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daniel bernoulli

**Focus on 29th International
North Sea Flow Measure-
ment Workshop, Southeast
Asia, Shale Oil**

Q3 2011



Flow Research, Inc.



*Multiphase Flow Loop at
Christian Michelsen Research*

Oil & Gas and Refining Power & Renewables

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Energy Monitor

Q3 2011

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Energy Monitor Q3 2011

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Table of Contents

Issues & Perspectives: North Sea Workshop . . . 9

Complex but promising multiphase flow on the rise . . . 9

Global Spotlight: Southeast Asia . . . 16

Obama says fast-growing Asia-Pacific will largely define the rest of the century; Countries seek help with oil claims . . . 16

Clinton talks trade investment at the ASEAN Summit — U.S. competing with China to develop southeast Asian markets . . . 17

Investors size up trade in Myanmar following Clinton's visit . . . 18

Japan commits \$26B to aid ASEAN infrastructure projects . . . 19

Southeast Asia — a ready market for natural gas . . . 20

Oil & Gas, and Refining . . . 22

In the News . . . 23

Libya close to 700,000 barrels a day in fast-paced recovery . . . 23

Libya resumes Italian gas exports . . . 23

Winter natural gas futures prices at lowest levels since 2001-2002 . . . 24

North Dakota now the fourth largest oil-producing state in U.S. . . . 24

Subsea market to more than double by 2016, predicts expert . . . 25

Enbridge to acquire ConocoPhillips' interest in Seaway Crude Pipeline System for US\$1.15B . . . 25

Poll supports Canadian oil to U.S. . . . 26

U.S. oil and gas industry invested \$71B in reducing greenhouse gas . . . 26

(Continued on page 6)

Table of Contents, continued

Upcoming Trade Shows . . . 27

Industry Pulse . . . 28

Is shale oil — not *gas* — the new U.S. energy boom? Keep an eye on the Niobrara oil shale play . . . 28

Shale oil saps African crude exports as Libya returns . . . 30

U.S. petroleum demand shows growth as deliveries rise . . . 31

Petroleum demand grows . . . 31

New Projects . . . 32

North America

BHP Billiton to spend \$4.5 billion on shale gas in 2012 . . . 32

Nebraska to help define new Keystone XL pipeline route . . . 33

Seaway Pipeline from U.S. Gulf Coast to Cushing, Oklahoma to reverse by early 2013 . . . 34

Enbridge to expand access to eastern markets for western crude oil . . . 34

Enbridge announces Bakken access expansion program . . . 35

Nexen and Inpex in Canadian shale gas agreement . . . 36

Asia-Pacific

Tokyo to build natural gas facility . . . 36

Mideast

PETRONAS resumes digging third well in Gharaf Oil Field . . 36

Africa

Libya seeks UK firms to develop oil and construction industries . . . 37

Company Korner: CMR Instrumentation . . . 38

Christian Michelsen Research AS — an R&D multiphase flow measurement force and resource for more than 30 years . . . 38

Power & Renewables . . . 40

In the News . . . 41

U.S. wind and biofuel consumption on the rise . . . 41

Renewable energy is used in all sectors of the U.S. economy . . . 42

WMO report says greenhouse gases reached new high in 2010 . . . 43

Novozymes opens Brazil bioenergy lab for enzyme products . . . 45

Upcoming Trade Shows . . . 46

Industry Pulse . . . 47

Geothermal's best growth potential in U.S. is in West . . . 47

U.S. hydropower output varies dramatically year to year . . . 50

Table of Contents, continued

New Projects . . . 51

North America

SolarStrong expected to build more than \$1B in solar projects . . . 51

Latin America

Pattern to build first commercial wind project in Puerto Rico — largest in Caribbean . . . 51

Skanska to build gas-fired thermal power plant in Rio . . . 52

Pattern signs PSA for largest wind project in Chile . . . 52

Africa

Bank of America Merrill Lynch funds fuel venture in Mozambique . . . 53

Asia-Pacific

Japan to build two nuclear reactors in southern Vietnam . . . 53

Europe

Major investment in Scottish wave energy from Alstom . . . 54

Company Korner: Juhl Wind 55

Wind power pioneer Juhl Wind announces historic year — revenue up 276% in Q3 and up 245% over nine months . . . 55

About Flow Research, Inc. . . . 57

(Continued on page 6)

Table of Contents, continued



Boulder Canyon, Boulder, Colorado

Photo by Flow Research

The **Energy Monitor** is part of the Worldflow Monitoring Service. Other publications include the **Market Barometer** and **Flash Reports**. **Worldflow Online** provides more in-depth information and analysis about the instrumentation business. Here is our **Worldflow** schedule:

Q3 2011

Market Barometer—October 2011

Energy Monitor—December 2011

Q4 2011

Market Barometer—December 2011

Energy Monitor—January 2012

Q1 2012

Market Barometer—February 2012

Energy Monitor—March 2012

Q2 2012

Market Barometer—April 2012

Energy Monitor—May 2012

Issues and Perspectives: North Sea Workshop

Complex yet promising multiphase flow on the rise

By Jesse Yoder, PhD, Flow Research

The future of multiphase flow measurement appears brighter than ever, according to discussions with manufacturers at the 29th International North Sea Flow Measurement Workshop, held October 25-28 in Tønsberg, Norway, about two hours south of Oslo. The workshop, one of the most significant events in the world of flow, alternates each year between Norway and Scotland.

