Update on IEAGHG activities and Implications of Gas Production from Shales and Coal for Geological Storage of CO2

Tim Dixon
IEA GHG R&D Programme

CSLF Technical Group, 5 November 2013

IEA Greenhouse Gas R&D Programme (IEAGHG)

- A collaborative international research programme founded in 1991
- Aim: To provide information on the role that technology can play in reducing greenhouse gas emissions from use of fossil fuels.
- Focus is on Carbon Dioxide Capture and Storage (CCS)
- Producing information that is:
  - Objective, trustworthy, independent
  - Policy relevant but NOT policy prescriptive
  - Reviewed by external Expert Reviewers

Partner Organisations:

IEAGHG

- Flagship activities:
- Technical Studies >250 reports published on all aspects of CCS
- International Research Networks
  - Risk Assessment
  - Wellbore Integrity
  - Monitoring
  - Modelling
  - Environmental Impacts
  - Oxy-combustion
  - Post-combustion Capture
  - Solid Looping
  - Social Research
- GHGT conferences – GHGT-12 in Austin USA, 5-9 Oct 2014

IEAGHG

- Other activities include:

- Facilitating R&D and demonstration activities eg IEAGHG Weyburn-Midale CO2 Monitoring and Storage Project – 'Best Practices for Validating CO2 Geological Storage' published Nov 2012

- International CCS Summer Schools - 2012 Beijing, 2013 UK, 2014 University of Texas Austin, USA

- Peer reviews, eg US DOE, US EPA; CO2CRC

- Active in international regulatory developments – **London Convention, UNFCCC, ISO TC265**

- Collaborations with IEA, GCCSI, CSLF, CCSA, EU ZEP and others

Update on IEAGHG activities

Recent Reports

Title	Contractor	Report number	Publication date
Iron & Steel	Swerea MEFOS, Tata, SINTEF	2013/4	July 2013
Post-Combustion CO2 Capture Scale-Up Study	Black &Veatch Ltd	2013/5	February 2013
4th IEAGHG Network Meeting on High Temperature Solid Looping Cycles	N/A	2013/6	March 2013
Key Messages for Communications Needs for Key Stakeholders	Uni Edinburgh & CSIRO	2013/7	March 2013
Interaction of CO2 Storage with Subsurface Resources	CO2CRC	2013/8	April 2013
Shale Gas Greenhouse Gas Footprint Review	Steve Goldthorpe Energy Analyst Ltd	2013/TR1	March 2013
Toward a Common Method of Cost Estimation for CCS at Fossil Fuel Power Plants	CCS Costing Methods Taskforce	2013/TR2	March 2013

Recent Reports

Title	Contractor	Report number	Publication date
Overview of the Current State and Development of CO_2 Capture Technologies in the Iron-making Process	IEAGHG	2013/TR3	April 2013
A Review of the Status of Global Non-CO_2 GHG Emissions and Their Mitigation Potential	IEAGHG	2013/TR4	April 2013
Incorporating Future Improvements in existing PC	IEAGHG	2013/TR5	May 2013
Mineralisation - Carbonation and Enhanced Weathering	IEAGHG	2013/TR6	July 2013
Induced Seismicity and its Implications for CO2 Storage Risk	CO2CRC	2013/9	June 2013
Potential Implications of Gas Production from Shales and Coal for CO_2 Geological Storage	ARI	2013/10	September 2013
Potential for Biomethane Production with CCS	Ecofys	2013/11	September 2013

Reports pending

Title	Contractor	Publication date
Developing Test Injection Study	CO2CRC	November 2013
Evaluation of reclaimed waste disposal for CO_2 Post Combustion Capture	Trimeric Corporation	November 2013
Biomass CCS - Guidance on accounting for negative emissions	Carbon Counts	November 2013

Studies underway

Title	Contractor	Publication date
Assessment of costs of capture at baseline coal power plants	Foster Wheeler Italia	July 2014
Comparing Approaches to Managing Storage Resources	BGS	October 2013
Barriers to CCS in Cement Industry	ECRA	October 2013
CO_2 Pipeline Infrastructure Review	Ecofys	October 2013
CO_2 Storage Efficiency in Aquifers	EERC	December 2013
Monitoring Selection Tool	BGS	December 2014
Techno Economic Evaluation for Different Post Combustion Capture Process Flow Sheet Modifications	Hamburg University of Technology	April 2014
Criteria of Fault Geomechanical Stability During Pressure	NGI	February 2014
Impact of CO_2 Impurity on CO_2 Compression and Transportation	Newcastle University	

