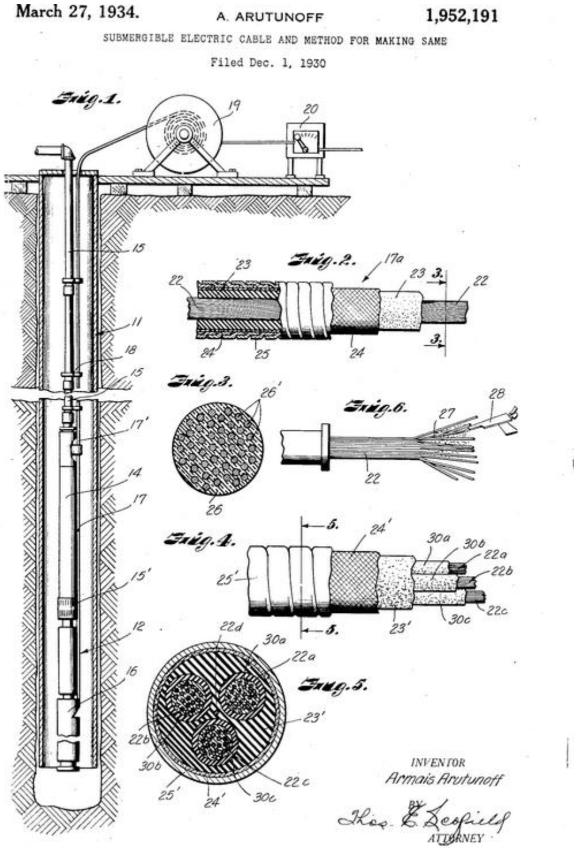
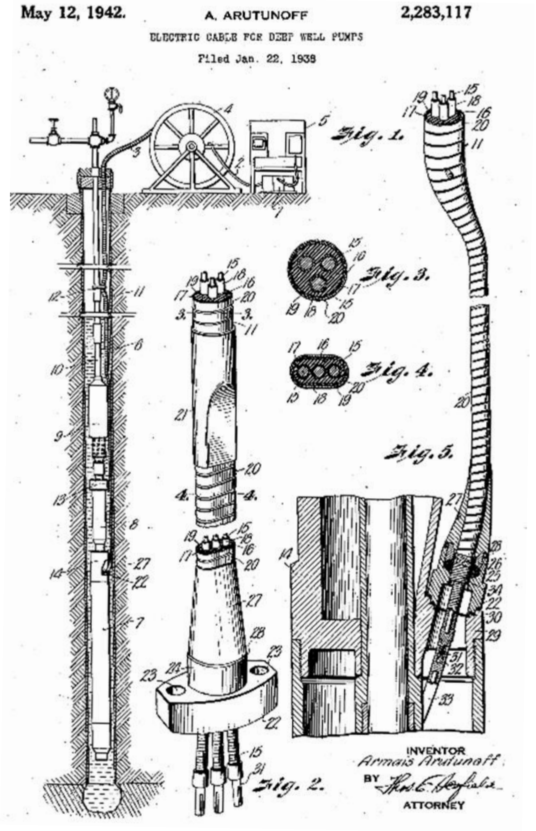
Permanent Magnet Motors

