Two-Pronged Approach to Multiphase metering Uncertainty Determination

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Practical Examples from CalTex Indonesia

Where Should Oil Companies Put Deep Water Metering Money?

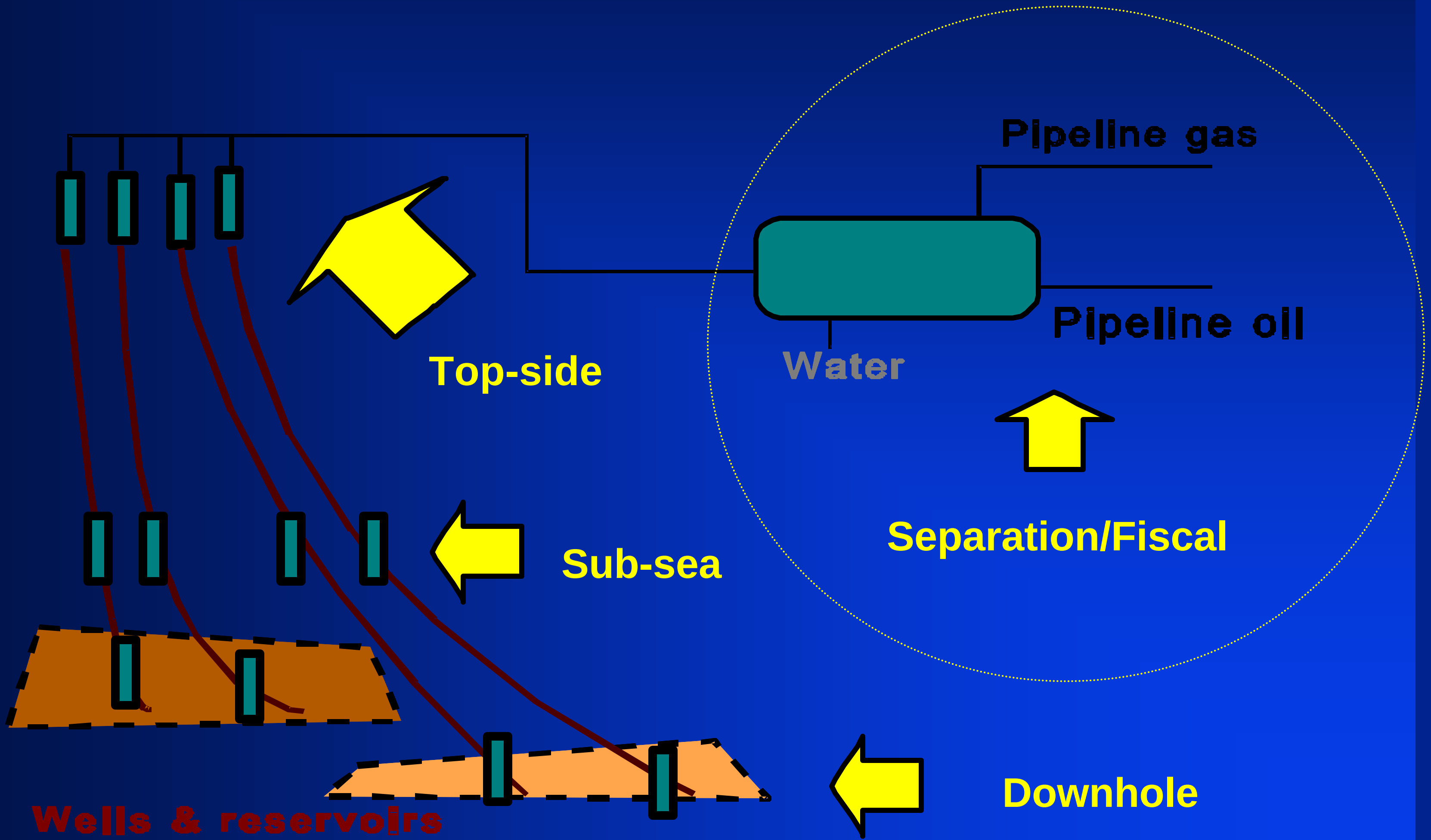
Scope of Talk

- Over View of Multiphase Meter testing
  - Step 1- Reference Multiphase Meter Characterization
    - Accuracy at Reference (Pr,Tr) Condition
    - Accuracy at Test (Pt,Tt) MultiPhase meter Condition
  - Step 2 - Test Multiphase Meter Characterization
- **Our Uncertainty review stimulates new Multiphase Meter Interests**
  - PVT or PTQ Meters using Assays, T, P and Real time modeling

Activities in Mutiphase Metering Standards

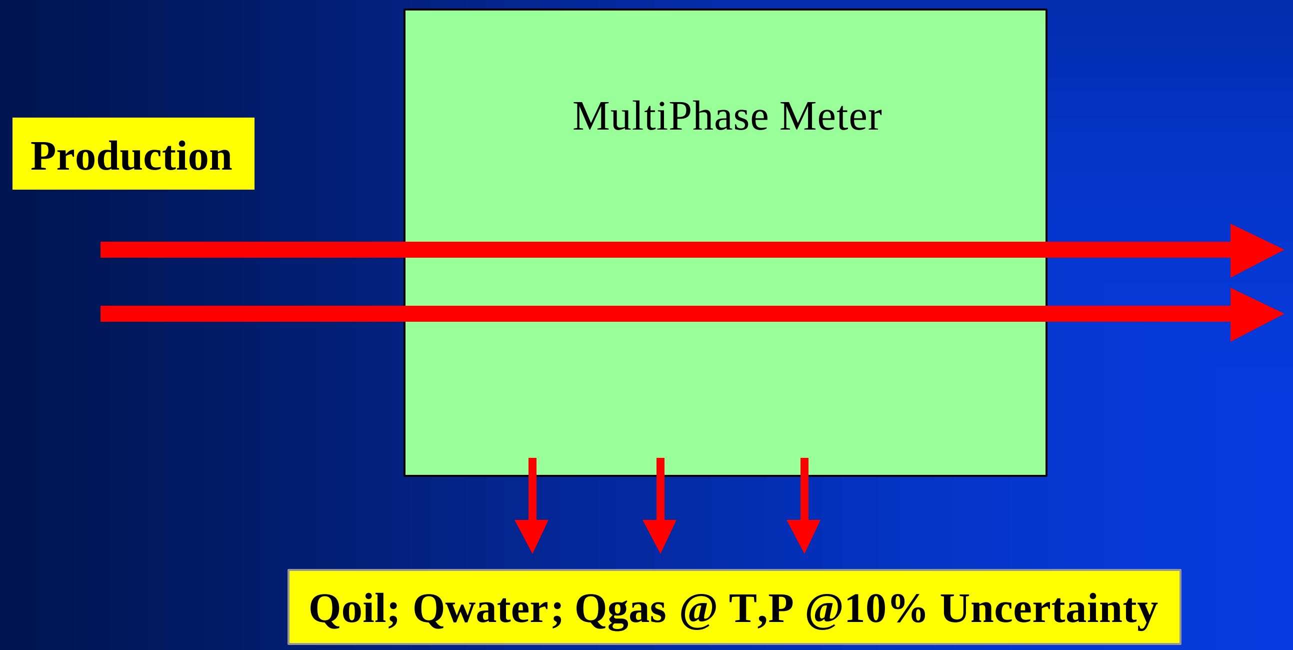
- Norwegian Soc. For Oil and Gas Measurement
  - Handbook of Multiphase Metering
  - Http://www.oilnet.no/nfogm/docup/index.asp
- API subcommittee on Multiphase Metering Standards
  - Liaison with Pending International Activities

Meter Locations



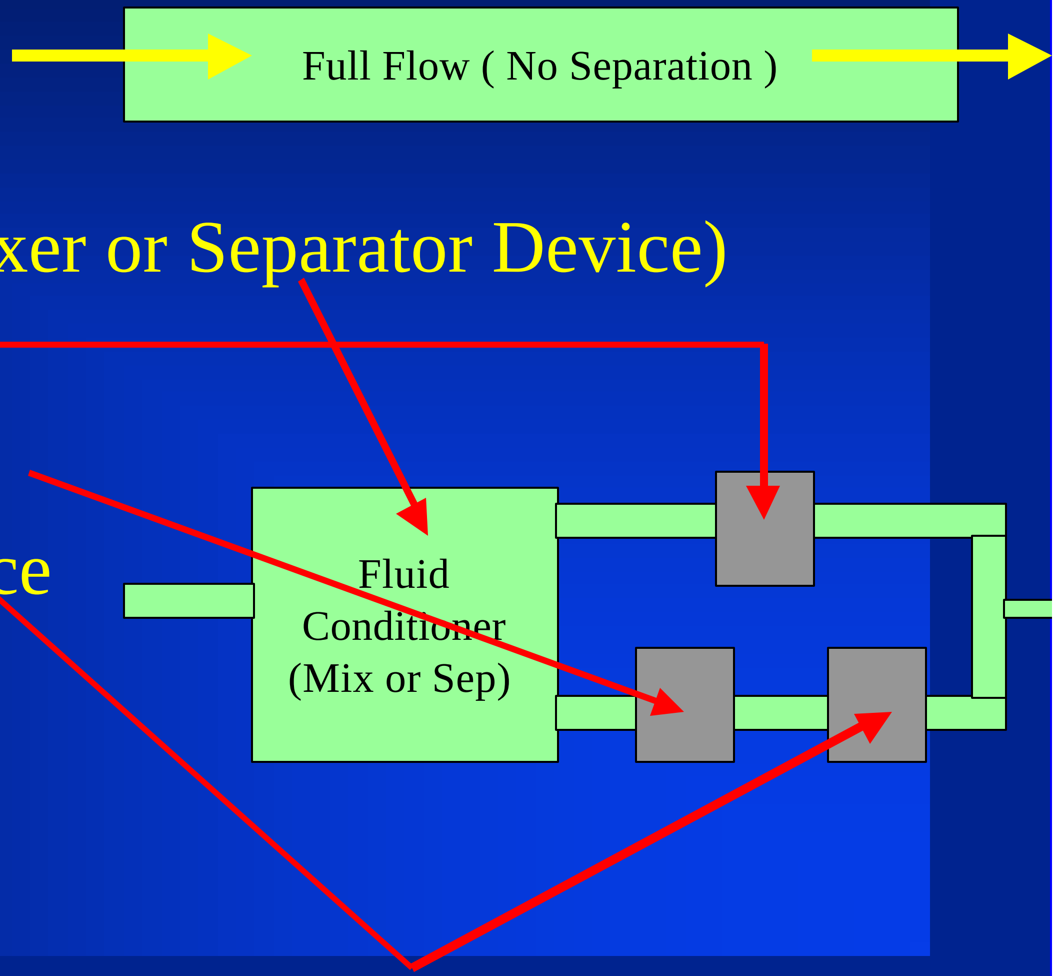
Definition of a (More than One Phase) Meter

