Fakultet kemijskog inženjerstva i tehnologije

Zavod za termodinamiku, strojarstvo i energetiku

ENERGETIKA

Studij: Kemijsko inženjerstvo (V semestar)

prof. dr. sc. Igor Sutlović

Ugljen – fosilno gorivo nastalo iz organskih sastojaka kroz dugi period u anaerobnim uvjetima pri visokim tlakovima i temperaturama

	Gustoća, kg/m^3	Donja toplinska vrijednost, MJ/kg	Udio vlage,%	Hlapljivi sastojci, % suhe tvari	Udio ugljika, % suhe tvari
Drvo	0,2-1,3	14,7	Suho d.	80	50
Treset	1,0	6,3-8,4	60-90	65	55-65
Lignit	1,2	7,5-12,6	30-60	50-60	65-70
Mrki ugljen	1,25	16,7-29,3	10-30	45-50	70-80
Plameni kameni ugljen	1,3	29,3-33,5	3-10	17-45	80-90
Mršavi kameni ugljen	1,35	33,5-35,6	3-10	7-17	90-93
Antracit	1,4-1,6	35,6-37,7	1-2	4-7	93-98

Izgled pojedinih vrsta ugljena

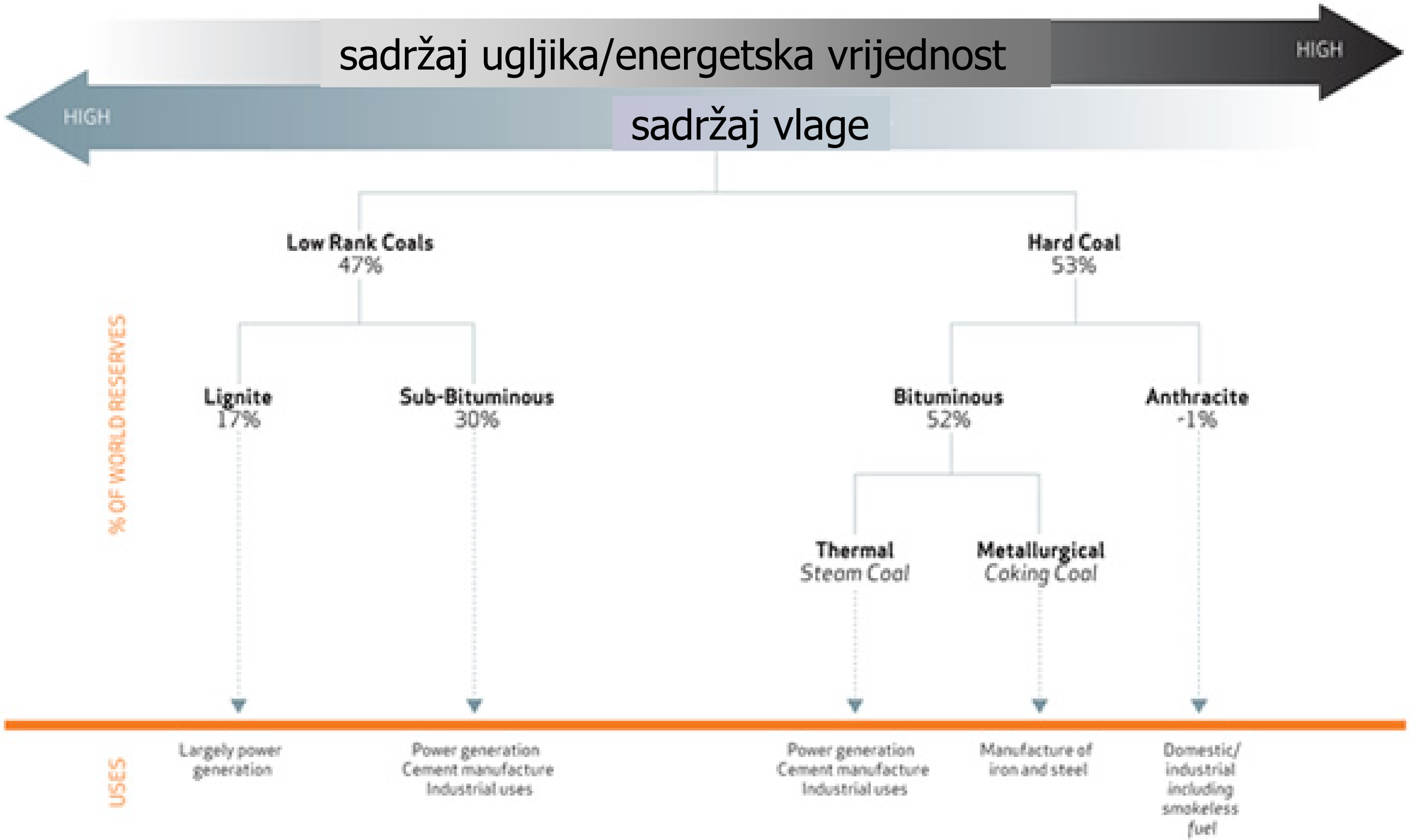
KAMENI UGLJEN

MRKI UGLJEN

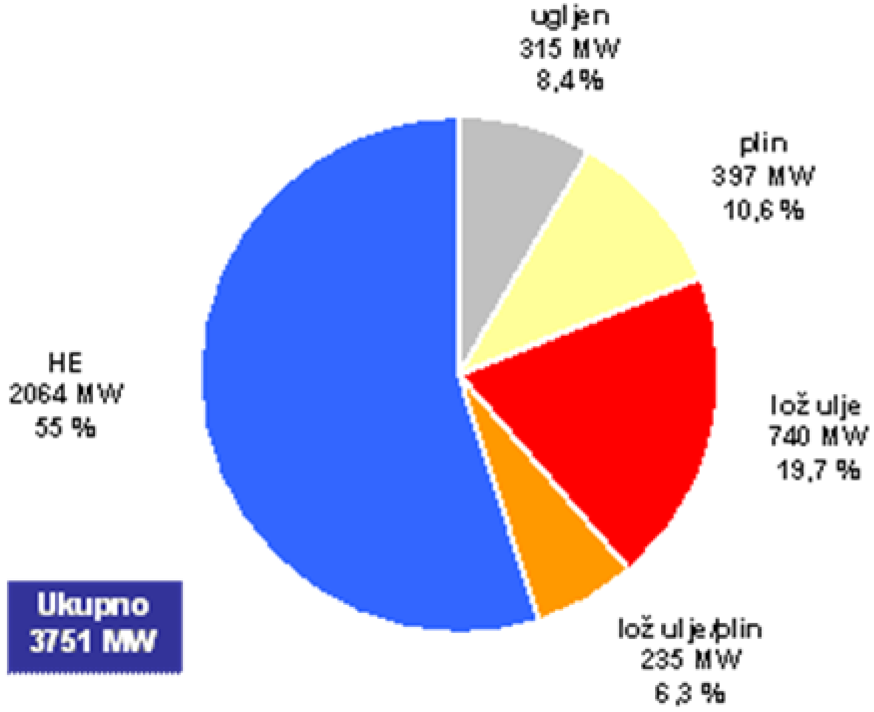
LIGNIT

TRESET

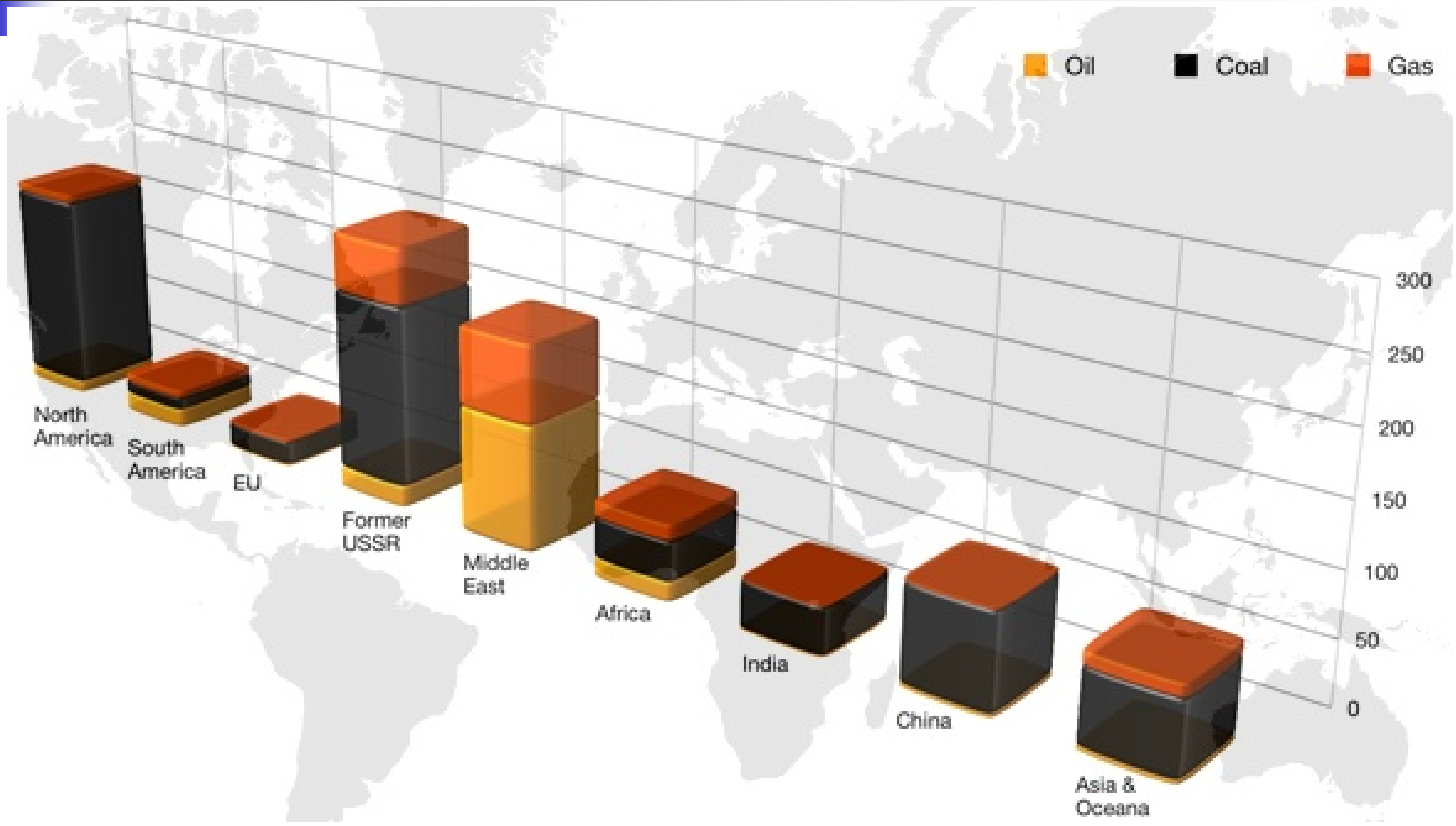
Vrste ugljena i njihove karakteristike i upotreba



Struktura kapaciteta za proizvodnju električne energije na teritoriju Republike Hrvatske (izvor: EI Hrvoje Požar)