Operator Panel Session

Arutunoff Patents: 1934 & 1942





Panel Session Members

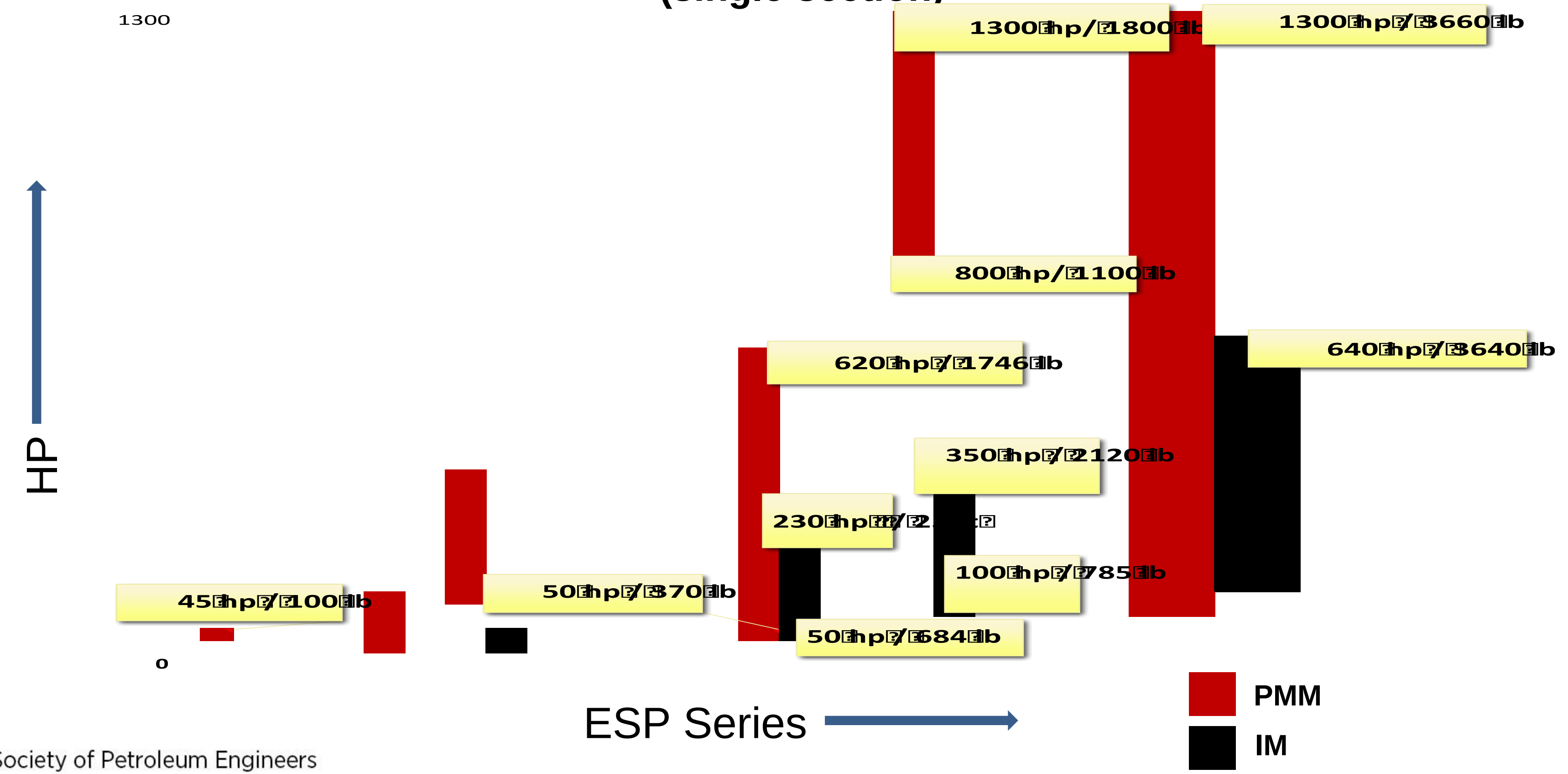
• Dennis Harris	Chevron
• Richard Delaloye	ConocoPhillips
• Jake Lucas	Merit Energy
• Edward Rubiano	Oxy
• Lanre Olabinjo	Chevron
• Cyril Girard	Statoil
• Chris Shaw	Shell

Operator Experience with PMM

- PMM: Another tool in the engineers tool box to effectively, efficiently and economically produce reserves
- Operator Applications: current, planned & conceptual
  - Why?
  - Where?
  - When?
  - Successes and challenges?
  - Future plans and concepts?
- No IP, no commercial content !