- More Than One "TYPE" of MPM
- Many ways to Categorize Types
  - Degree of Flow Conditioning

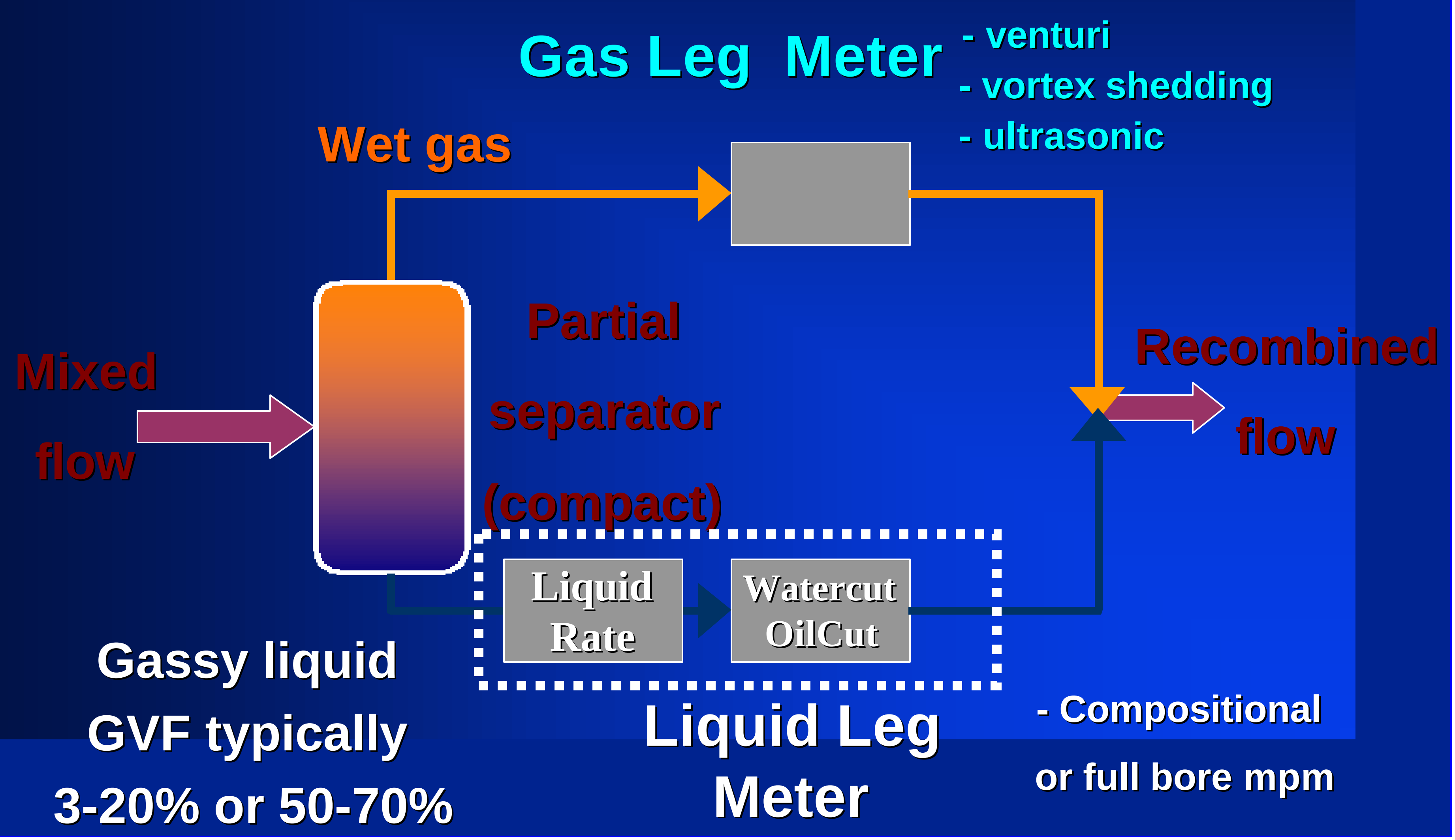


The MultiPhase Meter

- **Consists of:**
  - Fluid Conditioner (Mixer or Separator Device)
  - Gas Rate Device
  - Liquid Rate Device
  - Water/Oil Ratio   Device
- **Hydrocarbon Rate**
  - **Q**h=**Q**l*(1-WaterCut)
  - **Q**h=**Q**l*(OilCut)



Partial Separation Metering Concept

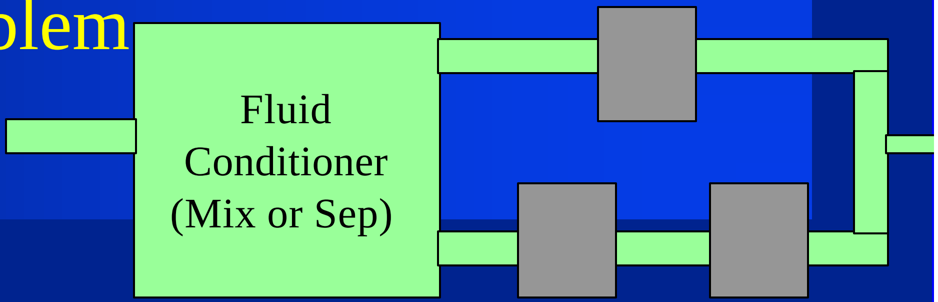


Dominant Source of Uncertainty in Multiphase Metering

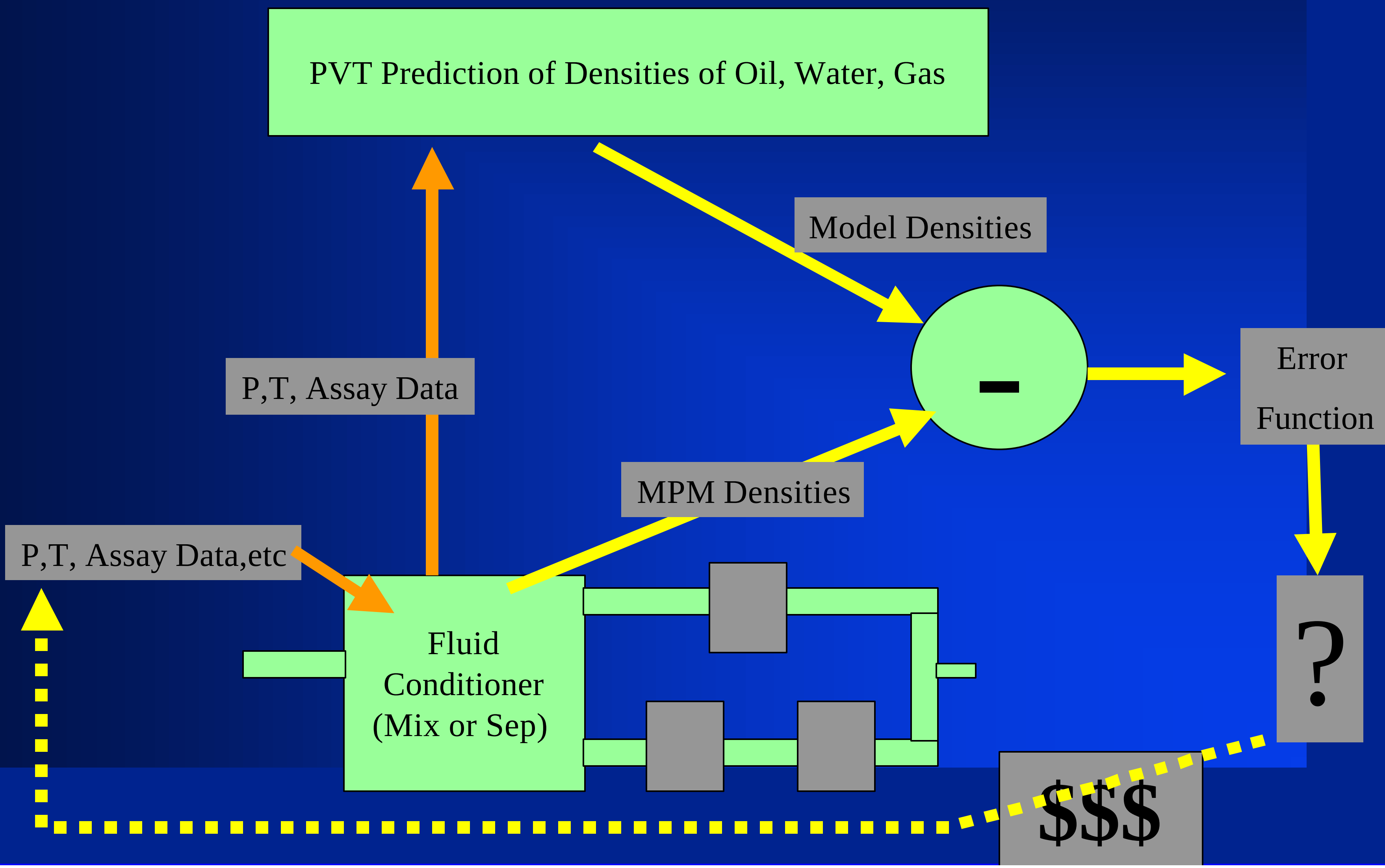
- Changes in Conditions & Fluid Properties with Time and Reservoir Management
  - Sensitivity of Devices and Models
  - Extrapolation beyond Empirical Data
  - Changes in Physical constants differentiating oil and water
    - i.e. Densities (Oil --->> Approaching Water)
    - i.e. Dielectrics (Oil --->> Approaching Water)
    - i. E. Nuclear (Energy peaks shifting and Merging)
- All Other Factors are Secondary

The Newest Initiative in MultiPhase Meters - PVT Model

- Consists of Previous listed components
- AND
  - PVT Model density prediction model based on fluid assay
  - Comparison of MPM and Model Densities
- However
  - No Clear Response to disagreement is proposed other than flagging potential problem