Attending a conference like the North Sea Flow Workshop in Norway makes it clear how truly international the flowmeter business has become. The 330 delegates from 29 countries as far-flung as Singapore, Oman, India, Nigeria, Brazil, Slovakia, as well as multiple European countries and the U.S. show not only the effect of globalization, but also the internationalization of flow research and development. In fact, much of the intellectual work being done to develop new products and flowmeter theories is done in multiple locations around the world. Even the development of the Elster's Q.Sonic Plus ultrasonic flowmeter was done by engineers and developers located around the world who communicated virtually online.

The workshop clearly had the flavor of a conference rather than an exhibition. While the event did feature exhibits from a number of flowmeter suppliers and some research institutes, the main focus of the workshop was the papers delivered on various topics related to flow. Nearly all the papers related to multiphase or ultrasonic flowmeters, although several were given on Coriolis flowmeters as well.

Multiphase flowmeter manufacturers were well represented at the workshop. Certainly the application remains one of the most complex to address, while at the same time successfully doing so holds the promise of large benefits for both suppliers and end-users.

Multiphase flow measurement began in the North Sea oil fields

Norway has become a center of product and development for multiphase and ultrasonic flowmeters because of the presence of Christian Michelsen Research (CMR) in Norway and the National Engineering Laboratories (NEL) in Scotland. The Christian Michelsen Institute did the research from 1982 to 1985 to create the Fluenta flare gas meter, and in 1985 actually founded Fluenta, now owned by Roxar, a unit of Emerson.

Today a number of multiphase companies call Norway home, including Roxar (Stavenger), MultiPhase Meter (MPM) (Stavenger), Framo Engineering (Bergen), and Abbon (Rud). Chris-

(Continued on page 10)



Jesse Yoder at North Sea Flow Measurement Workshop, Norway

Issues and Perspectives: North Sea Workshop

(Continued from page 9)

tian Michelsen Research itself is located in Bergen.

Multiphase flowmeters are used in oil and gas production to determine the mixture and amount of oil, gas, and water coming out of the well. This measurement used to only be possible after the fluids were physically separated. Multiphase flow measurement began in the area of the North Sea when the prospective decline in production of the North Sea oil fields made it necessary to find a way to analyze the increasing amounts of gas and water that were becoming a greater part of the fluid from the wells. Several research projects were undertaken at that time to develop multiphase technology that could provide this analysis on fluids as they came out of the wells.

How multiphase flowmeters work

The majority of multiphase flowmeters make a combination of measurements, including temperature, pressure, and differential pressure. They also typically use a nuclear source, usually gamma rays, to help determine the properties of the fluid. Some multiphase flowmeters use a high-energy gamma ray source, and others use a low-energy source of gamma rays. Some companies use both high- and low-energy gamma sources in their multiphase meters.

Most multiphase meters have a Venturi tube incorporated into the device. Bernoulli's theorem is then used to compute flowrate, as with other differential pressure (DP) flow devices. Density

(Continued on page 11)



View from the Quality Hotel Tønsberg, venue for the North Sea Flow Measurement Workshop October 25-28, Norway Photos by Flow Research

Issues and Perspectives: North Sea Workshop

(Continued from page 10)

is determined with a combination of temperature, pressure, and DP measurements. The gamma ray technology is used to determine the percent of gas, water, and oil that make up the fluid at the point of measurement. By combining these percentages with the DP flowrates, the amount of flow of each fluid type can be determined.

Benefits of multiphase flowmeters

Multiphase flowmeters have multiple advantages:

- They reduce the need for hardware installed on topside (onshore), offshore, and subsea applications. Because they reduce or eliminate the need for dedicated test separators by measuring flow at the wellhead, multiphase meters save on platform space and make it possible to drill with a smaller equipment footprint.
- Multiphase flowmeters make it unnecessary to individually test the performance of each individual well, since the data from a multiphase meter can provide similar data. This is especially important for subsea applications where the well testing flowlines can be especially long. Multiphase meters can reduce or eliminate the need for separate well-testing lines.
- Multiphase meters provide important data about the well itself. Changes in the gas/oil ratio can be detected more quickly in a realtime basis, while test separators provide slower response with fewer data points.
- Multiphase meters are useful for allocation metering situations, where the produced fluids must be commingled and sent to a processing facility. Without multiphase meters, the fluid from each well has to be sent through a test separator before being sent to the processing facility.