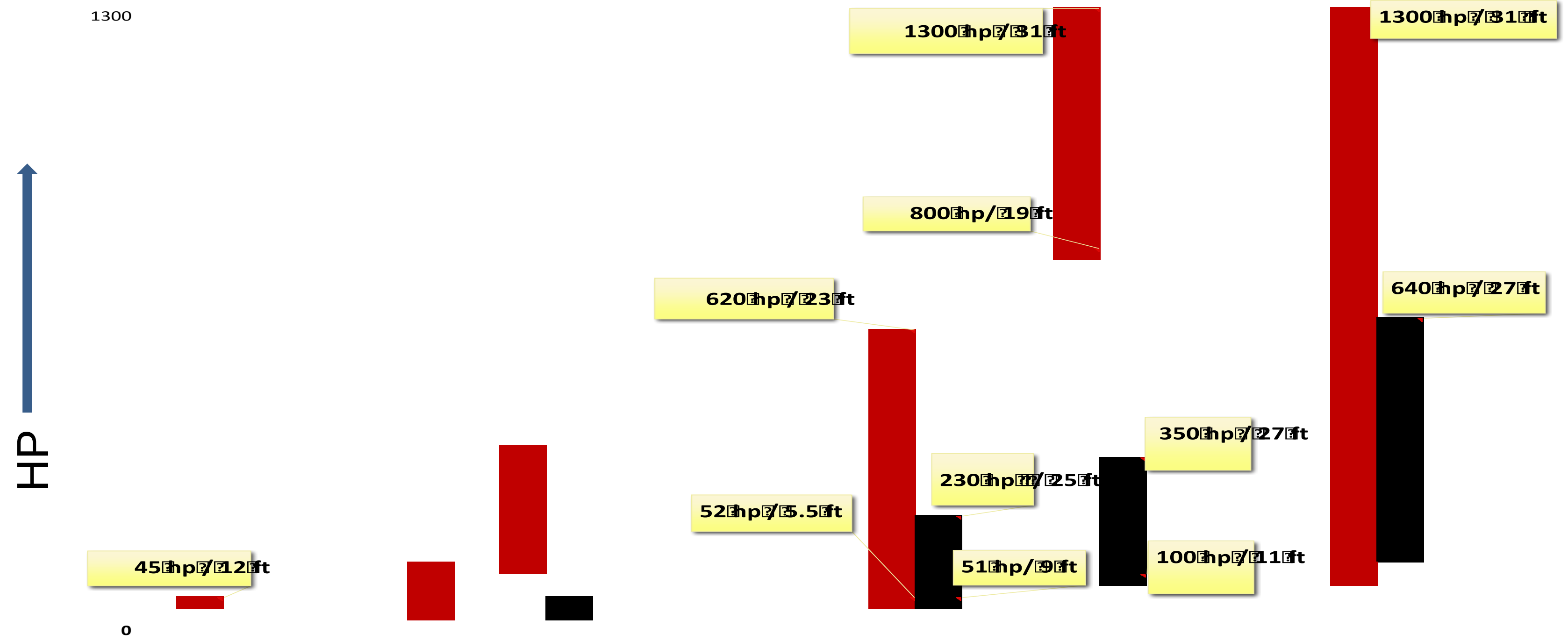
IM vs. PMM and Weight

(single section)



IM vs. PMM and Length

(single section)



ESP Series →

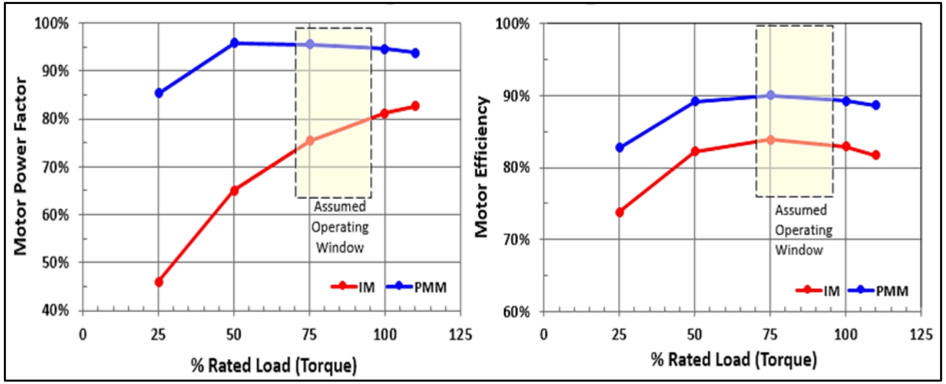
Permanent Magnet

Induction

Are the Energy Savings Valid?