IEAGHG Network Meetings and Conferences 2013+

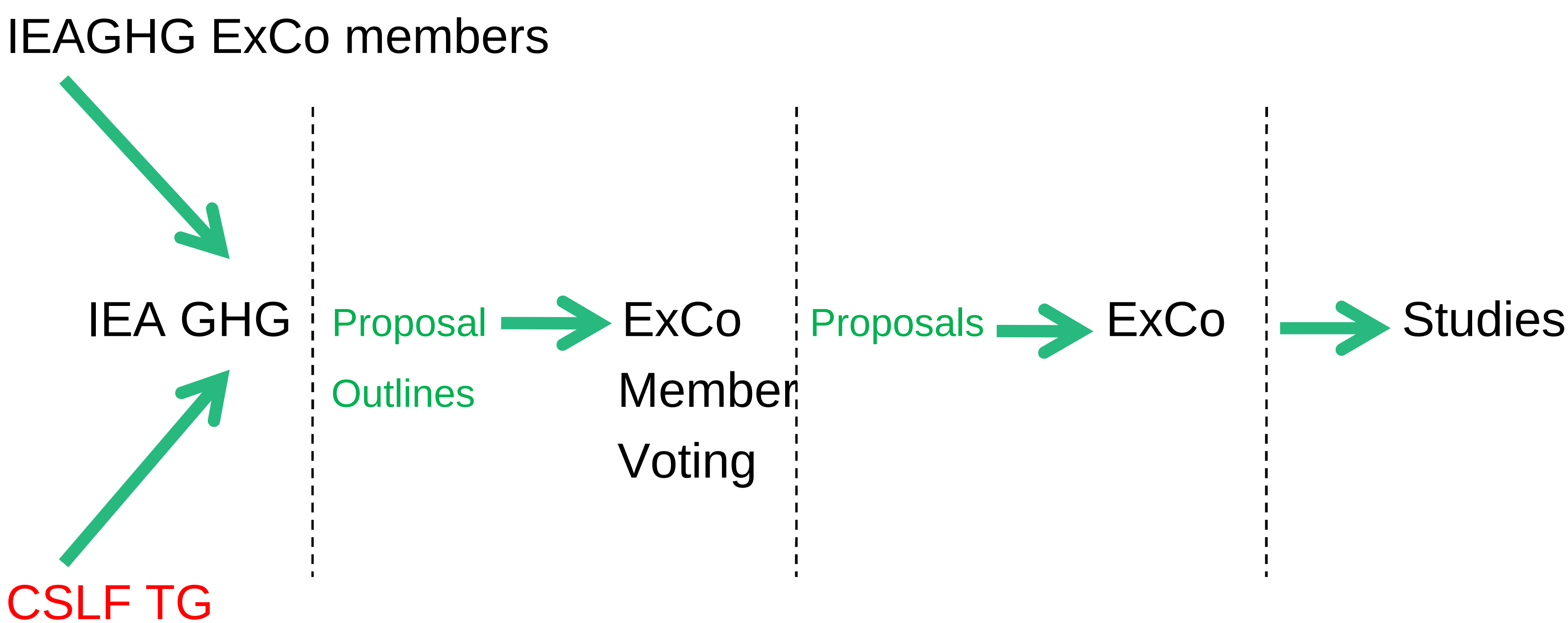
- Risk Management Network and Modelling Network
  - 10-12 Jun 2013, Trondheim. Hosts Statoil
- Monitoring Network and Environmental Research Network
  - 26-30 Aug 2013, Canberra. Hosts CO2CRC
- Post Combustion Capture Conference - 2
  - Bergen, Norway September 17th -20th 2013. Hosts Gassnova
- Oxyfuel Combustion Conference - 3
  - Leon, Spain 9th -13th September 2013. Hosts CUIDEN
- High Temperature Solid Looping Cycles Network
  - 2-3 Sep 2013, Cambridge. Hosts Cambridge University
- GHGT-12, Austin, Texas, 5-9 Oct 2014
  - Call for abstracts open, deadline 10 January 2014

Update on CSLF Collaboration with IEAGHG

Arrangement between CSLF Technical Group and IEAGHG

- How CSLF TG/PIRT and IEAGHG will interact for mutual benefit through increased co-operation
  - Mutual representation of each at CSLF TG and IEAGHG ExCo (no voting)
  - Liaison with PIRT co-chairs to discuss potential activities or projects – two way process
  - Activities would require approval by ExCo or TG
  - Due reference to org providing the resource
- Agreed by IEAGHG ExCo Oct 2007 and CSLF Technical Group Jan 2008