Leading multiphase flowmeter companies represented at the workshop

Below are product overviews from three leading companies that were represented at the workshop:

Roxar AS (a unit of Emerson Process Management)

Roxar has long been considered the leader in delivered product volumes, but has lately experienced a significant challenge for the top spot by Schlumberger. Roxar's technology model has been based upon that of Fluenta AS, a 2001 company acquisition. Fluenta had specialized in multiphase metering technology.

Roxar's newest multiphase flowmeter, the MPFM 2600, represents the third generation of their technology. The device can



Roxar's MPFM 2600

(Continued on page 12)

Issues and Perspectives: North Sea Workshop

(Continued from page 11)

be configured as a non-radioactive design for use in most applications, but does have an optional compact gamma density system available (where the GVF exceeds 95 percent) that can be field retrofitted. The meter was tested statically and dynamically in partnership with Christian Michelsen Research Instrumentation. Other design testing has been conducted by TÜV SÜD and CEESI laboratories. Field operation studies are now being performed.

Framo Engineering AS (a wholly owned company of Schlumberger Ltd)

In November 2007, Schlumberger became a majority owner of Framo Engineering and in June 2011 announced the acquisition of the remaining equity shares from Frank Mohn AS. Schlumberger announced that the combination of Schlumberger's subsea flow assurance and surveillance capabilities with Framo Engineering's subsea multiphase boosting and metering capabilities was an important step in the development of subsea technologies and solutions.

The Framo multiphase meters have established a firm niche in the subsea and topside market due to their technological robustness, accuracy, and flexibility. The company's proprietary Vx technology is used to monitor and optimize petroleum product reservoirs, and Framo considers Vx technology to be their primary distinguishing technical asset. The technology is also widely used for allocation processes with significant fiscal implications for operators and host country governments. The company says its Vx flowmeters were the first multiphase flowmeters used for fiscal production measurements.

The Vx technology uses sophisticated flow models and nuclear detector technology for high-quality, dynamic multiphase flow measurements. A specifically designed Barium-133 source and a smart detector operate at gamma ray energy levels that are as low as possible. The continuous well test data helps diagnose production anomalies, resolve problems, and maximize production efficiency.

Multi Phase Meters AS (a wholly owned company of FMC Technologies)

In October 2009, FMC acquired Multi Phase Meters AS (MPM), based in Stavanger, Norway. MPM was known for the development and manufacturing of high-performing multiphase flowmeters. The MPM product line was combined with FMC's Increased Oil Recovery (IOR) portfolio of technologies to offer a broader range of solutions for oil and gas customers.

MPM is now the brand name for a collection of multiphase-related products, including patented technology. MPM delivers high accuracy, self-calibrating, low maintenance multiphase meters. The meters offer consistent ac-



MPM's solutions for wet gas and crude oil applications

(Continued on page 13)

Issues and Perspectives: North Sea Workshop

(Continued from page 12)

curacy over the full operating range of a well, regardless of gas fraction, water cut, or fluid composition. The meters require virtually no maintenance and are constructed for a 25-year plus lifetime at extreme conditions. The MPM meters are manufactured for topside or subsea installations, and are available for multiphase, wet gas, or combined (dual) modes.

MPM's technology is based on 3D tomography using high frequency and broadband transceivers in combination with high rate data processing capabilities. A salinity measurement allows for water formation detection capabilities. In addition, a delivered device can include MPM's "Droplet Count" enabling very accurate measurements at ultra high GVF's, typically in the range from 99 percent and above.

Findings from papers at the workshop

Papers presented at the North Sea Flow Measurement Workshop included the following findings:

- A universal Venturi meter wet gas correlation that encompasses a wide range of wet gas flow conditions could benefit the industry significantly, according to Rick de Leeuw from Shell and Richard Steven from CEESI, who presented an independent review and offered ideas for future development. ISO has issued a report containing a new Venturi wet gas correlation called TR11583. The authors of this paper believe that this report is misleading and should be withdrawn.
- Contrary to popular industry belief, the response of an orifice meter to multiphase wet gas flow is more predictable than the response of many other gas meters, according to Richard Steven, CEESI; Gordon Stobie, ConocoPhillips; and others. Their research shows that orifice meters are useful as simple, inexpensive wet gas flowmeters.
- Confidence in multiphase technology is still an issue, and operators and suppliers need to continue to address issues involved, especially in high water depths, according to Total.
- The majority of custody transfer flowmeters are operating under conditions different from those in the calibration or verification lab. They are affected by temperature, pressure, viscosity, and environmental conditions as well as by upstream piping configurations. An approach based on design, diagnostics, and calibration can reduce performance uncertainty, according to André Boer and others from KROHNE.
- Applying a "Prognosis" diagnostic system can increase confidence in the integrity of DP measurements for wet gas with Venturi meters, as well as shifts in the liquid loading, according to Swinton Technology. Petronas and Centrica are applying the diagnostic technology on wet natural gas flow metering applications.
- A study in Aracaju, Brazil showed that a multipath ultrasonic liquid custody transfer flowmeter could tolerate a high percentage water cut and significant amount of gas entrainment, according to Shirley Ao, GE Energy Services.
- Traditionally, multiphase flowmeters are installed vertically downstream from a T-bend for

