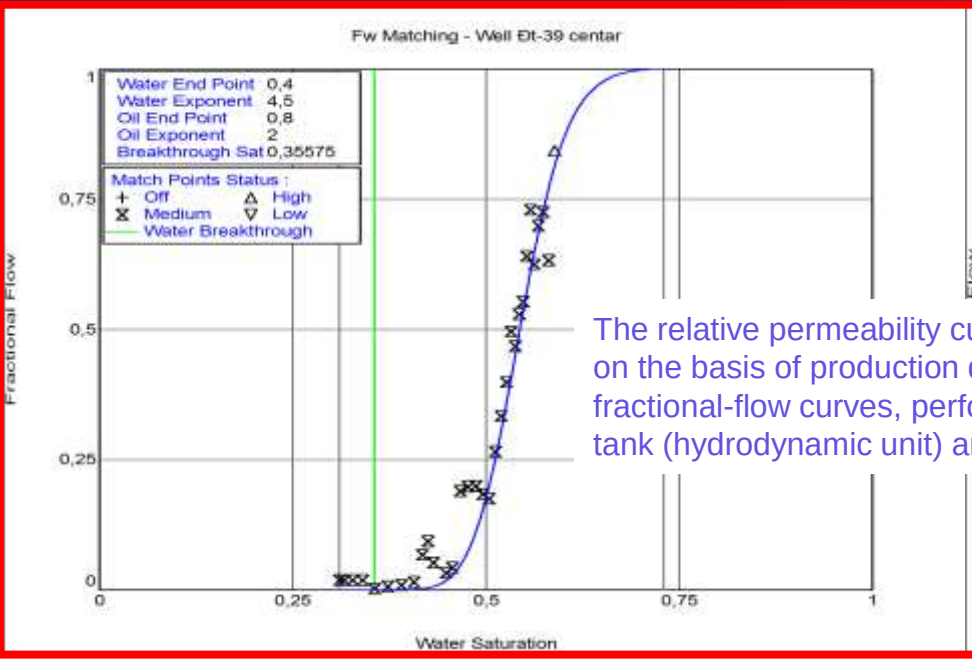
The drive indices show the relative magnitude of each drive mechanism contributing to total production.

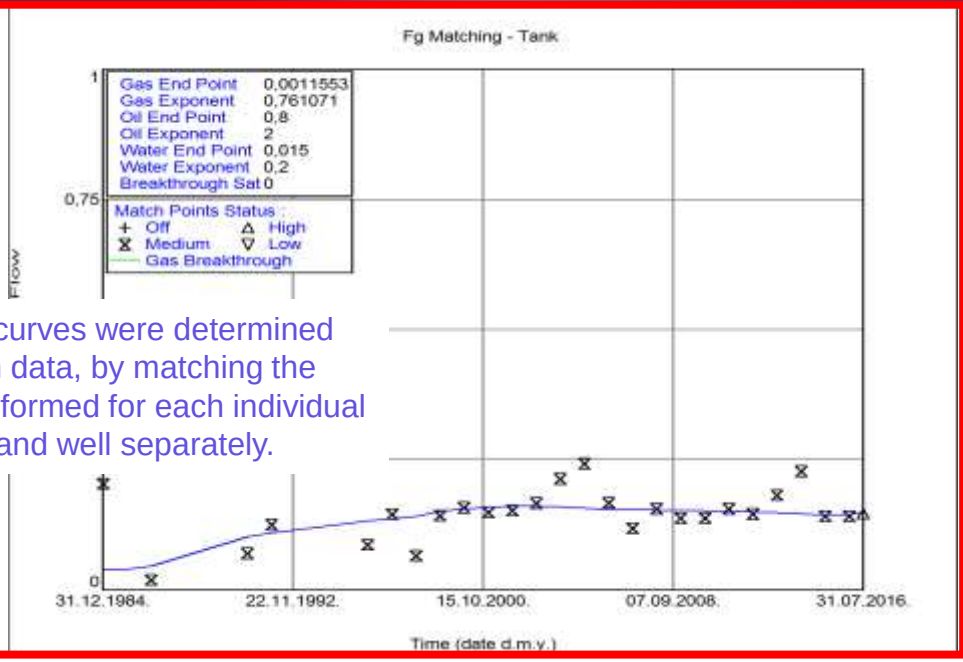
Tank Temperature	73,8	(deg C)
Tank Pressure	103	(BARa)
Tank Porosity	0,1	(fraction)
Connate Water Saturation	0,31	(fraction)
Water Compressibility	4,9e-5	(1/bar)
Formation Compressibility	6,96161e-5	(1/bar)
Initial Gas Cap Volume	3,6732e+7	(Sm3)
Oil in Place	6,15339e+6	(Sm3)
Production Start	05.10.1984.	(date d.m.y.)