- Is the time for trials and pilots over?
  - SPE-185129-MS
  - Know your application objectives
  - Design the complete system

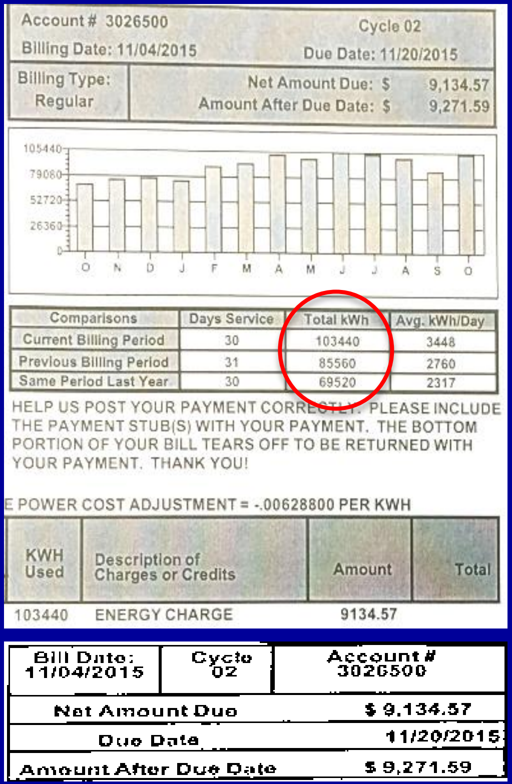
$/kWh savings
Reduced well construction cost
Reduce intervention cost



	Vendor-1 IM	Vendor-2 PMM	Vendor-3 PMM	Vendor-4 PMM
Motor cost	1.00	0.92	0.57	1.87
HP	**1.00**	**0.81**	**1.27**	**1.86**
SubSurface Equipment	1.00	0.63	0.63	0.62
Surface Equipment	1.00	0.99	0.79	1.12
Total Equipment	1.00	0.85	0.73	0.92

Industry Example of Actual Power Savings = 27%

Kay Electric Cooperative Blackwell, Oklahoma



Account # 3026500 Cycle 02
Billing Date: 11/04/2015 Due Date: 11/20/2015

Billing Type: Regular	Net Amount Due: $	9,134.57
	Amount After Due Date: $	9,271.59

Comparisons	Days Service	Total kWh	Avg. kWh/Day
Current Billing Period	30	103440	3448
Previous Billing Period	31	85560	2760
Same Period Last Year	30	69520	2317

HELP US POST YOUR PAYMENT CORRECTLY. PLEASE INCLUDE THE PAYMENT STUB(S) WITH YOUR PAYMENT. THE BOTTOM PORTION OF YOUR BILL TEARS OFF TO BE RETURNED WITH YOUR PAYMENT. THANK YOU!

E POWER COST ADJUSTMENT = -.00628800 PER KWH

KWH Used	Description of Charges or Credits	Amount	Total
103440	ENERGY CHARGE	9134.57	

Bill Date: 11/04/2015	Cycle 02	Account # 3026500
Net Amount Due		$ 9,134.57
Due Date		11/20/2015
Amount After Due Date		$ 9,271.59