(Continued on page 14)

Issues and Perspectives: North Sea Workshop

(Continued from page 13)

the most homogenous and predictable flow. New techniques with multibeam gamma-rays and electrical capacitance and resistance tomography allow success in non-vertical installations, which can be important for down-hole metering. The University of Bergen carried out tests at Christian Michelsen Research.

- Companies can realize large cost savings at allocation metering stations by using two liquid ultrasonic meters in series and omitting a prover, valves, and parallel metering tubes, according to a paper from Statoil. Using two ultrasonic meters also improves monitoring and increases calibration intervals, they maintain.
- Proving performance with turbine and ultrasonic can be improved by using flow conditioning techniques with appropriate sample and output update rates, according to Cameron's Caldon Ultrasonics and Cameron.
- Improvements in ultrasonic meter electronic design can enhance field proving techniques and optimize system design, according to Daniel Measurement and Control.
- One transducer no longer fits all ultrasonic applications, according to FMC Kongsberg Metering. Capitalizing on advances in electronics, signal processing, and software can help transducers optimize performance in a variety of conditions for both gas and liquids.
- Meters should be calibrated in similar conditions to their use, according to NEL. A conventional liquid flowmeter such as a helical blade turbine meter, for instance, needs to be adapted if it's moved from low to high viscosity conditions.
- Can calibration of ultrasonic meters move to an as-needed basis based on indications from a "condition-based" monitoring system? — Jim Witte from El Paso, and Elster
- Corrosion and contamination in the field can change the geometrical parameters of a pipe and alter the flow profile, affecting the accuracy of ultrasonic flowmeters. However, certain diagnostics can generate information that helps the user decide if they need to extend the recalibration period or act quickly to restore accuracy, according to SICK and KEMA.
- CEESI has developed a mathematical model using a database that helps determine how frequently a particular ultrasonic meter should be recalibrated. At the moment, Canada requires recalibration every five years, but most regulatory agencies don't specify a time period.

What it means

The workshop is, in part, an annual showcase of the latest oil & gas extraction process technologies, and a forum for the discussion of how well applications are being met by available solutions. Multiphase technology promises significant benefits to well operators. Multiphase metering, however, is an application that presents some of the most complex issues to users and manufacturers hoping to solve them. The history of multiphase metering extends back 30 years, and yet fewer than one percent of world's wells are equipped with the technology.

(Continued on page 15)

Issues and Perspectives: North Sea Workshop

(Continued from page 14)

Multiphase flowmeters today – complex instruments combining multiple technologies – demand that the operator be well-versed in the physics of the instrument in addition to its construction, installation, and use. In today's employment world, the lack of a large engineering resource familiar with flow and flow technologies is a serious concern to multiphase flowmeter suppliers, as the field performance of their devices is so dependent on the operators' adaptability and their ability to configure the instrument within a dynamic application.

We see two fundamental trends occurring in the multiphase world that are the direct results of the low adoption rate of the technology and the sophisticated and complex technologies that are employed.

The first trend involves how the technology is delivered. Multiphase meter manufacturers are increasingly looking to use product leasing and service contracts as ways of maintaining a continuing presence when their devices are deployed in the field. In this way, they can offer their operational expertise to insure that the meter performs most closely to its design specifications when encountering the highly diverse changes that multiphase applications present.

Second, we have identified an extremely unusual trend where users have frequently inserted themselves into the new product development process as a way of, hopefully, achieving the benefits of multiphase metering through product designs best suited to their own application criteria. It is relatively rare that a design process is generated from the eventual user of the product, but has become practically commonplace in the multiphase metering environment. Such is the perceived potential reward to users of reliable, accurate multiphase flow measurement.

Applications are driving the research in flow measurement. In particular, energy applications are driving flow research. With the price of crude oil in the range of \$100 a barrel, and projected to go higher, companies are pouring millions of dollars into developing flowmeters that can measure both oil and gas with a high degree of accuracy. The flowmeters that can do this best are ultrasonic and Coriolis meters. If variable area meters could measure oil or gas as accurately and reliably as ultrasonic and Coriolis meters, companies would spend millions of dollars to develop them too.

The best advice for end-users or suppliers who would like to see more research and development dollars go into certain "neglected" meters like variable area and vortex is: "Develop some high value applications, and companies will flock to your door." Vortex meters have already done this to some extent with steam flow applications.