Aquifer Model	Hurst-van Everdingen-Modified	
Aquifer System	Bottom Drive Aquifer	
Boundary Model	Infinite Acting	
Aquifer Permeability	0,140034	(md)
Tank Radius	1650	(m)

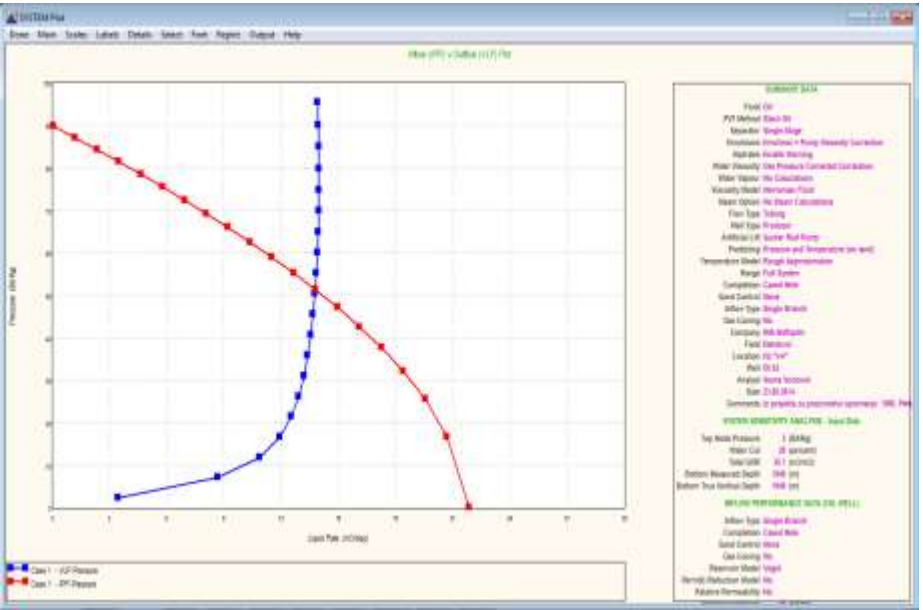
Example: Oil field Đeletovci

Well description





The relative permeability curves were determined on the basis of production data, by matching the fractional-flow curves, performed for each individual tank (hydrodynamic unit) and well separately.



Inflow performance curves were generated using Vogel's equation.