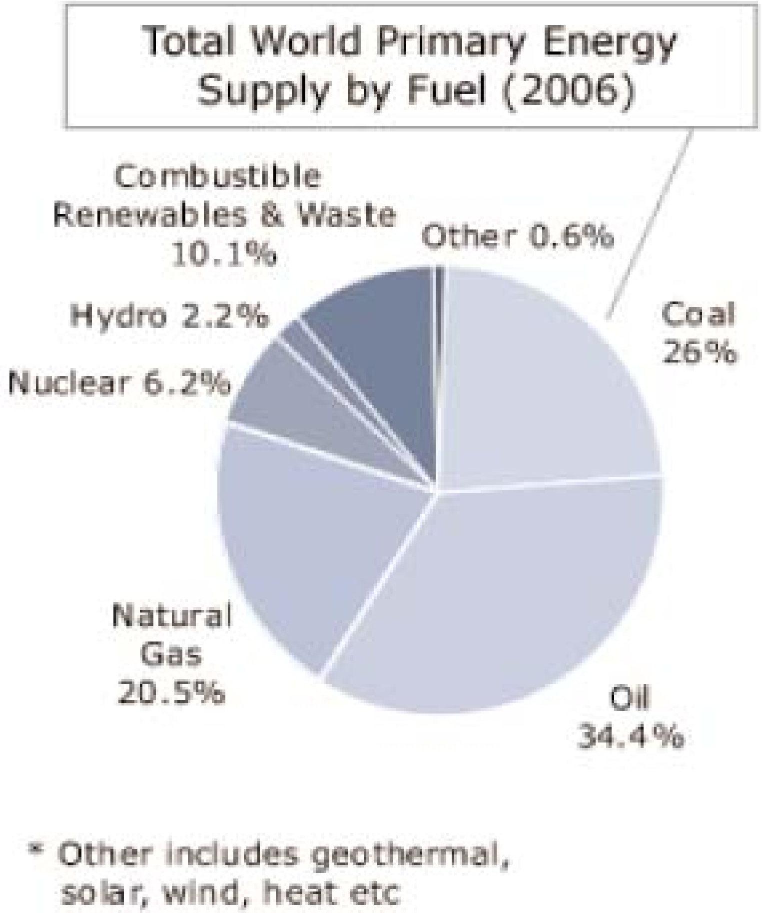
Raspored svjetskih rezervi ugljena

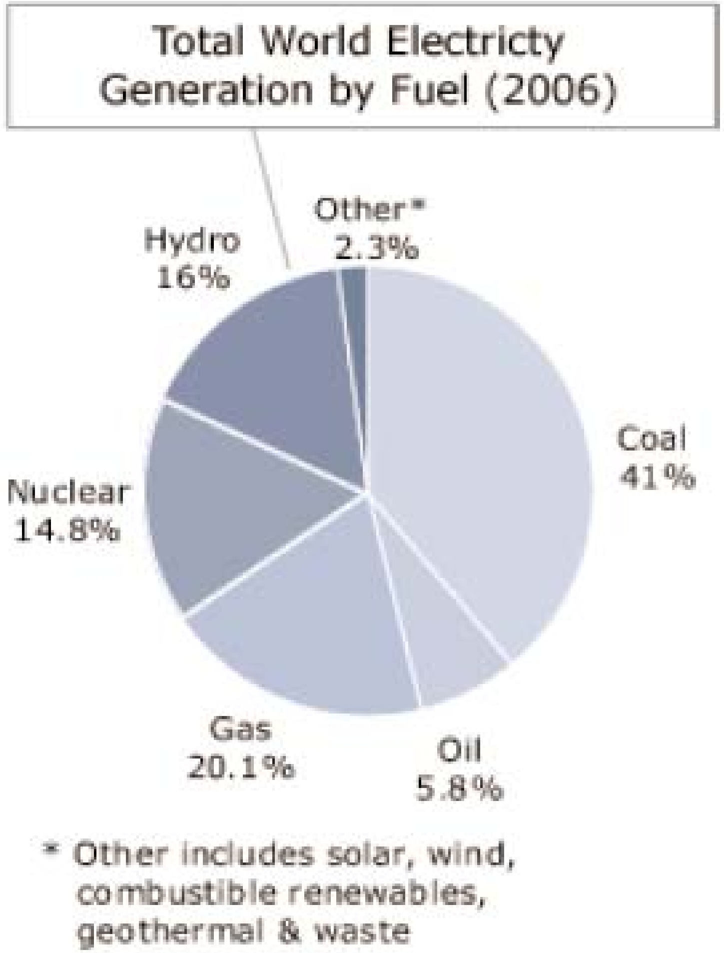


Najveći svjetski proizvođači ugljena

Top Ten Hard Coal Producers (2007e)			
PR China	2549Mt	Russia	241Mt
USA	981Mt	Indonesia	231Mt
India	452Mt	Poland	90Mt
Australia	323Mt	Kazakhstan	83Mt
South Africa	244Mt	Colombia	72Mt

Ugljen u svjetskoj statistici proizvodnje primarne i el. energije





Korištenje ugljena za proizvodnju el. energije

Poland	**93%**	**Israel**	**71%***	**Czech Republic**	**59%**
South Africa	93%*	Kazakhstan	70%*	Greece	58%
Australia	80%	India	69%*	USA	50%
PR China	78%	Morocco	69%*	Germany	47%

** only 2005 figures available for these countries*

Najveći izvoznici ugljena

Top Coal Exporters (2007e)			
	Total *of which*	Steam	Coking
Australia	244 Mt	112 Mt	132 Mt
Indonesia	202 Mt	171 Mt	31 Mt
Russia	100 Mt	85 Mt	15 Mt
Colombia	67 Mt	67 Mt	-
South Africa	67 Mt	66 Mt	1 Mt
PR China	54 Mt	51 Mt	3 Mt
USA	53 Mt	24 Mt	29 Mt

steam coal=bituminozni ugljen

coke coal=za proizvodnju čelika nizak sadržaj S

… i najveći uvoznici

Top Coal Importers (2007e)			
	Total *of which*	**Steam**	**Coking**
Japan	182Mt	128Mt	54Mt
Korea	88Mt	65Mt	23Mt
Chinese Taipei	69Mt	61Mt	8Mt
India	54Mt	31Mt	23Mt
UK	50Mt	43Mt	7Mt
PR China	48Mt	42Mt	6Mt
Germany	46Mt	36Mt	10Mt

Gdje se ugljen upotrebljava?

U energetske svrhe kod

- Proizvodnje električne i toplinske energije,
- Proizvodnje željeza i čelika,
- Proizvodnje cementa

- U proizvodnji kapljevitih goriva (coal to liquid fuel)
- Podzemno isplinjavanje ugljena