Companies are putting money into developing multiphase meters not so much because they do the measurement so well, but because the measurement is so valuable. Multiphase meters are at an early stage of their evolutionary cycle, and no doubt new technologies will emerge over time. In the meantime, companies are working hard to improve the existing technology. We have a long way to go with multiphase meters, and also with ultrasonic and Coriolis meters. Think of how different things looked ten years ago, then project ten years ahead. There are many new and exciting discoveries ahead in the flowmeter world.

Global Spotlight: Southeast Asia

Obama says fast-growing, Asia-Pacific will largely define the rest of the century; Countries seek help with oil claims

November 18, 2011 — U.S. President Barack Obama held talks Friday with Asian leaders attending the East Asia Summit in Bali, Indonesia. This is the first time that the United States and Russia attended the East Asia Summit as full members. Bali is the last stop on Obama's nine-day Asia-Pacific trip.

Obama's trip has focused on expanding economic ties with the soaring Asia-Pacific market and boosting the U.S. military posture in the region. Nuclear nonproliferation, disaster relief, and maritime security also are U.S. priorities.

Leaders of smaller Asian nations are increasingly alarmed over China's claims to maritime passage and rich oil reserves in the South China Sea.

Obama met with leaders of Asian countries that seek U.S. support in their territorial disputes with China over the South China Sea.

Obama told Australia's parliament in Canberra that developments in the Asia-Pacific region will largely define the century ahead and that the U.S. presence there is his administration's top priority.

He also announced a new military agreement that will allow more U.S. military aircraft and a rotating presence of U.S. Marines into Australia, a move largely seen as a hedge against China, which immediately objected.



Obama's nine-day trip focused on both expanding economic ties with the soaring Asia-Pacific market and boosting the U.S. military posture in the region. He arrived in Bali after stops in Hawaii and Australia. The visit marked a homecoming to the country where he lived for four years as a boy after his mother married an Indonesian man and moved them to Jakarta.

During Obama's visit to Indonesia the White House announced the sale of Boeing 737s and General Electric engines to Indonesia, Boeing 777s to Singapore, and Sikorsky helicopters to Brunei. Obama officials estimated the moves would support 127,000 American jobs.

Obama said the U.S. and Indonesia also plan on signing a \$600 million pact supporting sustainable development, public health, and improved public services in Indonesia.

www.voanews.com and Associated Press

Global Spotlight: Southeast Asia

Clinton talks trade investment at the ASEAN Summit — U.S. competing with China to develop southeast Asian markets

Bali, Indonesia; November 18, 2011 — Secretary of State Hillary Clinton promoted U.S. economic engagement with Asia during the East Asia Summit in Bali. The secretary focused her public remarks on increasing economic ties to the region.

Creating more business opportunities and jobs for Americans is one of the main objectives of U.S. involvement, Clinton said in an address to a group attending an Association of South East Asian Nations (ASEAN) Business and Investment Summit held on the sidelines of the ASEAN Summit in Nusa Dua, Indonesia.

The Secretary of State said while trade between the U.S. and Southeast Asia has tripled over the last 20 years, it still accounts for only 6 percent of U.S. global trade. And **with the region home to some of the fastest economies in the world, rich in natural resources and growing domestic markets, the potential for American trade and investment opportunities is great.**

The United States however is competing with China to develop southeast Asian markets. ASEAN Secretary General Surin Pitsuwan says **China is currently the number one trading partner with ASEAN countries.**

“We have already reached \$300 billion a year towards trade. I think prime minister of China



U.S. Secretary of State Hillary Rodham Clinton hopes to increase business engagement in Southeast Asia. Although trade between U.S. and the region has tripled over the last 20 years, it is still only 6 percent of U.S. global trade.

Wen Jiabao has put the figure at \$500 billion for the year 2015, very ambitious, but things seem to be going in the right direction,” Clinton stated.

Secretary Clinton wants more opportunities for American firms to compete in this economic arena and wants ASEAN to reduce trade barriers and apply the same rules to all investors.

Clinton says the U.S. supports ASEAN efforts to develop a Trans Pacific Trade Agreement that would create a regional legal frame work for trade and investment and would include standards for worker protections and the environment.

www.voanews.com

Global Spotlight: Southeast Asia

Investors size up trade in Myanmar following Clinton's visit

Yangon, December 7, 2011 — Just hours after U.S. Secretary of State Hillary Clinton left Myanmar, property prices began to soar. The price hike reflects shoots of optimism among investors sizing up the resource-rich former British colony.

Many Western multinationals remain publicly cautious about the investment prospects of a country entangled in U.S. and European sanctions following years of human rights abuses. But now it is no longer a matter of whether the sanctions will be lifted, but when.

In interviews with Reuters, many executives said Clinton's November 30 to December 2 visit — the first by a U.S. secretary of state in 50 years — had radically altered the investment mindset even if companies had yet to say so publicly.