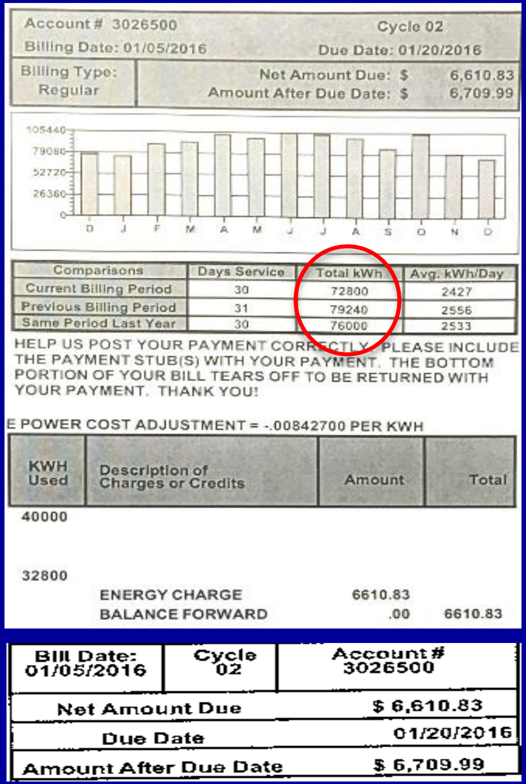
Oct'15
Pre-Work
2500 BFPD

8.8 ¢ / kWh

41.4
kWh/BF

- - -

$3.65/ BF



Account # 3026500 Cycle 02
Billing Date: 01/05/2016 Due Date: 01/20/2016

Billing Type: Regular	Net Amount Due: $	6,610.83
	Amount After Due Date: $	6,709.99

Comparisons	Days Service	Total kWh	Avg. kWh/Day
Current Billing Period	30	72800	2427
Previous Billing Period	31	79240	2556
Same Period Last Year	30	76000	2533

HELP US POST YOUR PAYMENT CORRECTLY. PLEASE INCLUDE THE PAYMENT STUB(S) WITH YOUR PAYMENT. THE BOTTOM PORTION OF YOUR BILL TEARS OFF TO BE RETURNED WITH YOUR PAYMENT. THANK YOU!

E POWER COST ADJUSTMENT = -.00842700 PER KWH

KWH Used	Description of Charges or Credits	Amount	Total
40000			
32800			
	ENERGY CHARGE	6610.83	
	BALANCE FORWARD	.00	6610.83

Bill Date: 01/05/2016	Cycle 02	Account # 3026500
Net Amount Due		$ 6,610.83
Due Date		01/20/2016
Amount After Due Date		$ 6,709.99

Dec'15
Post Work
2300 BFPD

9.1 ¢ / kWh

31.5
kWh/BF

- - -

$2.87/ BF

Savings of
$.78/BF

Alaska North Slope Application

Benefits

- PMM reduced weight and length enables deployment with wireline.
- Potential to reduce rig intervention and production delays.

Alaska North Slope Deployments

- Early deployment challenges included electrical and mechanical issues
  - Resolved and corrected through key design changes
- Multiple successful wireline pull/replace and startup of new motor and pump

Wyoming Application

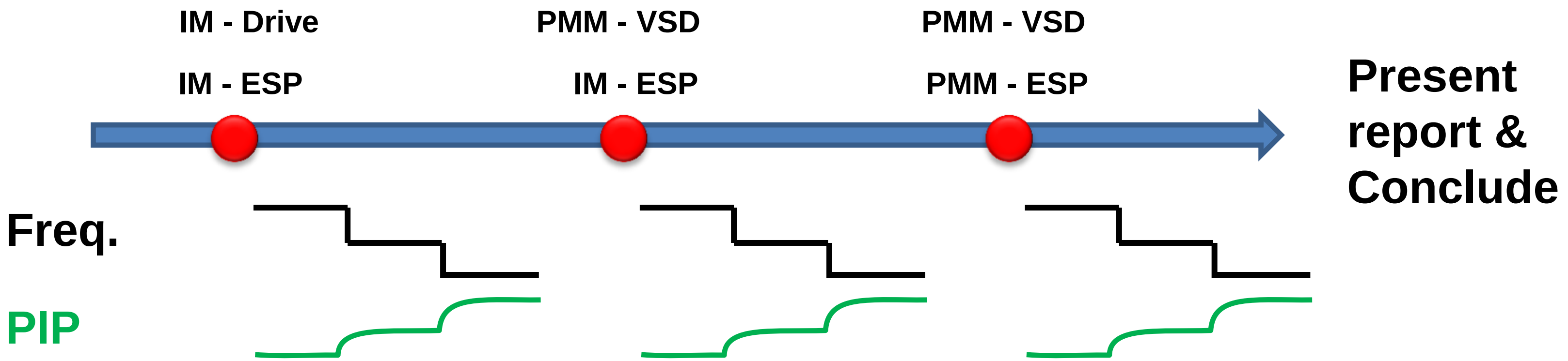
- Big Horn Basin/Wind River Basin North Central Wyoming
  - 1200 Producing Wells
  - DDP and Water-flood are main production drivers
- 4 Permanent Magnetic Motors installed March 2017 as trial
- 2 phases of the trial
  - Compare modeled electrical usage to actual (completed)
  - Assessing longevity of motors and issues during operations (in progress)