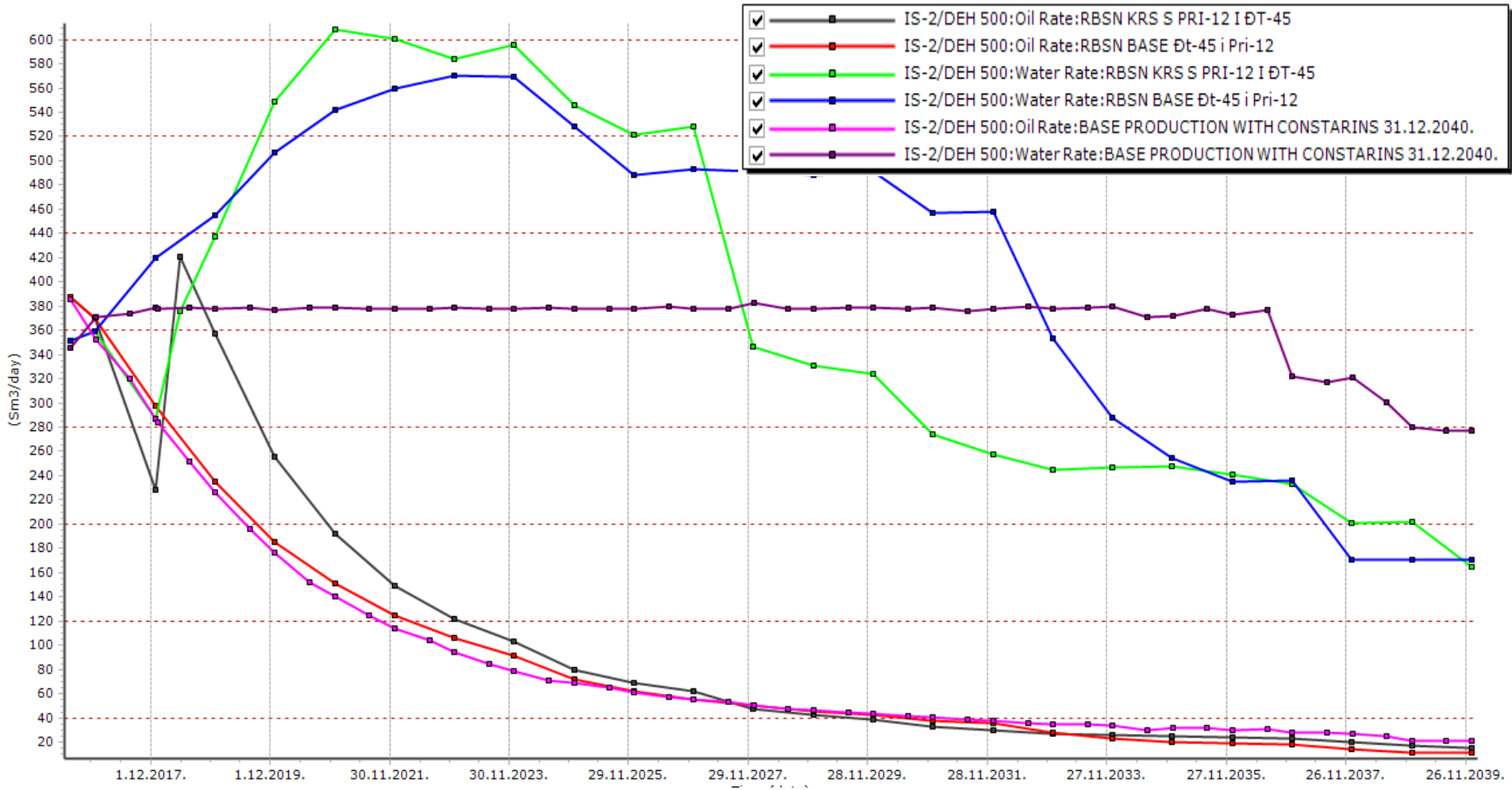
VLP corelation is based on SRP equipment and pressure/temperature drop thru tubing

→ Used method provides estimating of future production behavior for each individual well.

MBAL method/model can be replaced with 3D simulation (numerical) model in the future. Also, well production profiles can be generated by decline curves analysis (DCA) method.