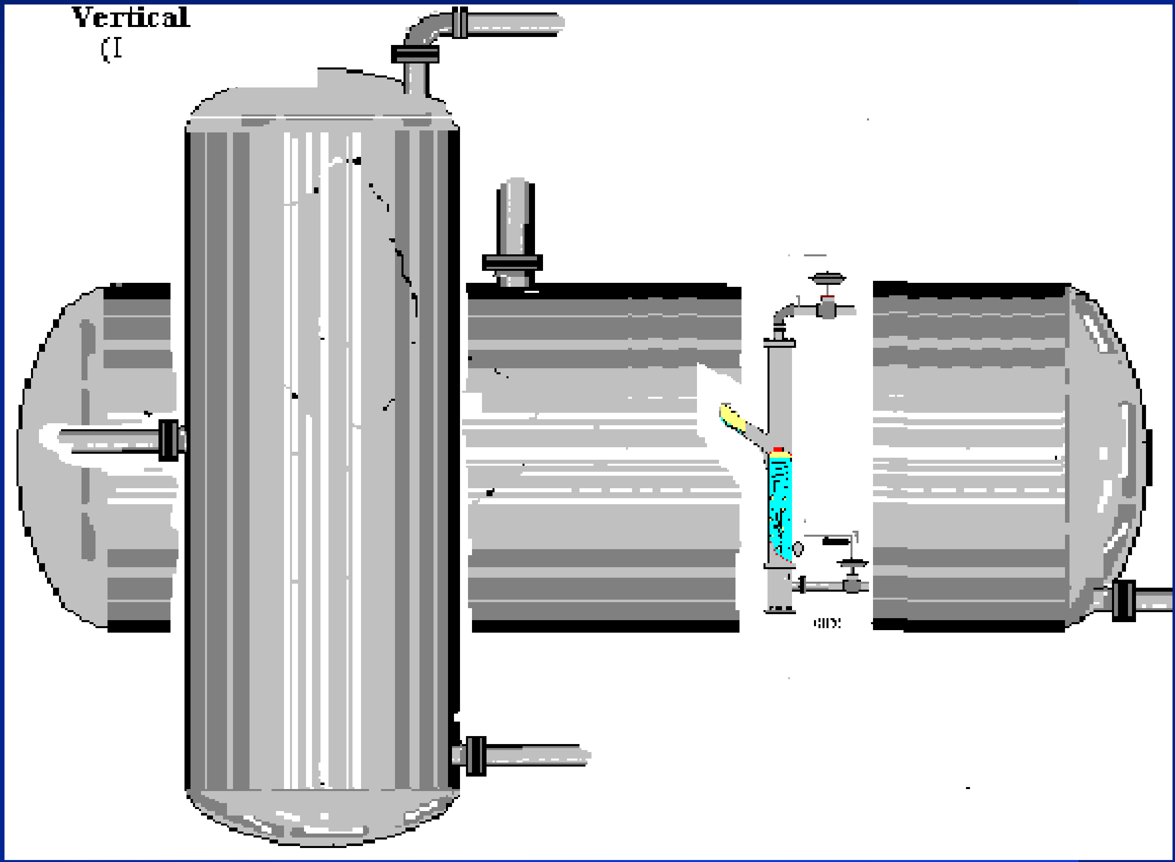


New Initiative -Real Time Performance Checking Against PVT Model

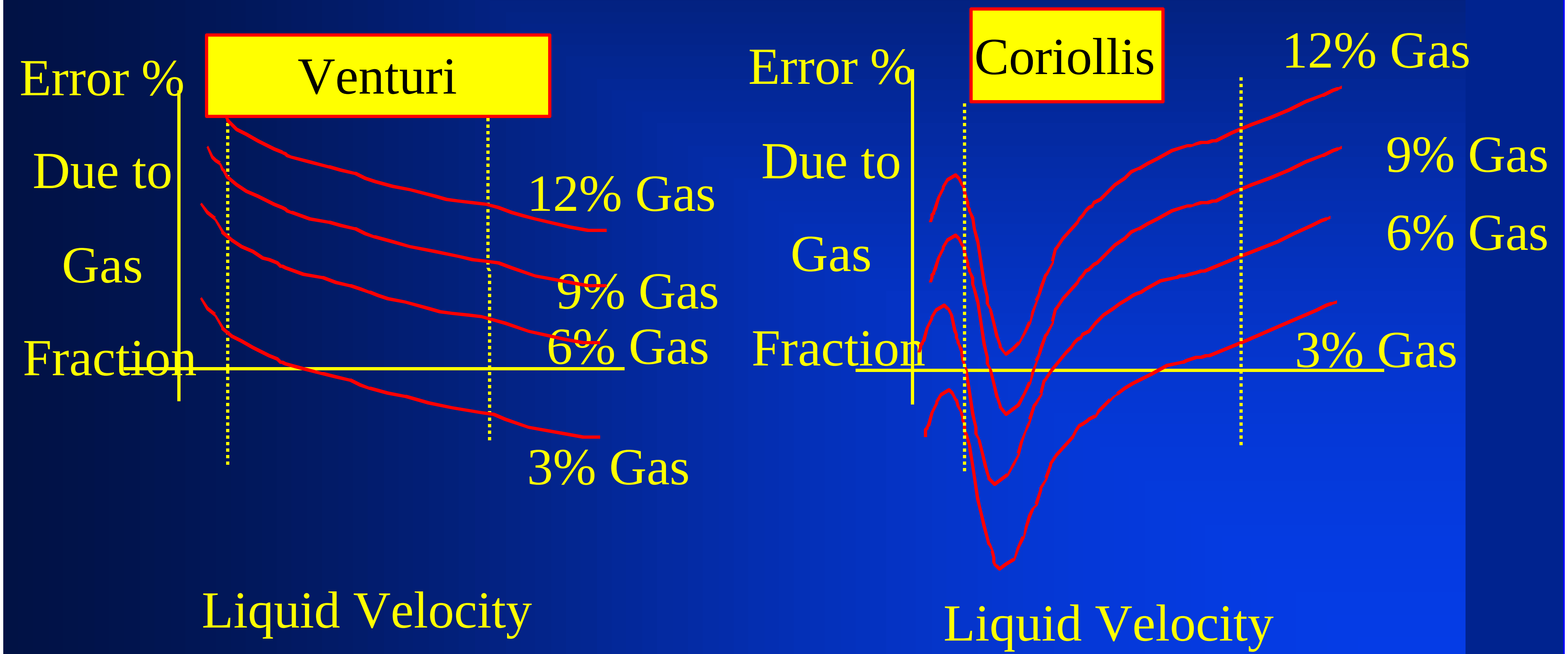


Reference Separators Options- High Viscosity Fluids

- Duri, Indonesia
- 100,000 bbl/d
- 7-10 MMscf/d
- 150 psig, 200 F
- 3x 20 ft GLCC
- 30 x 90 ft Vertical



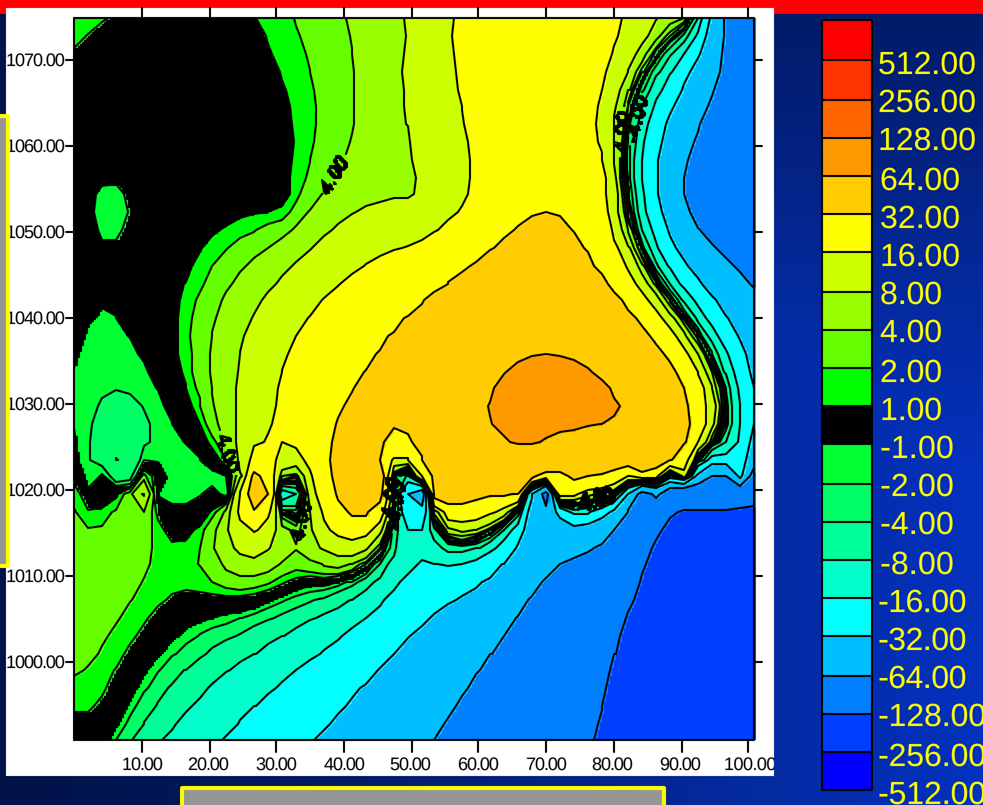
Reference Rate Meter Options Response to Gas(NEL Data-Skea '95)



Reference Watercut Meters

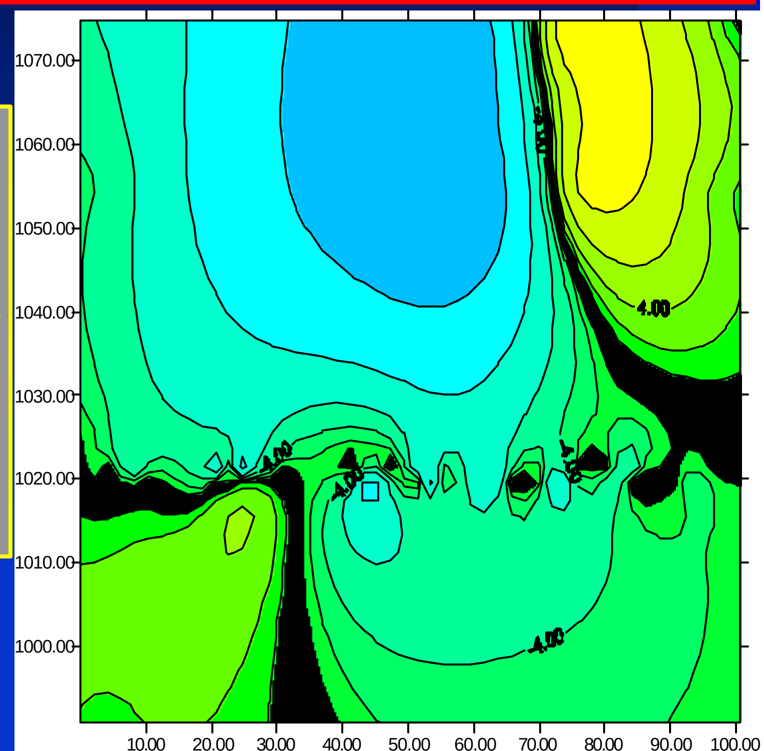
Dealing With *True* Complexity Forces Computer Modeling