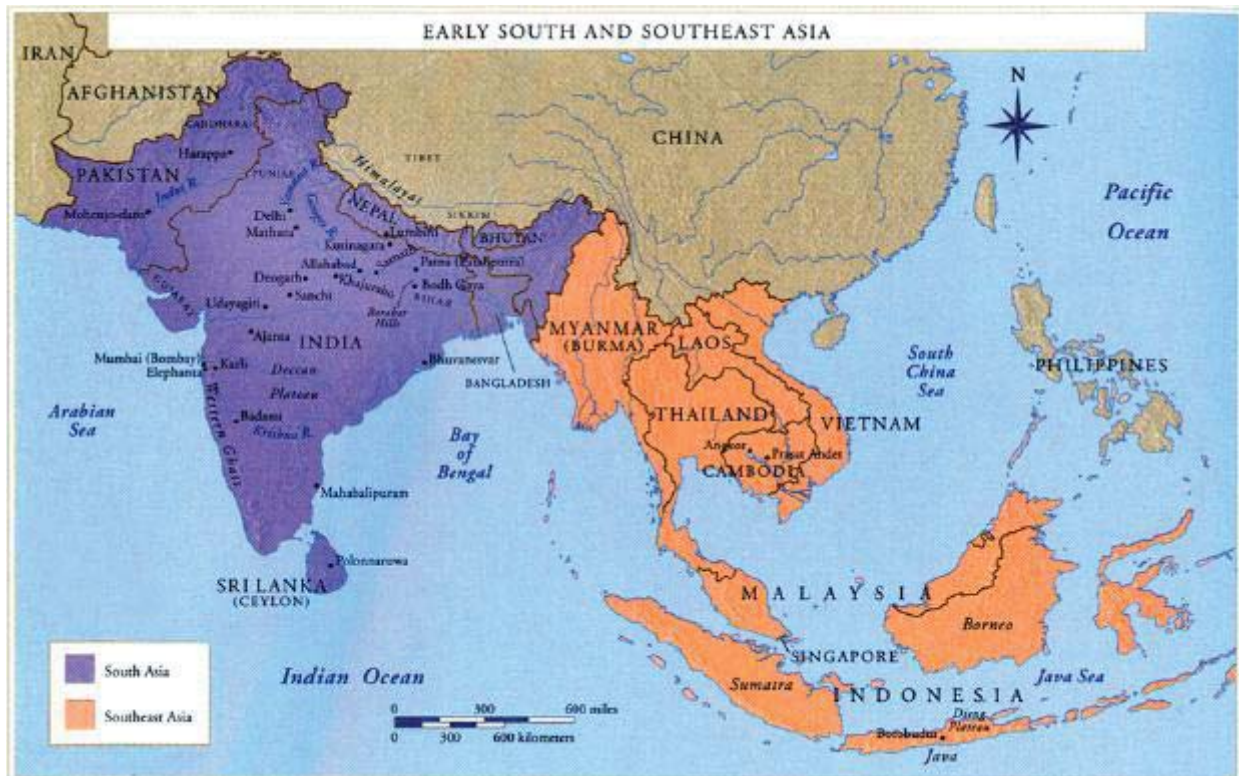
“It's a country that is very well placed in terms

of geography, in terms of demographics and in terms of timing,” Andrew Pullar, an investment manager with the Sentient Group, a resource-focused private equity outfit, said in Yangon.

Many of these executives expect sanctions to be gone by next year or by 2013 at the latest, opening up one of Asia's final frontiers — a country of 55 million people that was among the region's richest just half a century ago before the coup ushered in 49 years of disastrous and brutal military rule.

Myanmar sits strategically between India and China with ports on the Indian Ocean and Andaman Sea, all of which have made it a vital energy security asset for Beijing's landlocked western provinces and a priority for Washington.

(Continued on page 19)



Global Spotlight: Southeast Asia

(Continued from page 18)

Myanmar, whose sought-after resources include natural gas, timber, and precious gems, is **building a multi-billion-dollar port through which oil can reach a 790-km (490-mile) pipeline now under construction** with Chinese money and workers.

State-owned Myanma Oil and Gas Enterprise data showed Myanmar has 115 million barrels of onshore and 100 million barrels of offshore proven oil reserves. The proven onshore gas reserves are 400 billion cubic feet and offshore are 16 trillion cubic feet.

Chevron is among a handful of U.S. companies allowed to do business in Myanmar under a clause that excludes investments that began before sanctions were put in place.

Exxon Mobil Corp said it sees potential in Myanmar.

France's Total SA, which already has a project in Myanmar, has said it would like to play a bigger role pending concrete signs of democratic reform.