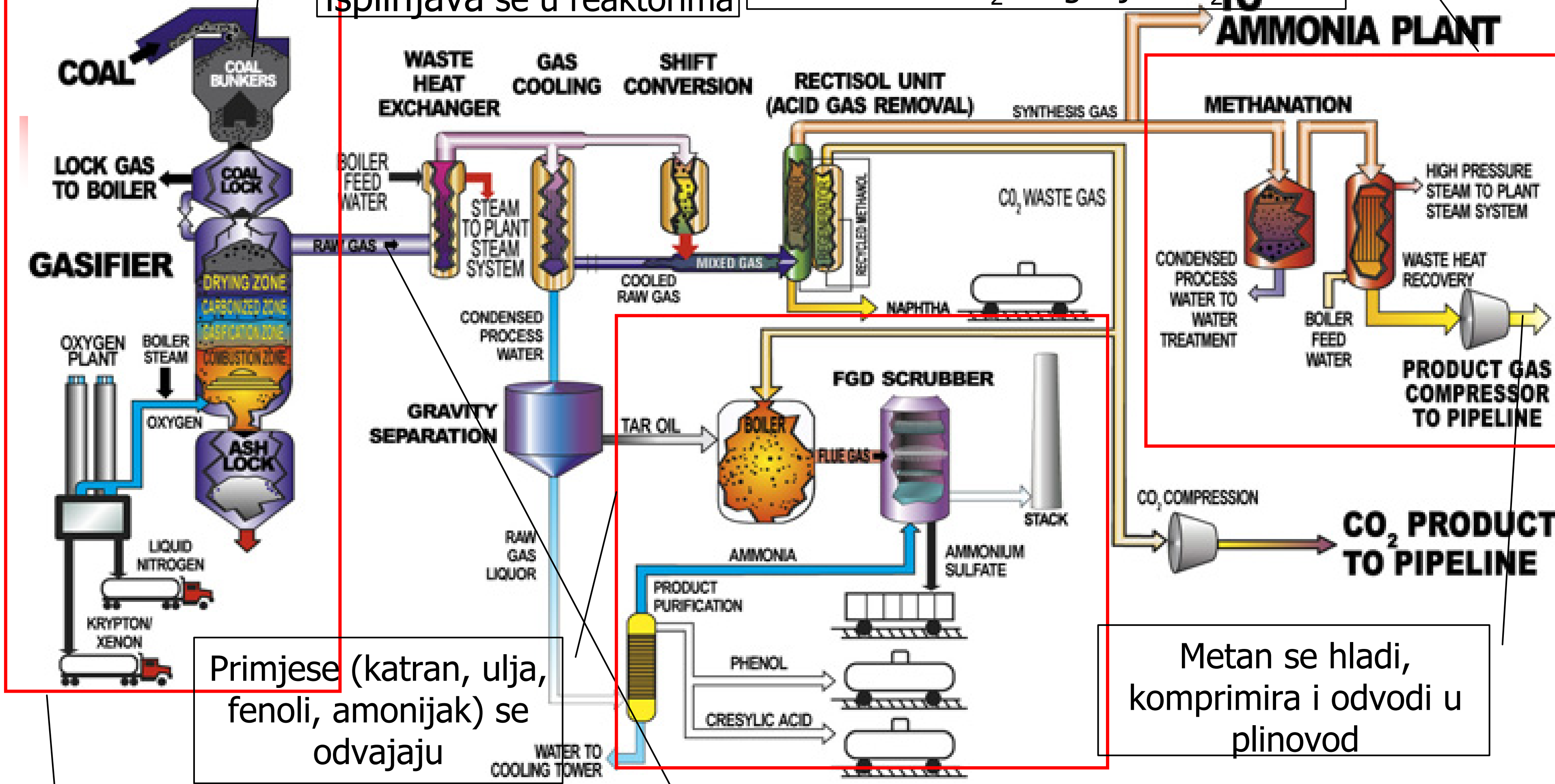
- Budućnost energetske upotrebe ugljena (i ostalih fosilnih goriva) povezana je s ekološkim problemima odnosno s emisijama stakleničkih plinova – GHG- Greenhouse Gas Emission),
- Najveći porast potrošnje ugljena u energetske svrhe očekuje se u zemljama u razvoju, prvenstveno zbog povećanja proizvodnje električne energije.
- Nužno je riješiti problem emisija stakleničkih plinova.

Hvatanje (capture) CO_2

- poslije izgaranja (post-combustion) - sastoji se od izdvajanja CO_2 iz dimnih plinova
- prije izgaranja (pre-combustion) – gorivo se posebnim postupkom razdvaja na vodik i CO (sintetski plin). Vodik se koristi kao gorivo, a CO se prevodi u CO_2 koji se skuplja
- korištenjem kisika za izgaranje (oxyfuel) – gorivo izgara uz prisustvo čistog kisika što u odsustvu dušika dovodi do veće koncentracije CO_2 u dimnim pinovima što ga čini lakšim za hvatanje

18000 t lignita dnevno isplinjava se u reaktorima

Metan nastaje prolaskom pročišćenog plina preko nikl katalizatora tako što CO i CO_2 reagiraju s H_2