S A L T



Water cut

S A L T

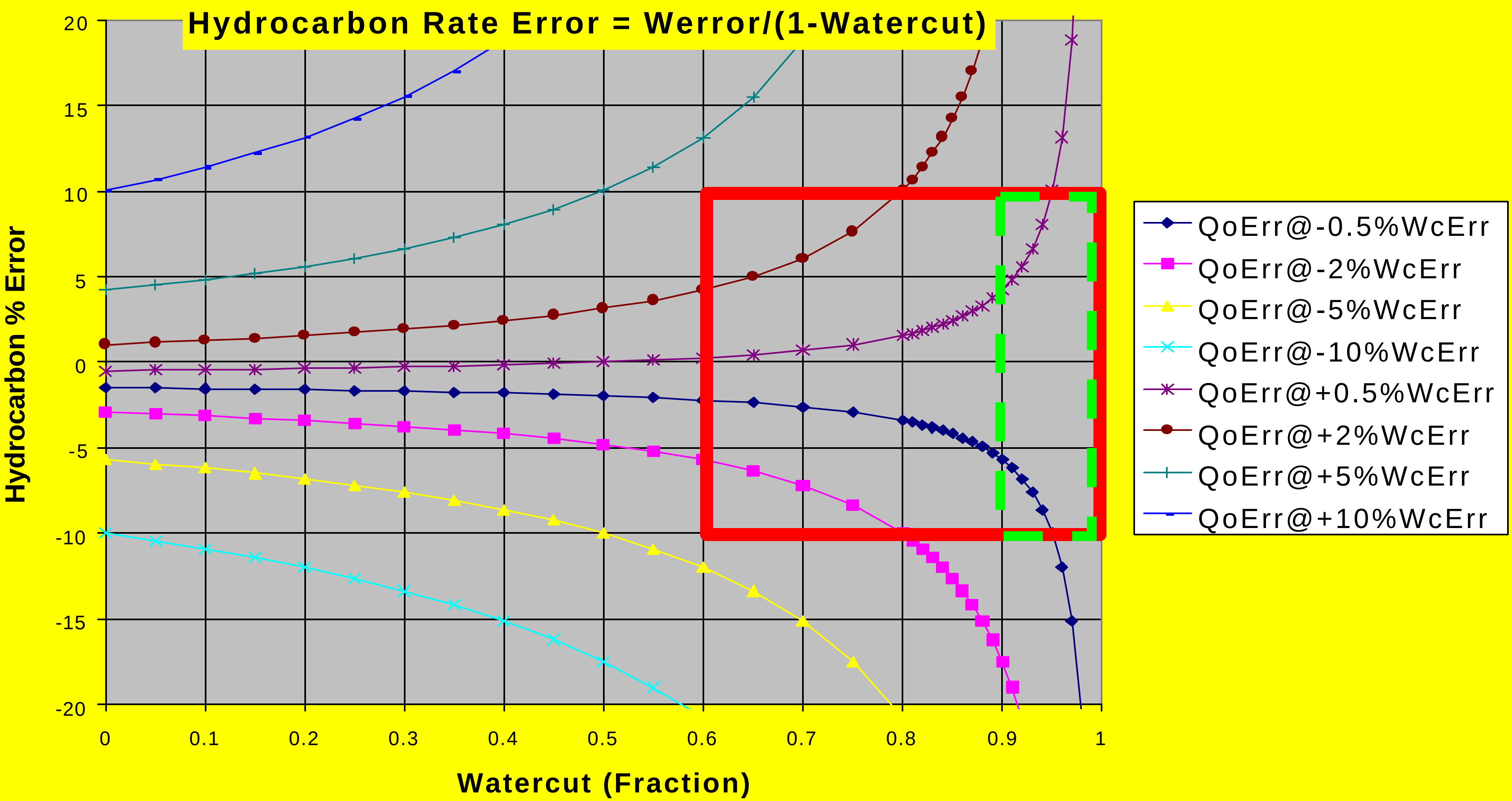


Water cut

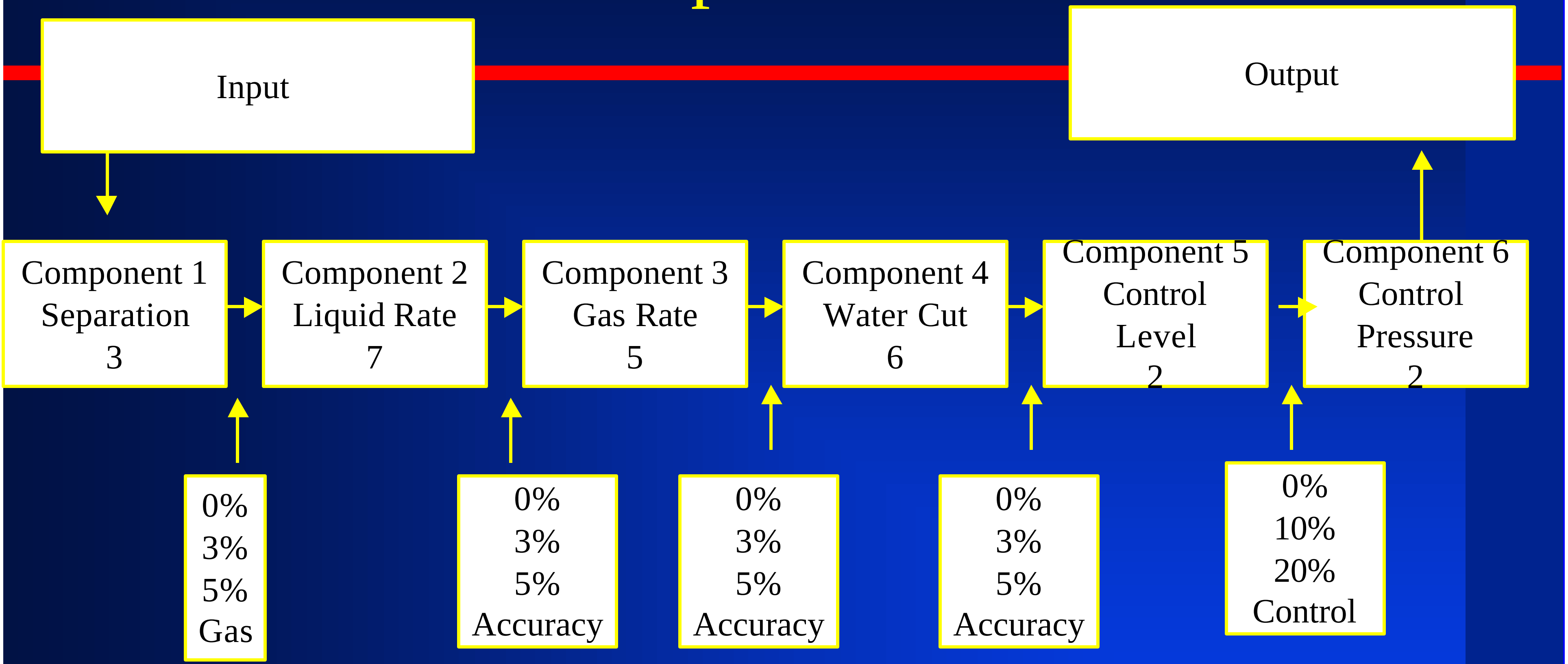
Both Meters Claim 10% Uncertainty in WaterCut
But Performance is a Very Strong Non-Linear Function of Production

Oil = ($$$):
Why Do Meter Vendors Sell Watercut Accuracy?

Hyrocarbon Rate = Qliquid * (1- Watercut)