IEA GHG – Study generation



CSLF proposed studies

- 'Development of Storage Coefficients for CO2 Storage in Deep Saline Formations'. IEAGHG Report 2009/13. Presentation at CSLF TG Mar 2010
- 'Geological Storage of CO_2 in Basalts', IEAGHG Report 2011/TR2. Presentation at CSLF TG Sep 2011
- Potential Implications of Gas Production from Shales and Coal for CO_2 Geological Storage. ARI. Report published 2013. IEAGHG Report 2013/10. Presentation at CSLF TG Nov 2013
- Additional new study ideas invited from CSLF TG/PIRT
- Outline required by 20 Jan 2014

Potential Implications of Gas Production from Shale and Coal on CO_2 Storage

- Study proposed by CSLF TG
- Study undertaken by ARI, US
- Aim of Study:
  - Assess potential for geological storage of CO_2 in shale and coal formations and the impact of gas production on CO_2 storage capacity in the shales and on underlying DSF by compromising caprock integrity.

Potential Gas Reserves and CO_2 Storage Potential

- Coals – previous assessment IEAGHG PH3/3
  - Basins selected
  - Coal rank specified (affects CO_2/CH_4 replacement ratio)
  - Estimate recoverable CBM resources
  - Estimate recoverable ECBM resources
  - Storage capacity associated with CBM and ECBM estimated as 488Gt
- Shales – Used US EIA as base
  - Preliminary characterisation
  - Establish areal extent
  - Estimate risked gas in place, estimate recoverable gas
  - Risked storage potential estimated at 740Gt

RD&D Status in Coals

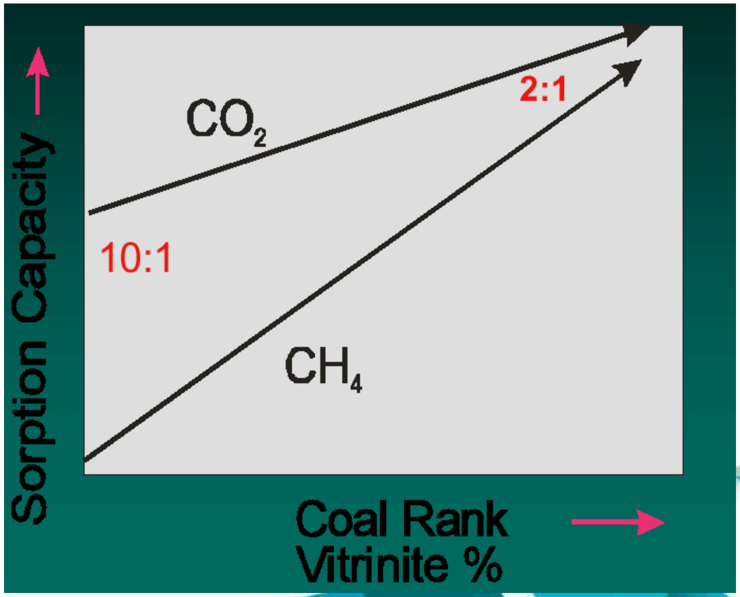
- ECBM and CO_2 Storage in development phase
- Several worldwide projects including US RCSP phase II
- key knowledge gaps / technical barriers identified:
  - Information on available storage capacity in deep, unmineable coals
  - Guidelines for location-specific criteria defining “unmineable coals”
  - Geological and reservoir data defining best settings for injection and storage, e.g. depositional settings and reservoir properties
  - Near-term and longer-term interactions between CO_2 and coals and between N_2 and coals,
  - Need for formulating and testing alternative reliable, high volume CO_2 and/or N_2 injection strategies and well designs, in multiple reservoir settings.
  - Integrating CO_2 storage and enhanced recovery of coalbed methane

RD&D Status in Shales

- Significantly less advanced than for coal seams
- But multiple research projects, e.g. experiments on Barnett shale – trapping gas within organic matter; CSIRO – transport and sorption experiments on Muderong; NETL – storage capacity and injectivity research
- Research gaps identified:
  - Information on available capacity (except a few targeted settings).
  - Geological and reservoir data defining favourable settings for injectivity and storage; depositional settings and reservoir props.
  - Understanding near-term and longer-term interactions between CO_2 and shales.
  - Formulating and testing alternative reliable, high volume CO_2 injection strategies and well designs.
  - Integrating CO_2 storage & enhanced recovery of methane