“Myanmar provides a really good risk-reward situation,” said Christian Oram, a British businessman who has worked in the information technology sector in Myanmar for 13 years and now plans a \$30 million Myanmar-focused fund. **“The early growth phase promises potentially extraordinary returns. You can't get extraordinary returns in Vietnam anymore, or Thailand. . . . In Myanmar we are just getting started.”**

www.reuters.com

Japan commits \$26B to aid ASEAN infrastructure projects

Indonesia, (Kyodo); November 18, 2011 — Japanese Prime Minister Yoshihiko Noda pledged 2 trillion yen (\$26 billion) in aid for projects to strengthen integration among Association of Southeast Asian Nations member nations.

Noda also expressed his commitment to boosting cooperation with the region over maritime security and safety amid China's increasing assertiveness at sea, a Japanese official said.

Aid will be provided for **33 “flagship” infrastructure projects** from Japan's official development assistance, Japan Bank for International Cooperation, and private sector funds, the official said, adding that Tokyo will also work with the Asian Development Bank and hopes to increase technology exports to the region.

The Japan aid is aimed at boosting ASEAN “connectivity” through better infrastructure in such fields as transport across borders and simplifying customs procedures.

These efforts to improve links within the region are part of the ASEAN vision to create an economic community by 2015.

Although Japan is not directly involved in the South China Sea, it is keen to help ASEAN resolve disputes peacefully, given tension over the Senkaku Islands in the East China Sea, which are administered by Japan but claimed by China and Taiwan.

China is involved in territorial disputes in the South China Sea with four ASEAN members — Brunei, Malaysia, and most recently and notably, Vietnam and the Philippines.

mdn.mainichi.jp

Global Spotlight: Southeast Asia

Southeast Asia — a ready market for natural gas

Southeast Asia includes countries that are significant natural gas exporters and importers, as well as those in between.

In “Rest of Asia” (excluding Japan and China), Indonesia, Malaysia, and Australia, in that order, are the largest producers and exporters. Indonesia, Malaysia, Kazakhstan, India, and Australia have the largest natural gas reserves. The Rest of Asia region as a whole has more natural gas reserves than North America.

LNG is important in the region due to the difficulty of transporting natural gas by pipeline from island to island and to and from the mainland.

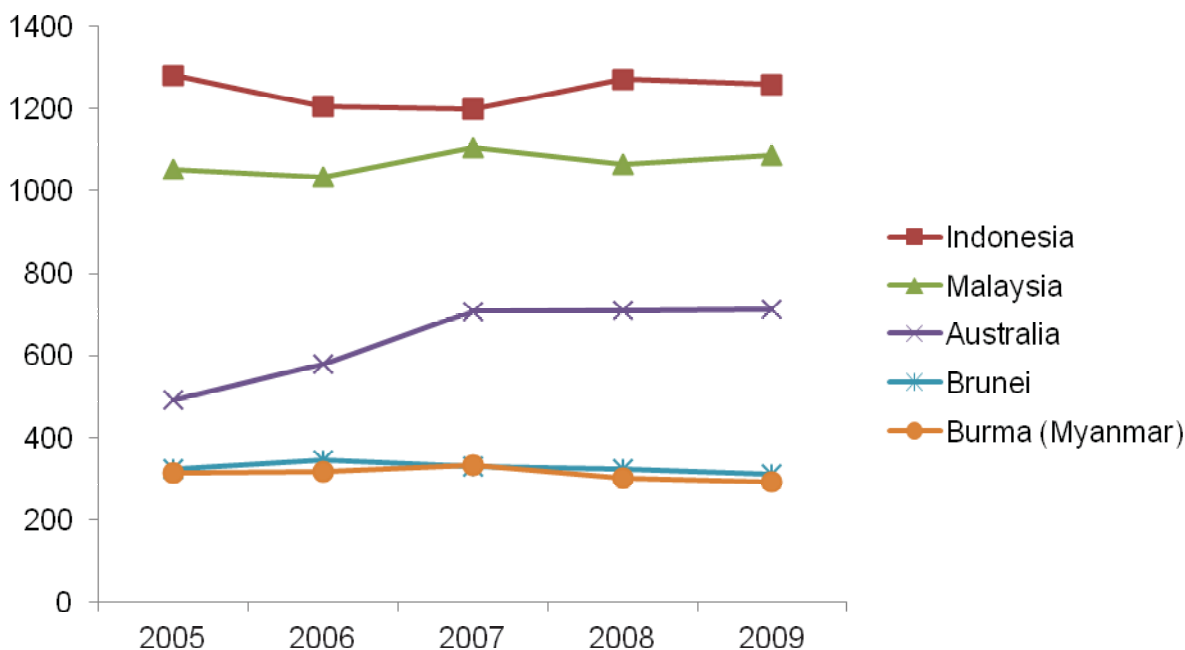
While any of the Rest of Asia countries are islands, or largely surrounded by water, some Southeast Asian countries are connected by land.

There are currently over 1,500 miles of natural gas pipelines interconnecting the Southeast Asian countries. These pipelines provide significant opportunities for gas flow measurement. More than 60 percent of Southeast Asia’s natural gas is consumed by the power sector.