Scope of Reference MultiPhase Meter Options

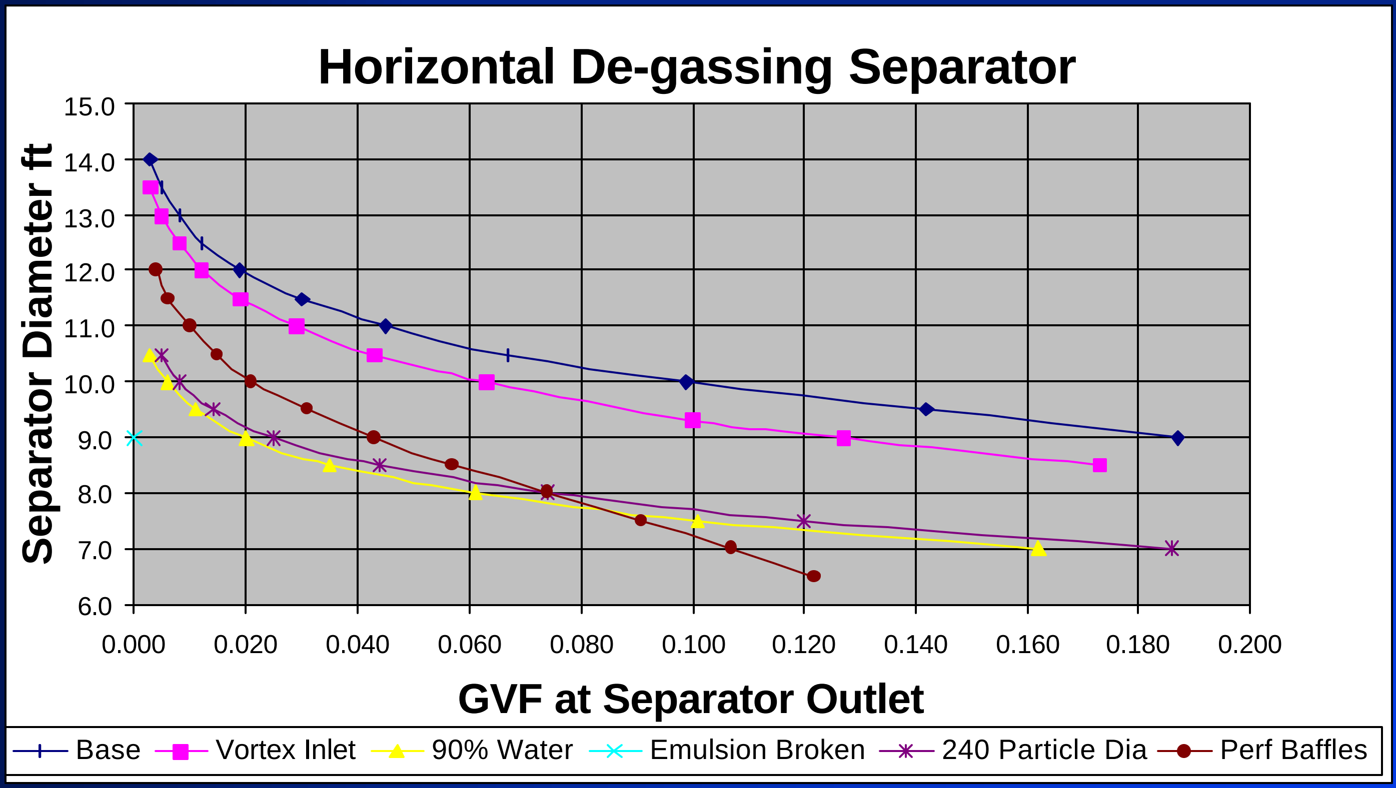


3x3x7x3x5x6x2x2 = 22,680 combinations and options

Ranked by Cost,Weight, Footprint, Energy Use, Accuracy, Uncertainty, Credibility

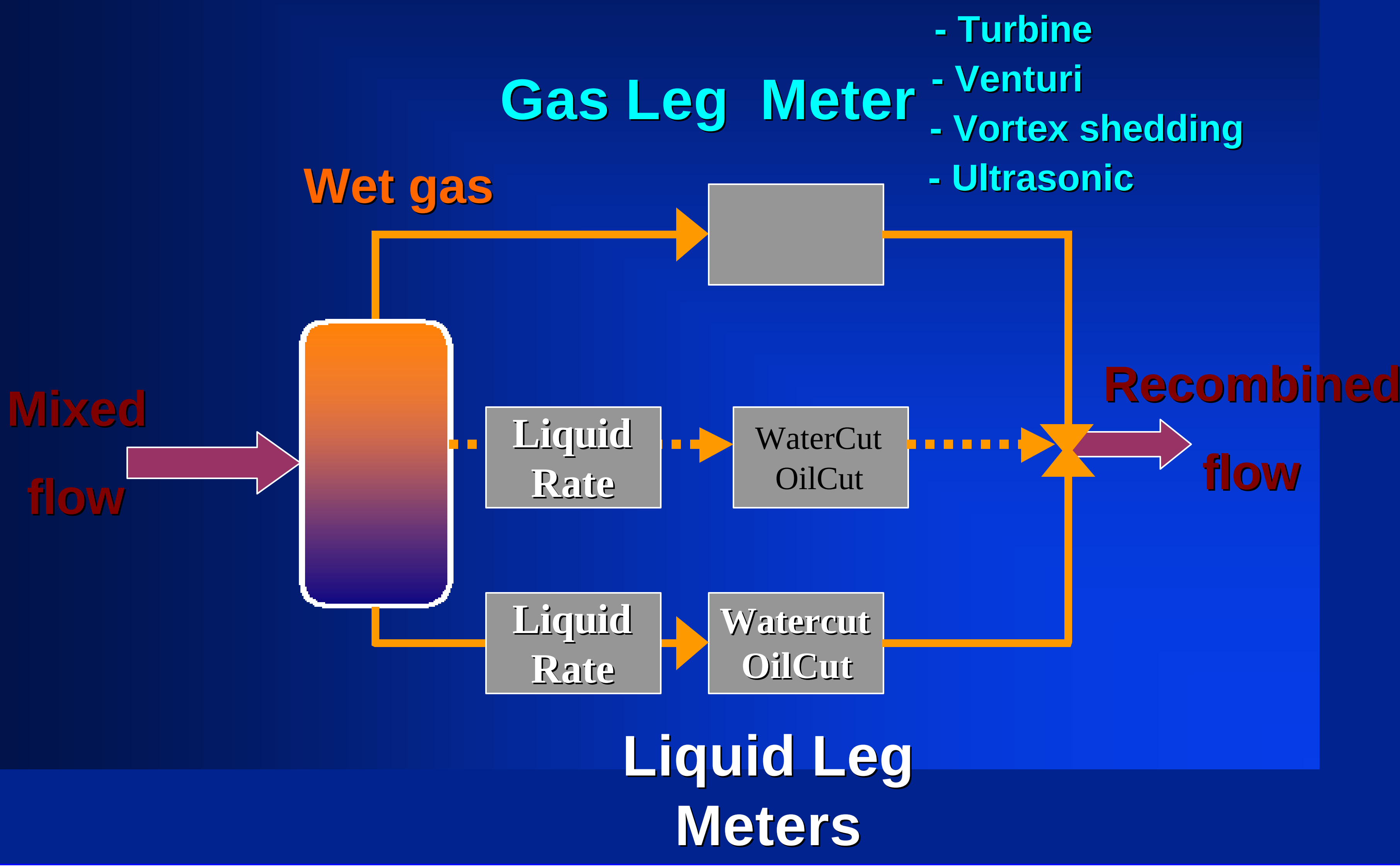
Separation Metering Introduces Separator Performance Issues

Gas Carry Under & Oil Water mixing

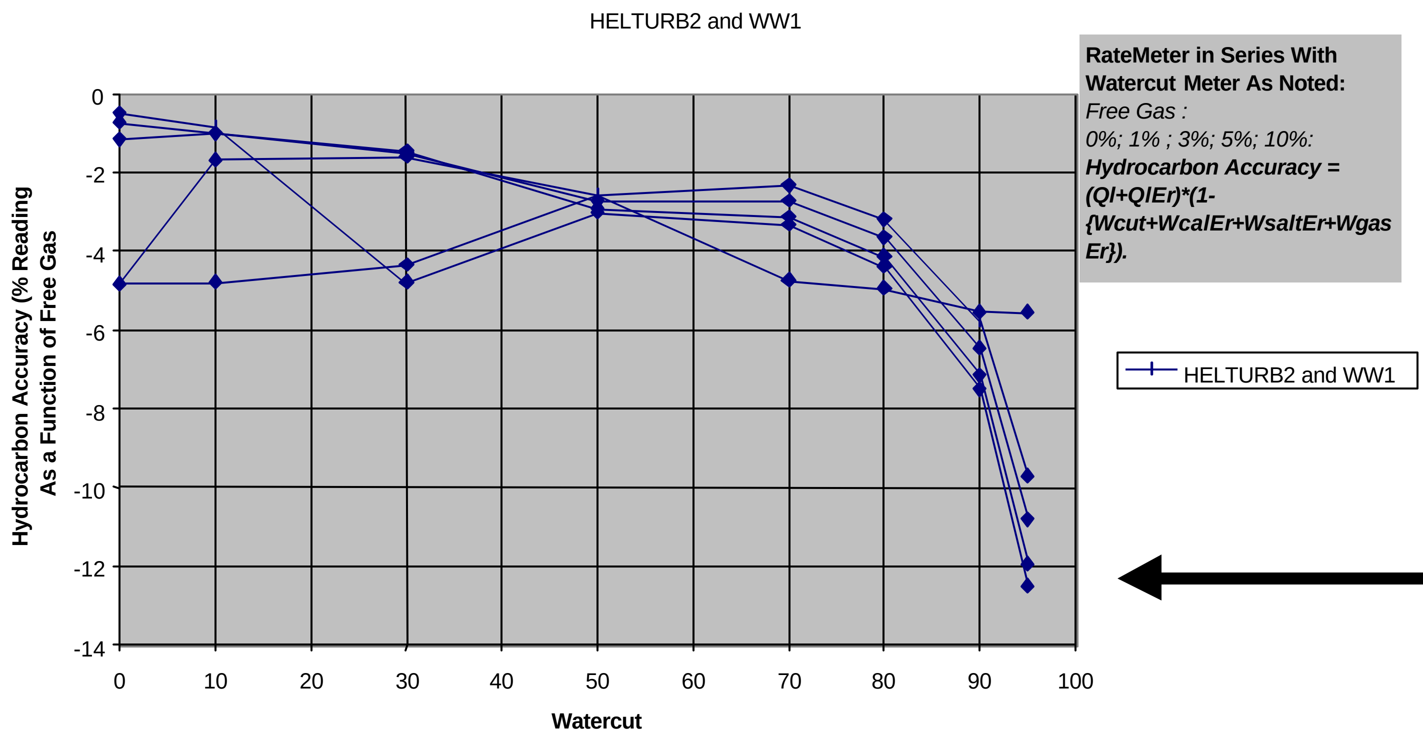


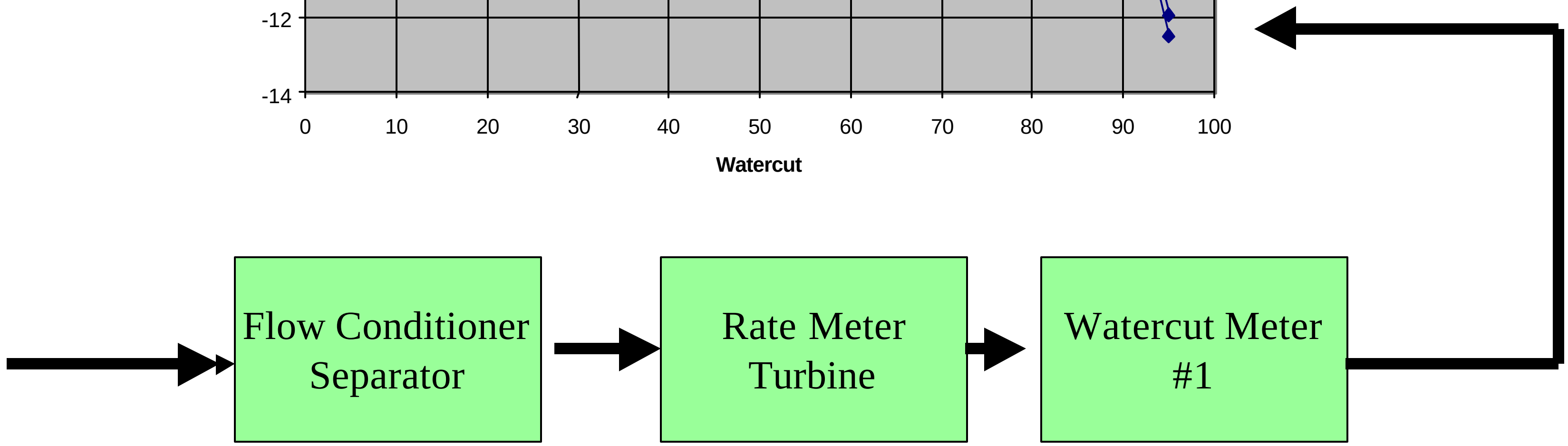
Reference Metering MUST BE

3 to 4 Times More Accurate than Test Meter



Hydrocarbon Accuracy = (Qliquid+ QlEr)*(1 - { Wcut + WcalEr+WsaltEr+WgasEr})