Wyoming Application

- Asset Challenges:
    - High water cut ~99%
    - Slim Hole/Highly Deviated Wellbores
- PMM Challenges
    - Logistical Issues
    - Cost Prohibitive
- Benefits:
    - Electrical Efficiencies
    - Design Advantages
    - Decreased Operating Temperature
    - Power Reduction Incentive

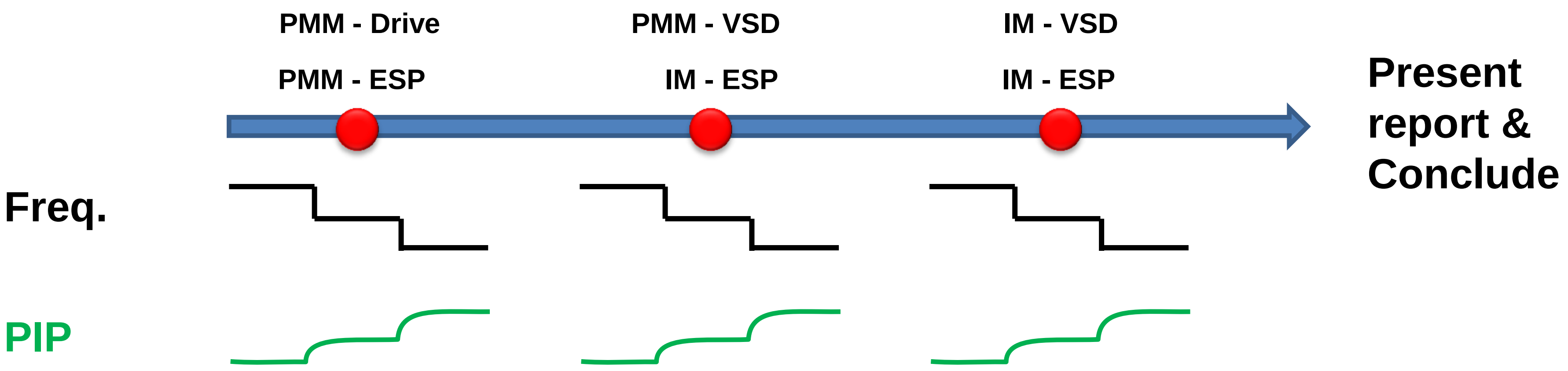
Oxy onshore

- **Energy Consumption – test 01**
  - IM to PMM (Using same ESP pump) – low flow
  - Install three PMM



Oxy onshore

- Energy Consumption – test 02
  - PMM to IM (Low flow, mid flow and High flow)
    - PMM installed with no proper measurements to compare with.



Offshore West Africa Application

- Average ESP run life +5 years, average production ~1000 BPD
- Delayed production after failure 6 – 15 months
- Intervention costs increasing, avg. $10 MM
- PMM permits Alternative Deployment & Intervention:
  - Reduced intervention time to ~2 month
  - Reduced intervention cost to ~$1.5 MM
  - Fits existing infrastructure (slickline w/ majority gas lift wells)

Offshore West Africa Application

- Challenges:
  - Increasing tubing from 2-7/8” to 4-1/2” inside 7”, 29# liner
  - Considerations & plan for possible 20 year, non-rig interventions
- Actions taken:
  - Changed well head
  - Changed clamp style to fit inside tight casing
  - Factory spliced MLE to ESP cable (improve reliability, reduce rig time, reduce size of splice, designed custom splice clamp)
  - Numerous fit tests and equipment adjustments for assurance
  - Coordination with in-country staff
- Project started 2013 w/ installs April 2017