Examples: Oil field Đeletovci

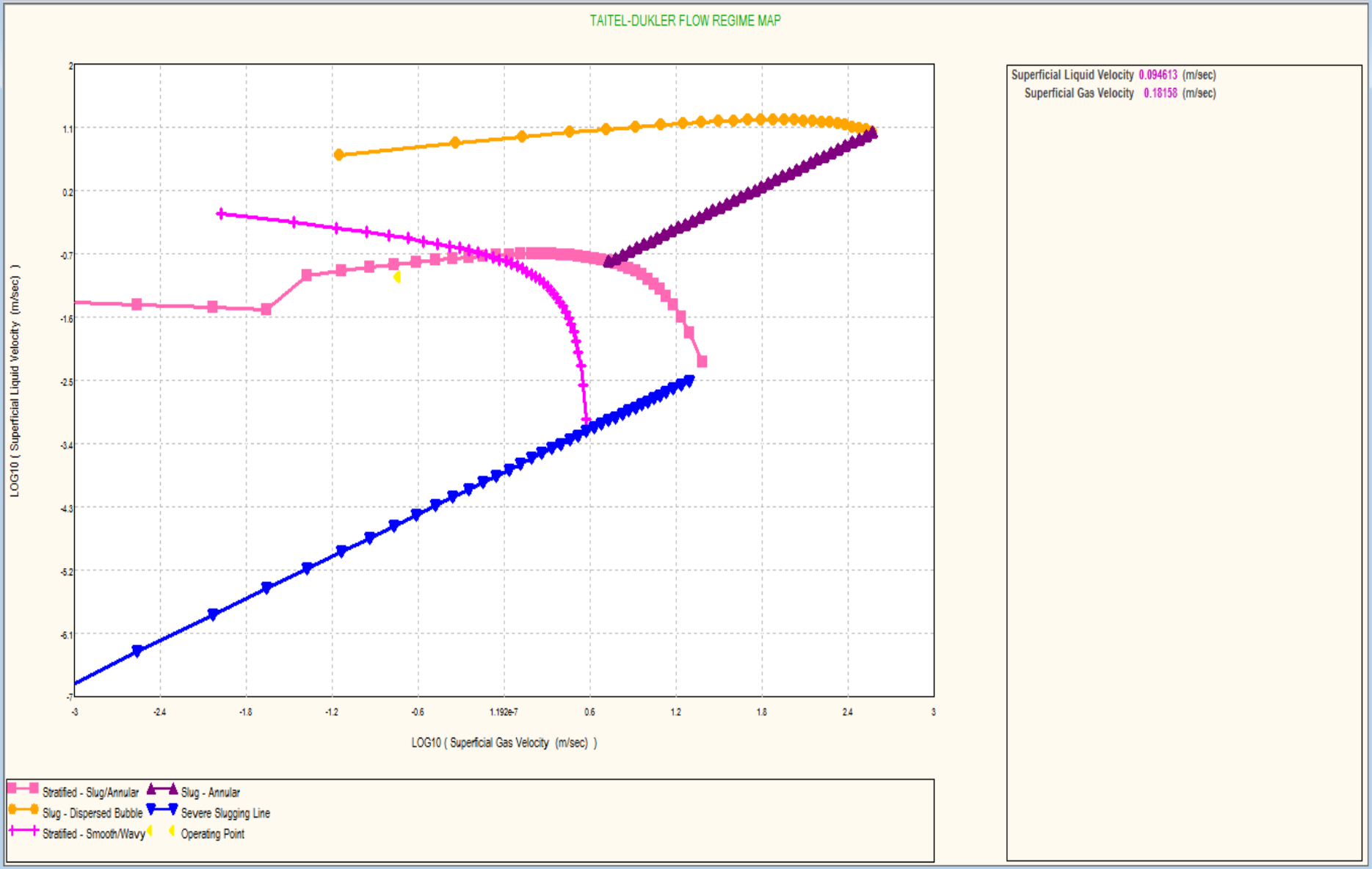
Prediction screnarios (oil rate vs. water rate)