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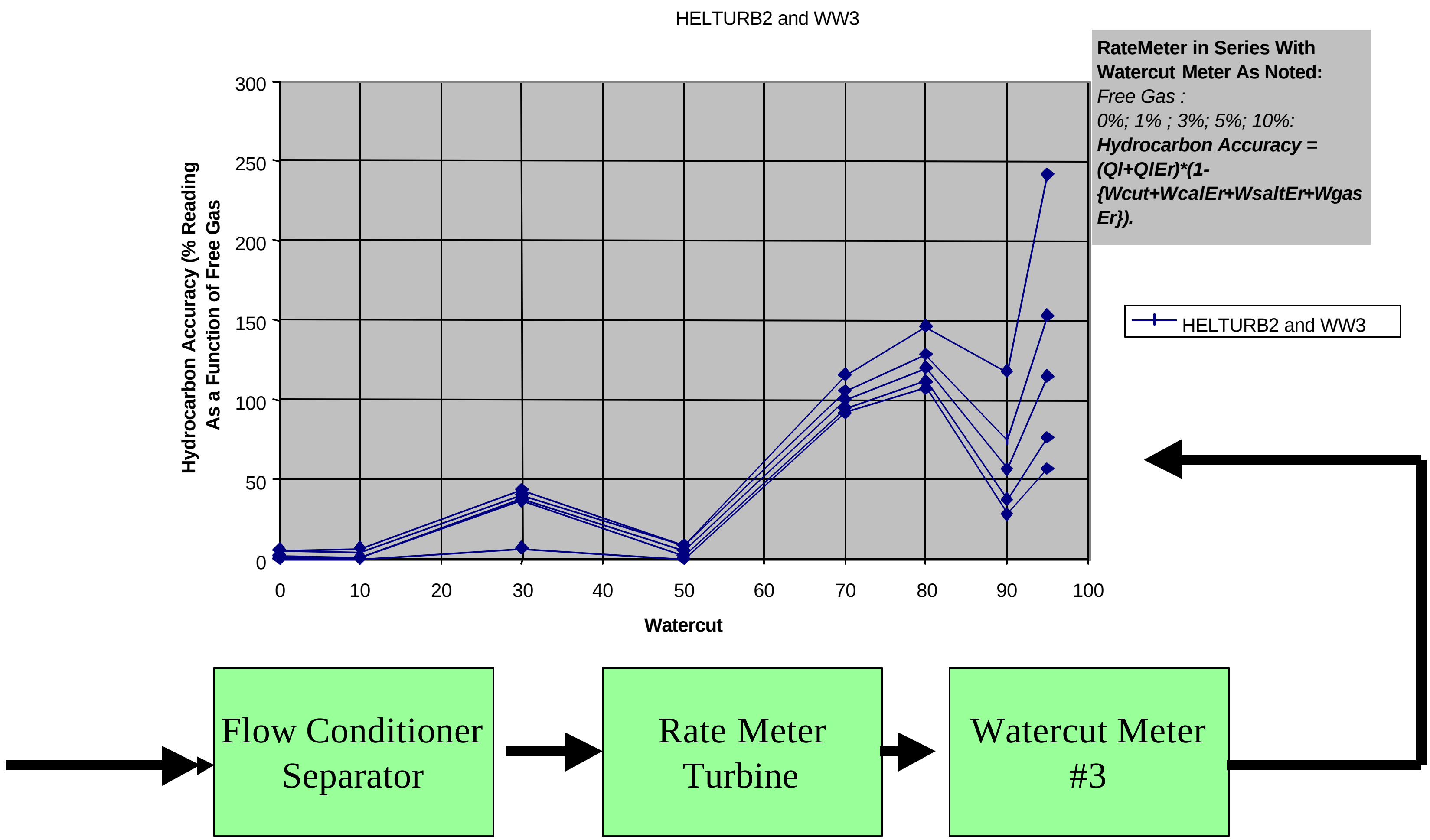

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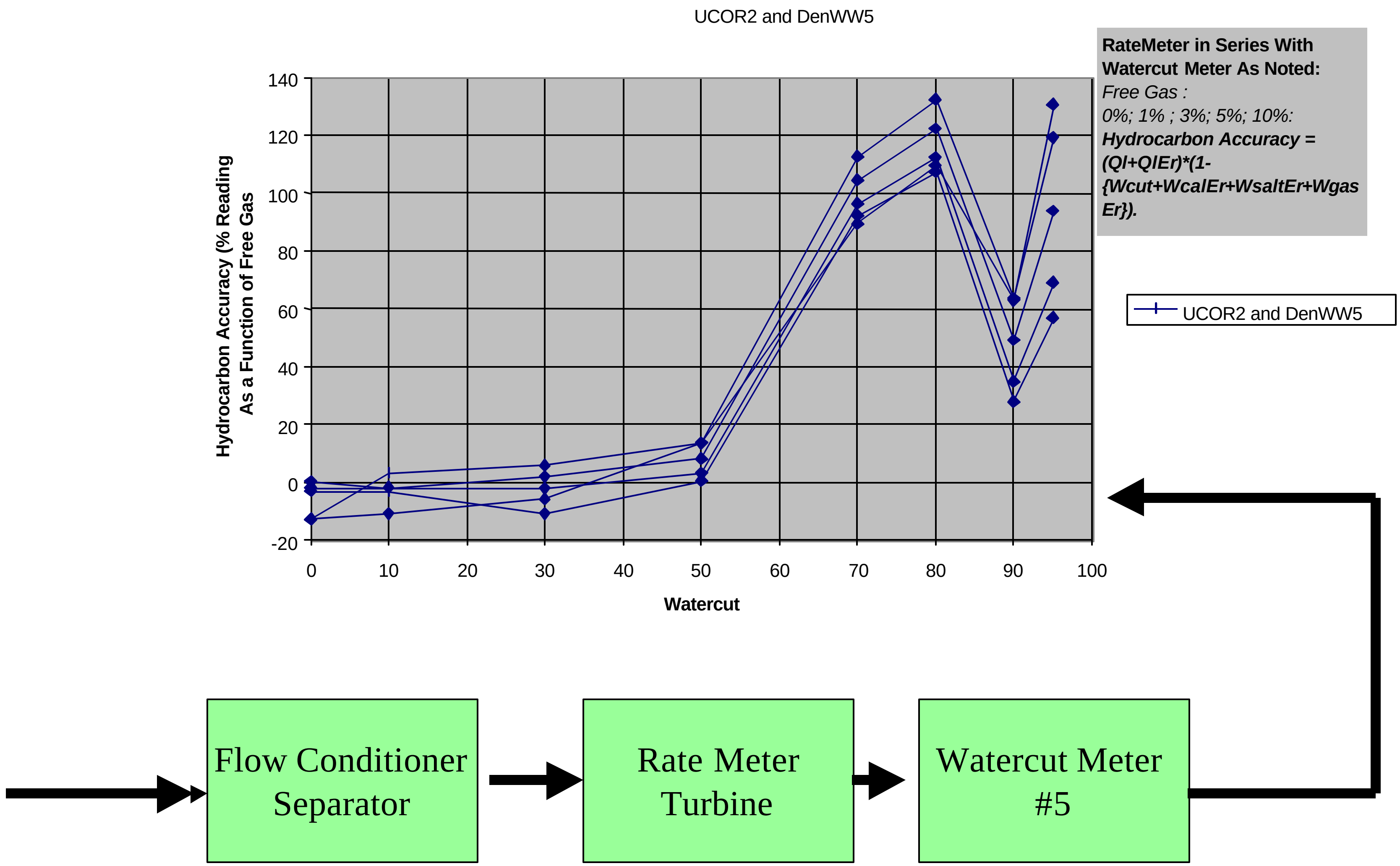
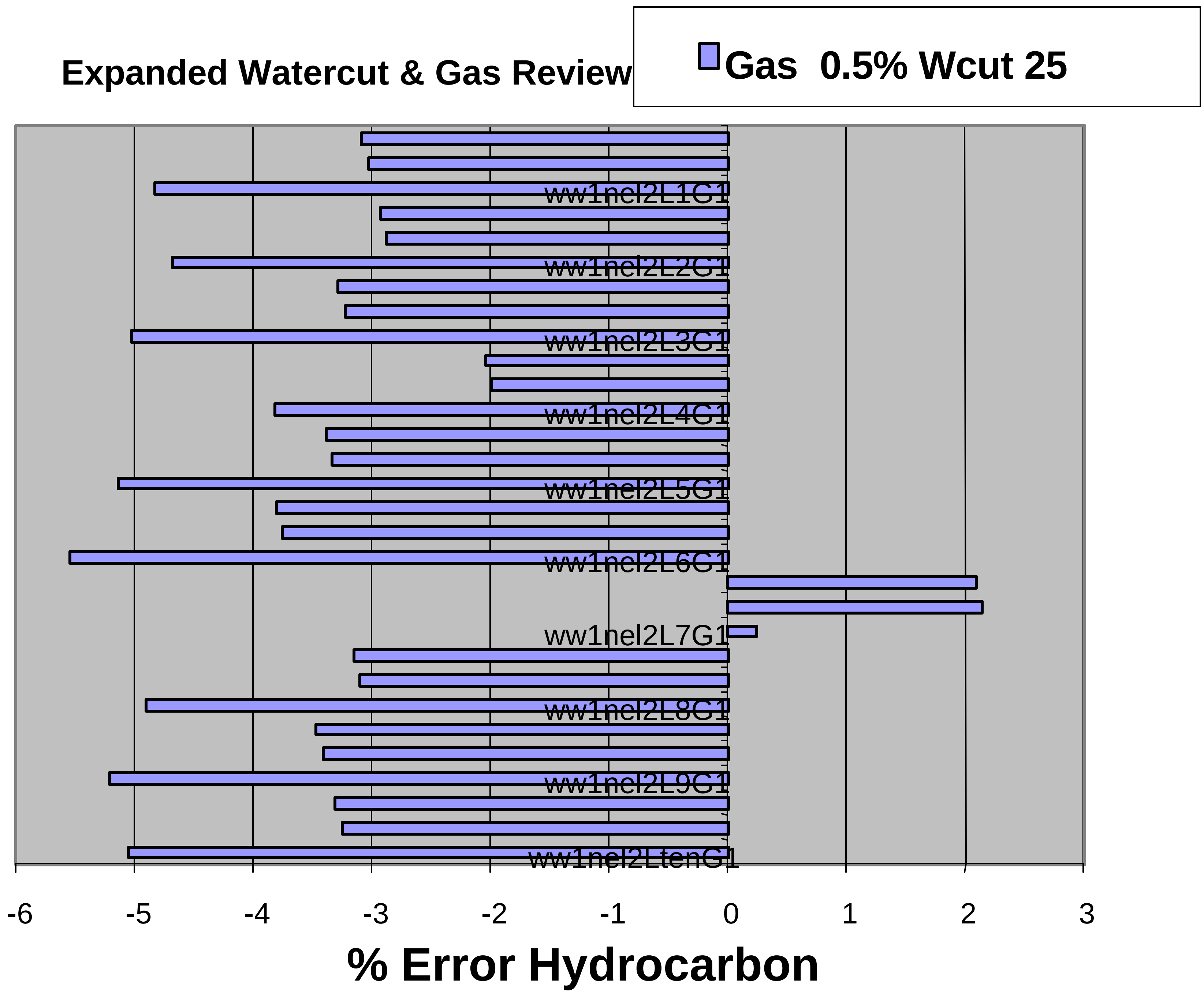
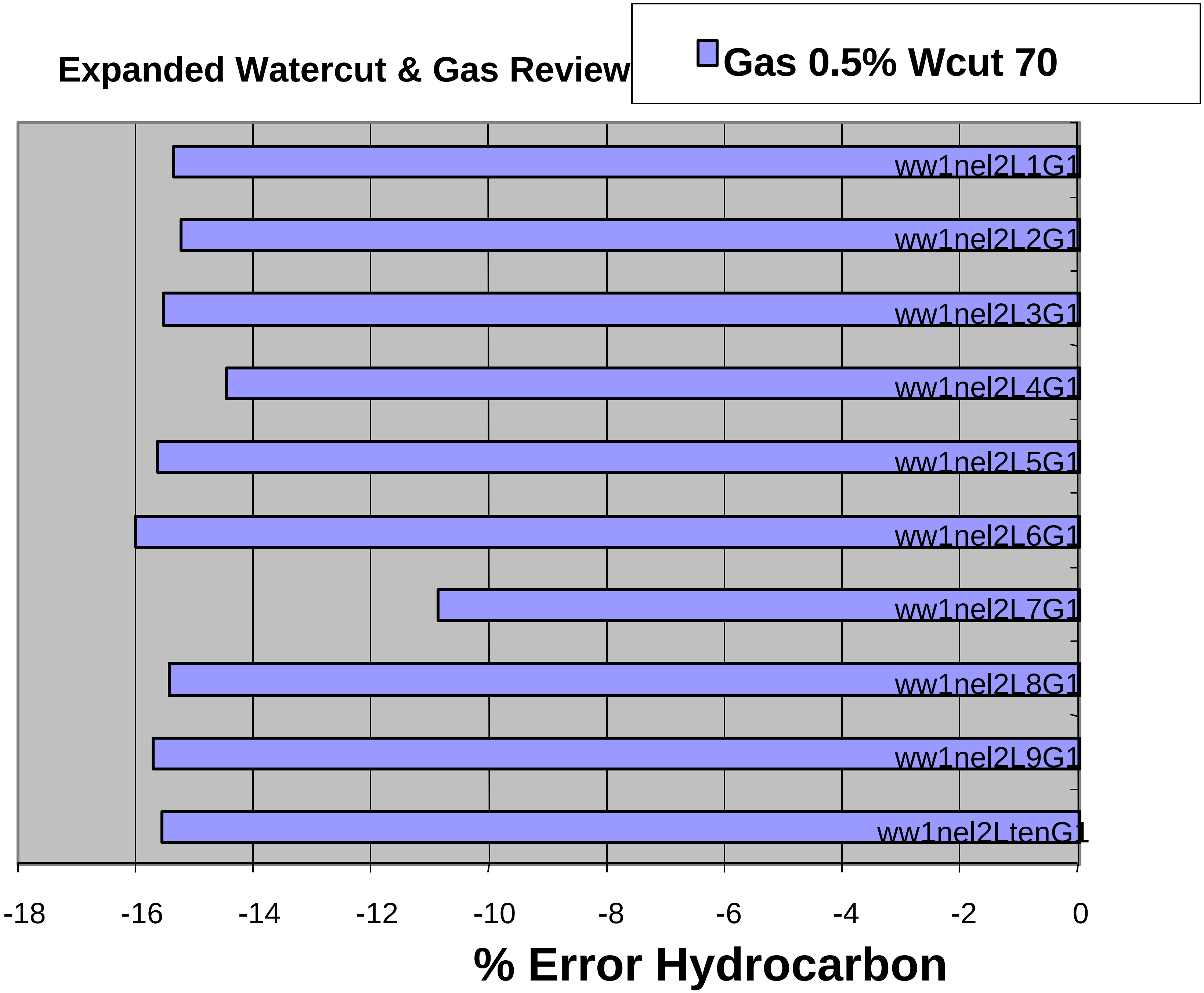
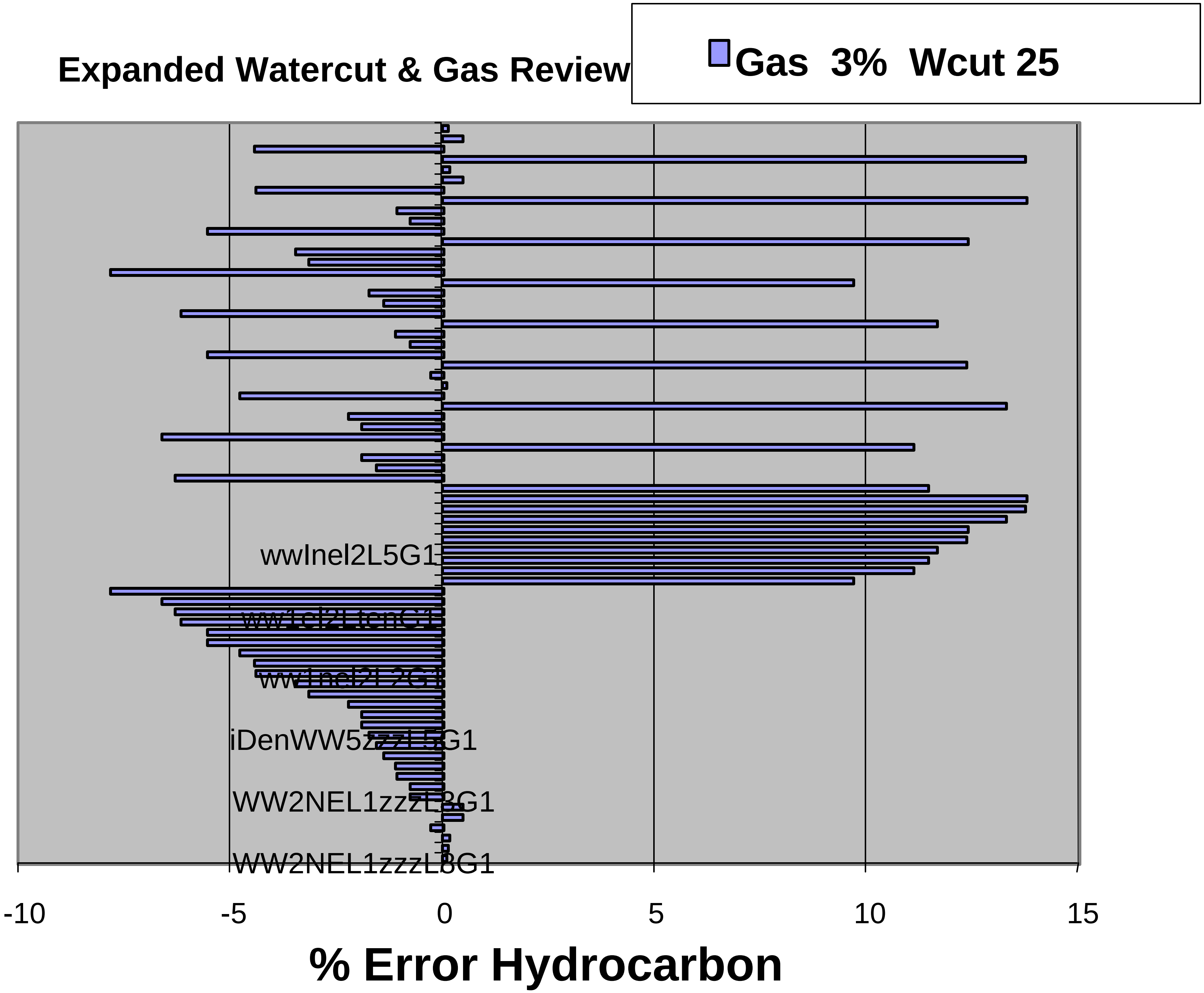