Trapping Processes and Mechanisms in Coal

- Adsorption trapping - molecules form layer upon surface area
  - Adsorption primarily in micro-pores
  - Properties affecting capacity and rate of CO_2 uptake are **coal rank**, maceral content, moisture content
  - CO_2 retention capacity also related to in-situ pressure and temperature
  - Transport through coal dependent on seam perm and intrinsic perm of matrix. Flow of CO_2 in cleats displaces CH_4 – research in early stages



Trapping Processes and Mechanisms in Shales

- Gas stored by adsorption and in natural fractures
- Adsorbed vs. free gas depends on TOC, pore size distribution, mineralogy, diagenesis, rock texture, reservoir temperature and pressure.
- Reports on CO_2 isotherms are sparse. But some info, e.g. black gas shales, Kentucky, Barnett, Marcellus shale, NY and Muderong shale, WA
  - Marcellus shale – CO_2 stored preferentially over CH_4 by 3:1
- Mass transport paths differ from coal – dual organic/ inorganic pore system – can dissolve into organic material and diffuse through nano pore network
- Geochemical alterations can affect porosity, permeability and diffusion props of shale

Injectivity Issues

- Coal and shale low permeability – can be increased with hydraulic fracturing
- CO_2 adsorption – coal swelling – significant barrier to CO_2 injection in coal seams. Shrinks on desorption and increases on readsorption
- Injectivity also affected by:
  - Thermal effect of CO_2 injection
  - Wellbore effects
  - Precipitate formation
- Injectivity increased by using horizontal wells – can take advantage of orientation of natural fractures
- Injectivity may be maintained by alternating CO_2 and N_2
- Some of the same issues expected with shale, but research to date is not sufficient

Storage Integrity in Coals

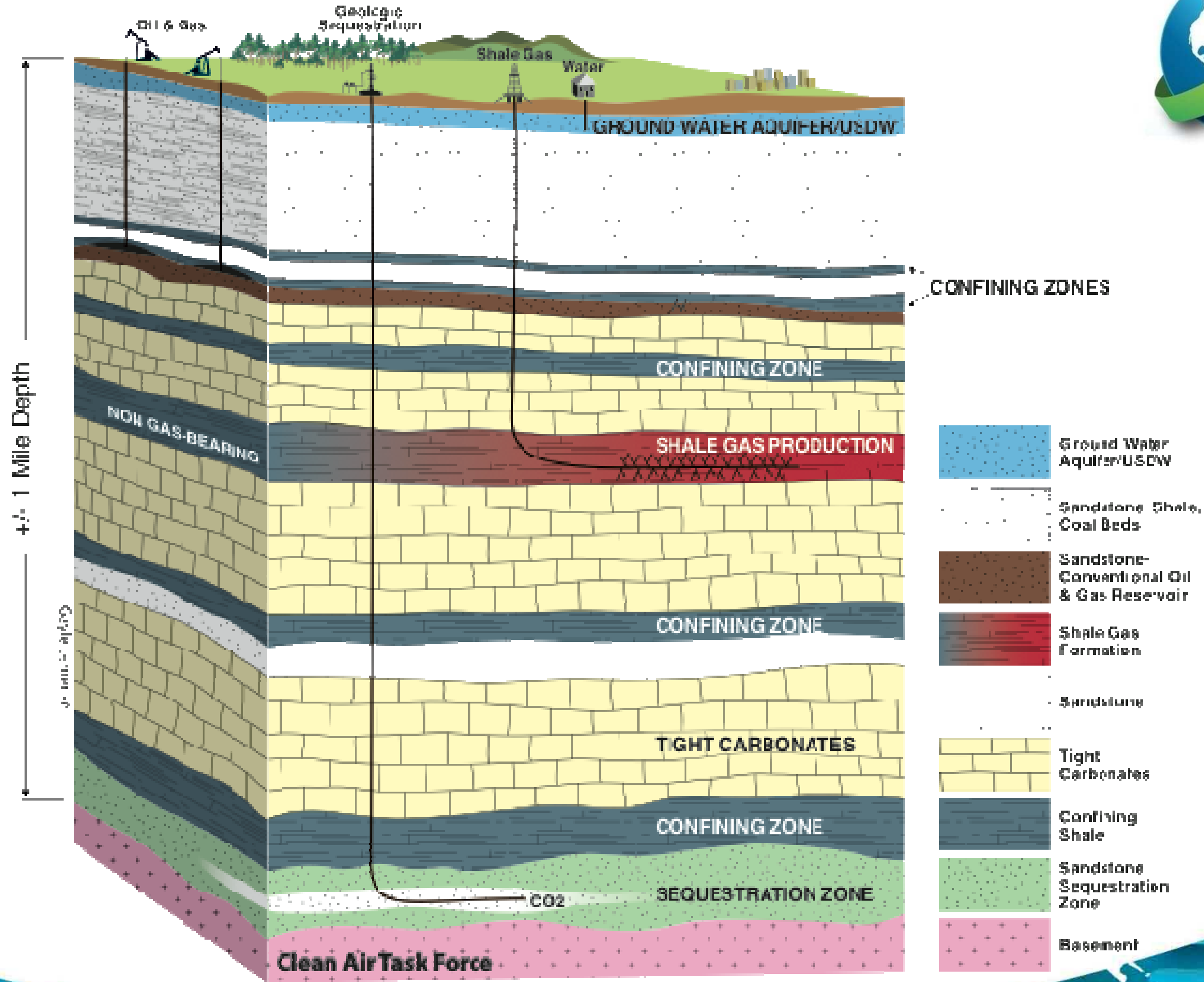
- Geomechanical processes can lead to risk of developing leakage pathways for CO_2
- Risk scenarios were considered and those particular to coal seams are:
  - Insufficient CO_2-coal contact volume due to coal bed heterogeneity
  - Injectivity loss due to coal swelling caused by CO_2 adsorption
  - CO_2 and/or methane leakage through pre-existing faults and discontinuities
  - CO_2 and/or methane leakage through outcrops
  - CO_2 and/or methane desorption caused by potential future coal bed water extraction.