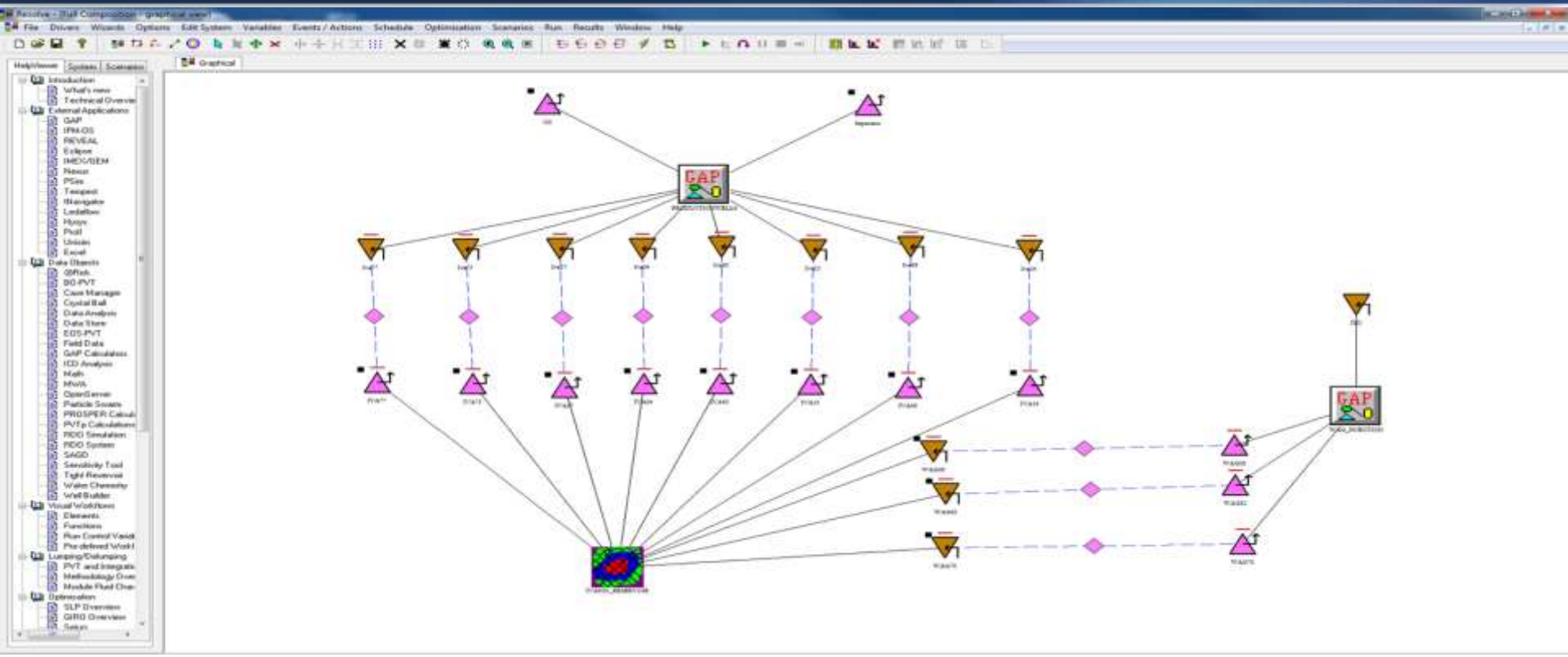
- Current water disposal pump capacity-380 m^3/d ***BOTTLENECK!***
- Aditional water injection capcatiy nedded to conduct maximum production
- Pipeline flow regime problems (emulsion, slug flow and parafin deposition)

TAITEL-DUKLER FLOW REGIME MAP

Done Main Scales Labels Details Select Font Replot Output Colours



Reservoir modeling (ECLIPSE) Integrated with IPM



EOR Ivanić- *Existing Reservoir model is not combined with surface GAP model and without bottelnecks. With integration of these models it is possible to predict bottelnecks in surface equipment to act proactive and to remove them to achive maximum production potential form reservoir.*