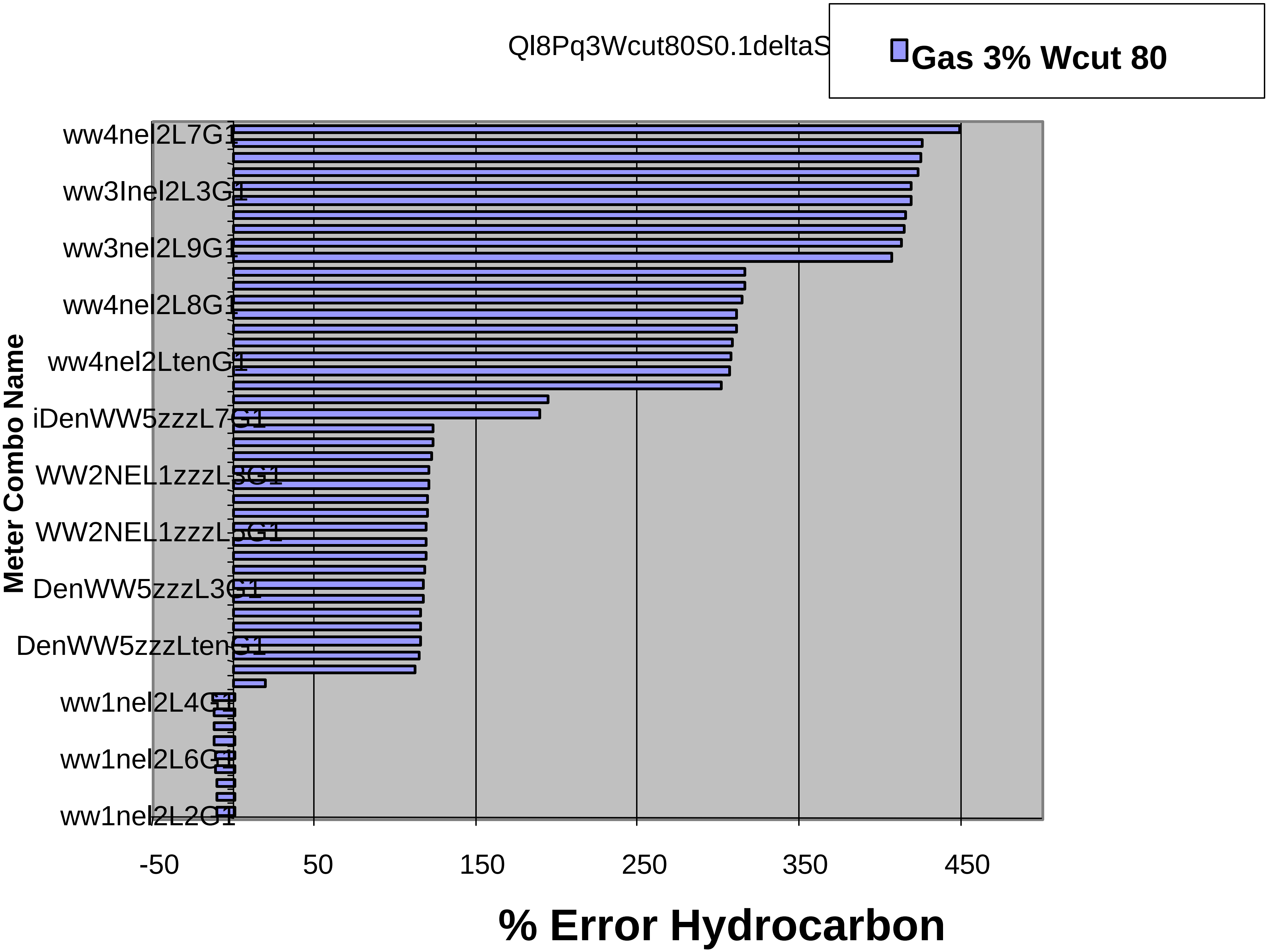

Expanded Watercut & Gas Review
Gas 0.5% Wcut 25
ww1nel2L1G1
ww1nel2L2G1
ww1nel2L3G1
ww1nel2L4G1
ww1nel2L5G1
ww1nel2L6G1
ww1nel2L7G1
ww1nel2L8G1
ww1nel2L9G1
ww1nel2LtenG1
-6
-5
-4
-3
-2
-1
0
1
2
3
% Error Hydrocarbon