Statoil

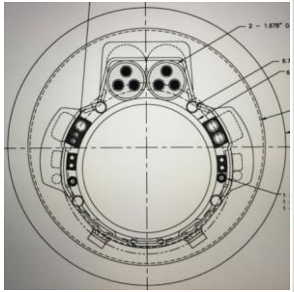
- **PMM to drive ESPCP, Russia (Technology)**
- **PMM for Shale, USA land (OPEX, Well geometry)**
- **PMM deployed by Wireline (retrofit)**
- **PMM for Engineered ESP (Runlife)**
- **PMM benefit in general**
  - **15%** lower operating current
  - **14%** higher power factor
  - up to **85%** lower idle current
  - up to **10%** less power consumption
  - Decreased motor heating by **20-25%**
  - Motor is shorter and lighter by up to **60%**

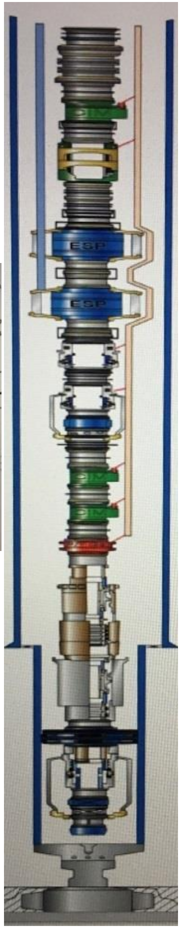
Deep Water ESP "Base Case"

- "Testing In-Well Dual Canned ESP Completion System"

  (OTC – 26002 – MS, 2015: Tijerina, Baker; Pardo, Hope, Chevron)

- Twin 1200 HP ESP (triple x 400 HP)
  - Length: 3 x 35 = 105 ft x 2 = 210 ft.
  - Weight: 3 x 2,500 = 7,500 lb.





- Possible PM Motor alternative?
  - ~ 35 ft, ~ 2,000 lb single section
  - Reduced completion complexity, fewer connections
  - Potential to reduce casing size?
  - Possibly higher RPM and alternative intervention?

Deepwater Subsea

- Challenges:
  - High Failure Frequency
  - High intervention costs
  - Intervention delays (deferment)
- Base Case: OTC-26002-MS Dual Canned ESPs
  - High complexity, high workover cost
  - Tree Preferences (Hz vs. Vertical)
  - Casing Program

Deepwater Subsea

- New Thinking:
  - Low Cost Intervention
    - Thru Tubing Installation
    - Thru Tree
    - Cat B Rig
  - High Reliability ESP rated 20 ksi and 350F
    - Failure rate 2 yrs @ 90%, (5 yrs at 50%)
    - Single ESP 4.5” CT Suspended inside 6” 39# 4.962” id with 6-5/8” can at set depth
    - PM Motor 700 HP at 4500 rpm, 5kV and 90A

Conclusions

- Benefits & Opportunities
  - Higher power density
  - Energy efficient
  - Shorter, lighter
  - Higher HP for single sections
  - Reduce well construction cost?
  - High speed (> 6,500 rpm)?

- Potential Applications:
  - Where ALS is challenged
  - Slim line, reduced casing
  - High DLS, S-curve
  - Cable deployed
  - Alternative deployment / intervention
  - Offshore / Deepwater interventions & reduced cost

Conclusions

- Limitations / Challenges
  - VFD compatibility
  - Integrating communication, automation, optimization
  - Safety issues?
  - Limited services, small western footprint, limited inventory

Operator Experience with PMM

- Message to other Operators
  - PMM deployed successes and application opportunities
  - Encourage new product development
  - Are Pilots and Trials still necessary?
- Message to Vendors / Suppliers
  - Improve reliability, marketing, service & equipment availability.
- General Message:
  - Advance PMM technology awareness & adoption
  - How to reduce operator costs thru economies of scale

SPE Electric Submersible Pumps Symposium
24–28 April 2017
The Woodlands Waterway Marriott Hotel & Convention Center
The Woodlands, Texas, USA

Thank You!
Questions for Operators?