Storage Integrity in Coals

- Risks need to be evaluated for each site, but it can be concluded that:
  - Risk of leakage much higher for open cavity completions than for cased well completions.
  - Coal properties and available technology should minimise risk that hydraulic fractures will grow out of the interval. Techniques to monitor fracture height need further development.
  - The processes of de-pressurisation, followed by re-pressurisation during CO_2 injection, lead to risks of leakage path formation by slip along discontinuities in the coal and overburden.
    - Most likely mechanism is slip on pre-existing discontinuities which cut across the coal seam - sensitivity studies needed.
  - Relationships between the amount of slip and the increase in flow (if any) along a discontinuity need to be developed.

Potential Overlap of Gas Shales, Storage Reservoir and Caprock

- Significant geographical overlap of DSF and shale gas (US)
- Potential conflict of resource?
- Higher permeability shales more suitable to gas production/ storage
- Lower permeability shales less suitable for gas production, but good caprock candidate,
- Shale formations geographically extensive – possibility of one formation used for both purposes
- Assessment needs to be site specific
- Can potentially co-exist in the same area



Oil & Gas
Geologic Sequestration
Shale Gas
Water
GROUND WATER AQUIFER/USDW
CONFINING ZONES
CONFINING ZONE
NON GAS-BEARING
SHALE GAS PRODUCTION
CONFINING ZONE
TIGHT CARBONATES
CONFINING ZONE
SEQUESTRATION ZONE
CO2
+/- 1 Mile Depth
Clean Air Task Force
Ground Water Aquifer/USDW
Sandstone, Shale, Coal Beds
Sandstone-Conventional Oil & Gas Reservoir
Shale Gas Formation
Sandstone
Tight Carbonates
Confining Shale
Sandstone Sequestration Zone
Basement

Conclusions

- Increased gas production due to technological developments in horizontal drilling and hydraulic fracturing – increased potential for CO_2 storage in shale/ coal
- Fracking process can potentially decrease storage security in shales and coals, though this can be avoided with appropriate reservoir selection and management.
- Potential storage worldwide: Coal – 488Gt, Shale – 740Gt
- Geographical overlap of DSF and shale gas, but not necessarily resource conflict due to depth – will need to be managed.
- Knowledge gaps identified
- Research less advanced for shale than coal – additional work needed

CSLF proposed studies

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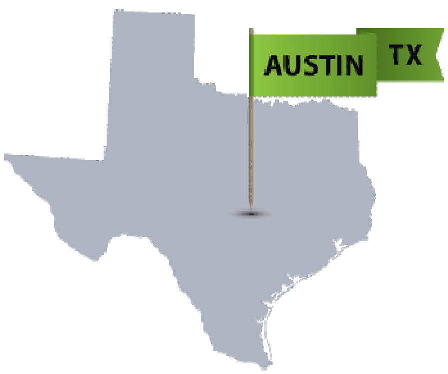
5–9 October 2014

AUSTIN, TX – USA



- Call for papers 27th September 2013
- Deadline for abstracts 10th January 2014
- Registration opens 7th March 2014
- Authors notified 2nd May 2014
- Early bird closes 13th June 2014

Thank you

Any questions?