Expanded Watercut & Gas Review
Gas 0.5% Wcut 70
ww1nel2L1G1
ww1nel2L2G1
ww1nel2L3G1
ww1nel2L4G1
ww1nel2L5G1
ww1nel2L6G1
ww1nel2L7G1
ww1nel2L8G1
ww1nel2L9G1
ww1nel2LtenG1
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
% Error Hydrocarbon



Expanded Watercut & Gas Review
Gas 3% Wcut 25
wwlnel2L5G1
ww1cl2LtcnG1
ww1nel2L2G1
iDenWW5zzzL5G1
WW2NEL1zzzL3G1
WW2NEL1zzzL8G1
-10
-5
0
5
10
15
% Error Hydrocarbon



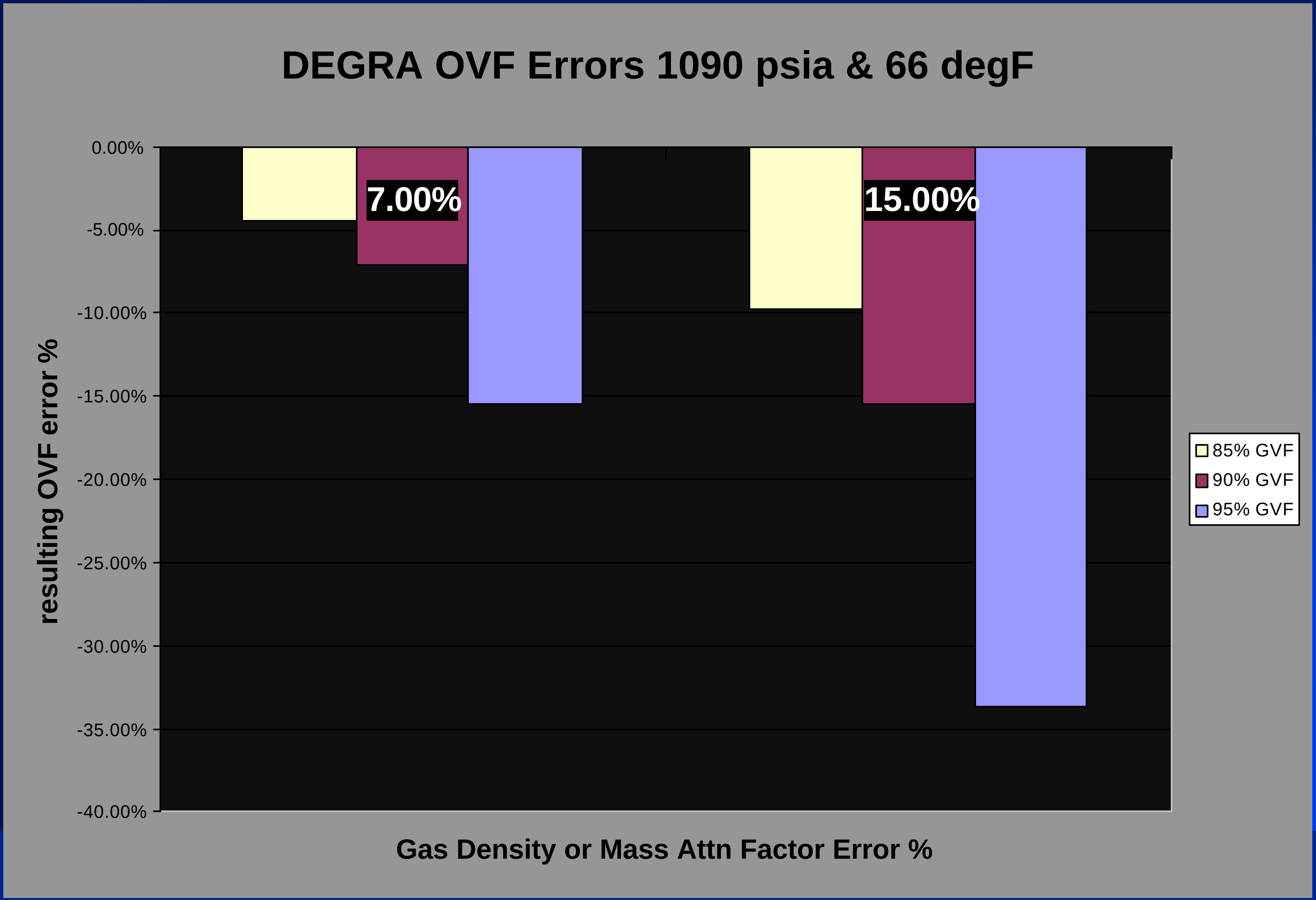
Ql8Pq3Wcut80S0.1deltaS
Gas 3% Wcut 80
Meter Combo Name
ww4nel2L7G1
ww3Inel2L3G1
ww3nel2L9G1
ww4nel2L8G1
ww4nel2LtenG1
iDenWW5zzzL7G1
WW2NEL1zzzL3G1
WW2NEL1zzzL5G1
DenWW5zzzL3G1
DenWW5zzzLtenG1
ww1nel2L4G1
ww1nel2L6G1
ww1nel2L2G1
-50
50
150
250
350
450
% Error Hydrocarbon

Beyond Normal Uncertainty

Errors in input physical properties cause errors in fractions and flow rates:

- With low GVF fluids, both phases are appreciably affected
- With wet gas / high GVF fluids (80%+ GVF), significant errors in input properties have only limited effect on calculated GVF – errors generally less than +/- 2% - but substantial impact on calculated oil VF and rate
- As meter pressure increases so does resulting error in oil or gas VF and rate
- Similarly, oil or gas VF error increases with gas volume fraction

Inaccurate fluid properties lead to errors



Errors in input physical properties cause errors in fractions & total flow rates:

- **Errors in multiple input properties may partially offset each other but create the risk of very high total errors**
- **A resulting error in total bulk density (computed from the phase fractions and densities) leads to errors in calculated total flow rate as well as phase rates**

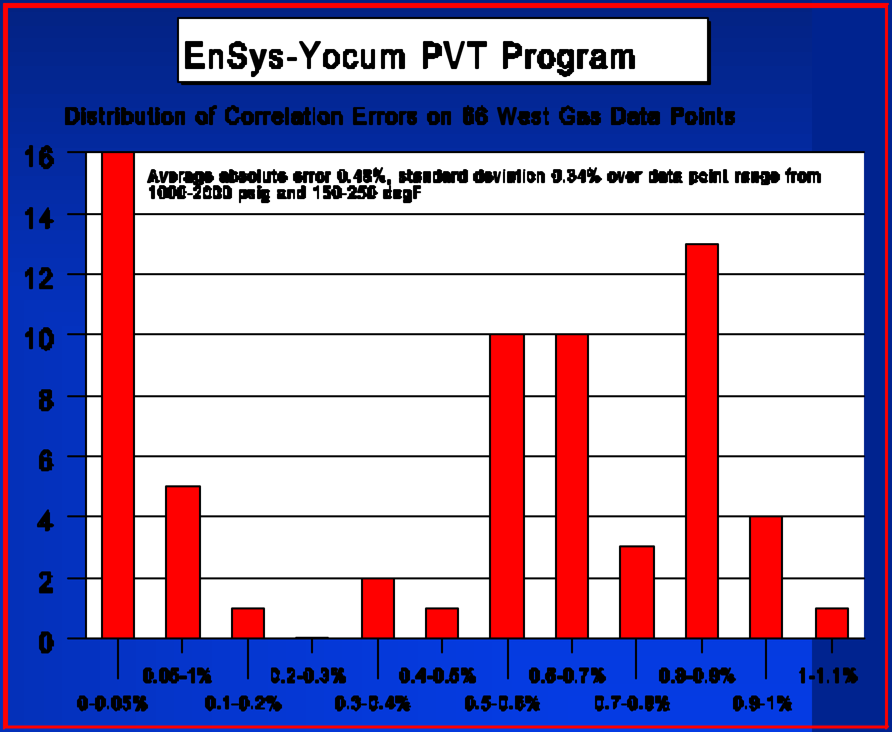
90% GVF Fluid	*Gas density error*		*oil density error*	
	7%	15%	7%	15%
Mass flow rate error	+ 3%	+6.5%	+ 0.3%	+0.7%

Sources of PVT data uncertainty

- Reservoir fluid laboratory PVT "assay"
  - the most accurate source of fluid property data
  - uncertainty +/- 1% to +/- 5%
- Compositional analyses plus Equation of State modeling or incomplete assay
  - uncertainties on phase densities go to 10-15%
- Produced fluid properties drift over months
  - GOR and Watercut
  - due to differential zone depletion and gas coning

Sources of PVT data uncertainty

- Curve fitting / regression of properties against P,T
  - typical errors (EYI regression model method)
  - gas/condensate good data
    - +/- 0.5-1 %
  - black oil good data
    - +/- 1-2 %
- what about poor data?



Methods to reduce PVT data uncertainty

- Reservoir fluid assays
  - multiple samples, repeat sampling - costly
- Partial data / EOS modeling
  - field sampling to update and anchor base PVT data ($$)
  - on-line compositional analyses linked to fluid assay
- Corroboration through:
  - PTQ simulation across total field:
    - rate accuracy +/_ 2-3% for wells
    - 4-10% for surface facilities including flow lines and separators
  - Reconciliation against fiscal meters
- Water Has High Current Uncertainty

Summary Thought!

- Multiphase Meters **Require good quality fluid assay data** to:
  - minimize errors
  - allow Reference Meter comparisons
- **Good quality fluid assay data with updating allow Multiphase flow predictions from Models**
- Perhaps we can skip the Multiphase Meter!
- **Can Customer $$ be better Spent on PVT Meters and their Uncertainty Reduction ?**
- **Is the optimum configuration hardware metering integrated with PVT/PTQ simulation metering?**

Where Should Oil Companies Put Deep Water Metering Money?