Many of the opportunities for flow measurement in this region are related to LNG gasifi-

(Continued on page 21)

Exporters of Dry Natural Gas: Rest of Asia (excluding Japan and China)
(Billion Cubic Feet)



Source: U.S. Energy Information Administration

Global Spotlight: Southeast Asia

(Continued from page 20)

cation, transportation, and re-gasification. LNG has to be converted into liquid form in order to be transported on ships, and this provides measurement opportunities. It is also measured at the delivery point, and again as it is re-gasified and delivered into pipelines for transportation to its ultimate point of use. There are nine LNG liquefaction facilities planned for Australia alone.

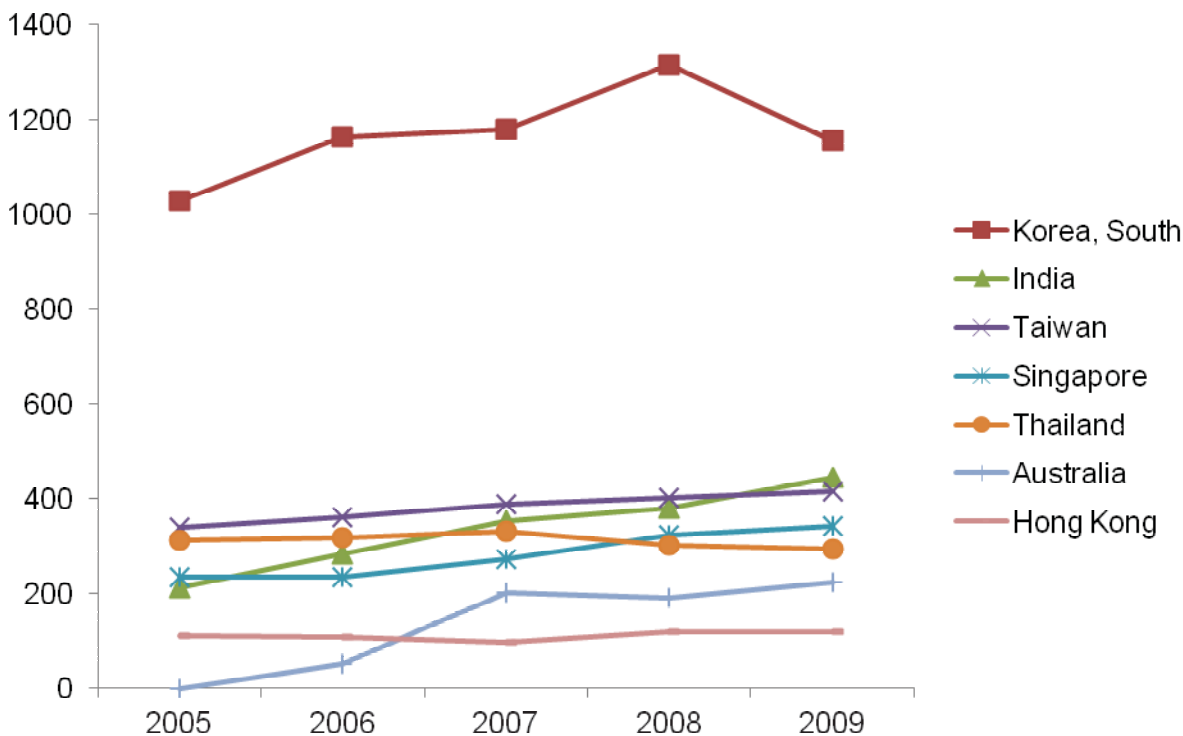
Because consumption of natural gas is expected to continue its positive growth in the Rest of Asia region, we see regasification terminal growth as a natural result of this trend and as an opportunity for process measurement device suppliers of all types.

South Korea, the world's second-largest LNG importer behind Japan, is by far the largest gas importer in this group. It is also the twelfth largest holder of natural gas reserves in the world as of January 2010, with significant new discoveries that same year.

China should increase its purchases of LNG from these countries as it seeks to reduce its dependence on coal. Natural gas production in Australia/New Zealand is forecast to accelerate quickly through 2035 as a result of recent coastal and offshore resource discoveries.

From Module A: An Analysis of the Regional Gas Flowmeter and Natural Gas Markets, a study in Flow Research's 2011 report, The World Market for Natural Gas and Gas Flow

**Importers of Dry Natural Gas: Rest of Asia (excluding Japan and China)
(Billion Cubic Feet)**



Source: U.S. Energy Information Administration

Oil & Gas and Refining

This section covers important events in the oil, gas, and refining industries, which include companies producing petroleum, hydrocarbon liquids, and natural gas and extracting oil. It also includes petrochemical companies.

In the News . . . 23

Trade Shows . . . 27

Industry Pulse . . . 28

New Projects . . . 32

Company Korner: Christian Michelsen Research . . . 38