Primjese (katran, ulja, fenoli, amonijak) se odvajaju

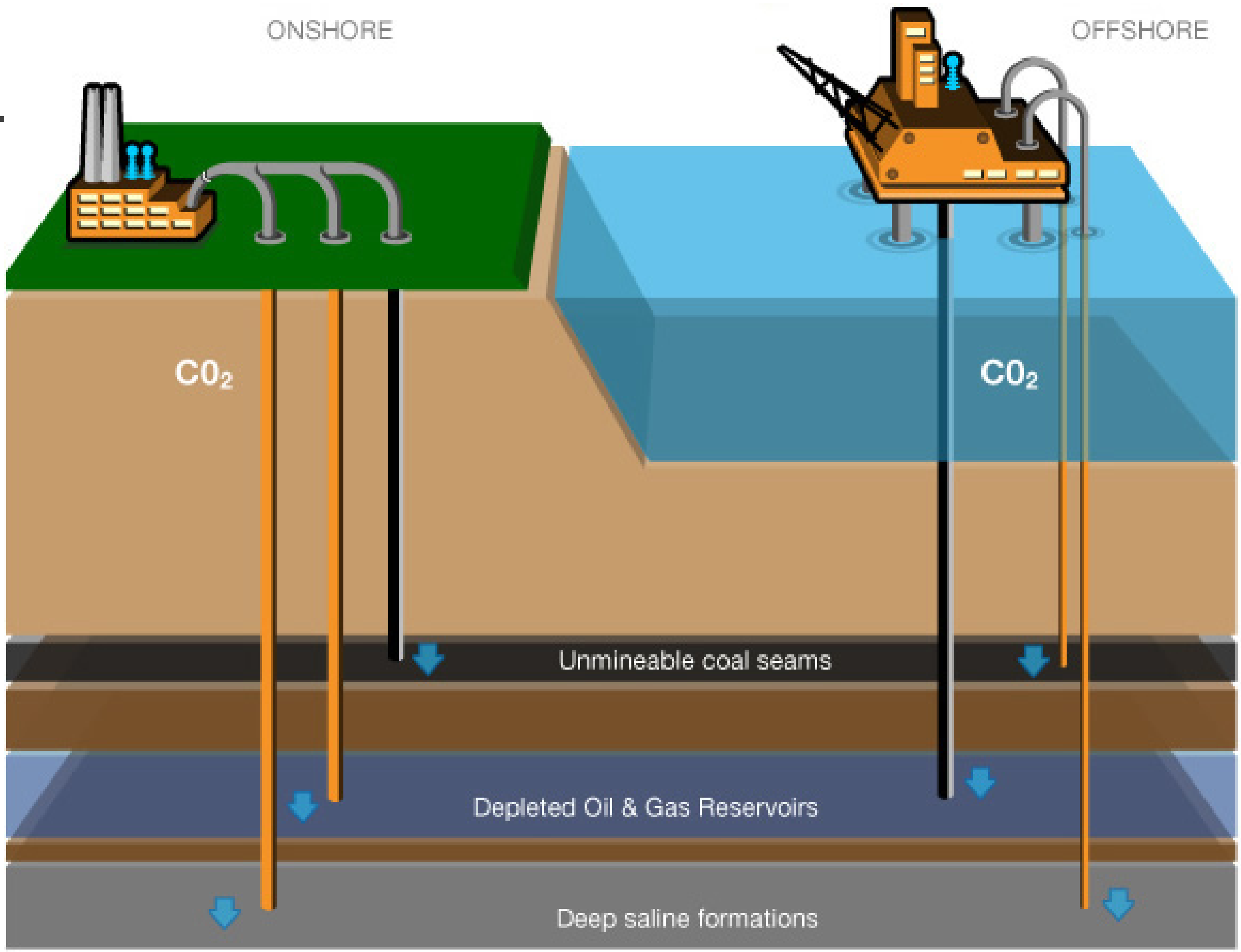
Metan se hladi, komprimira i odvodi u plinovod

Para i kisik ubacuju se u dno reaktora da dođe do intenzivnog izgaranja (temp. 1200°C)

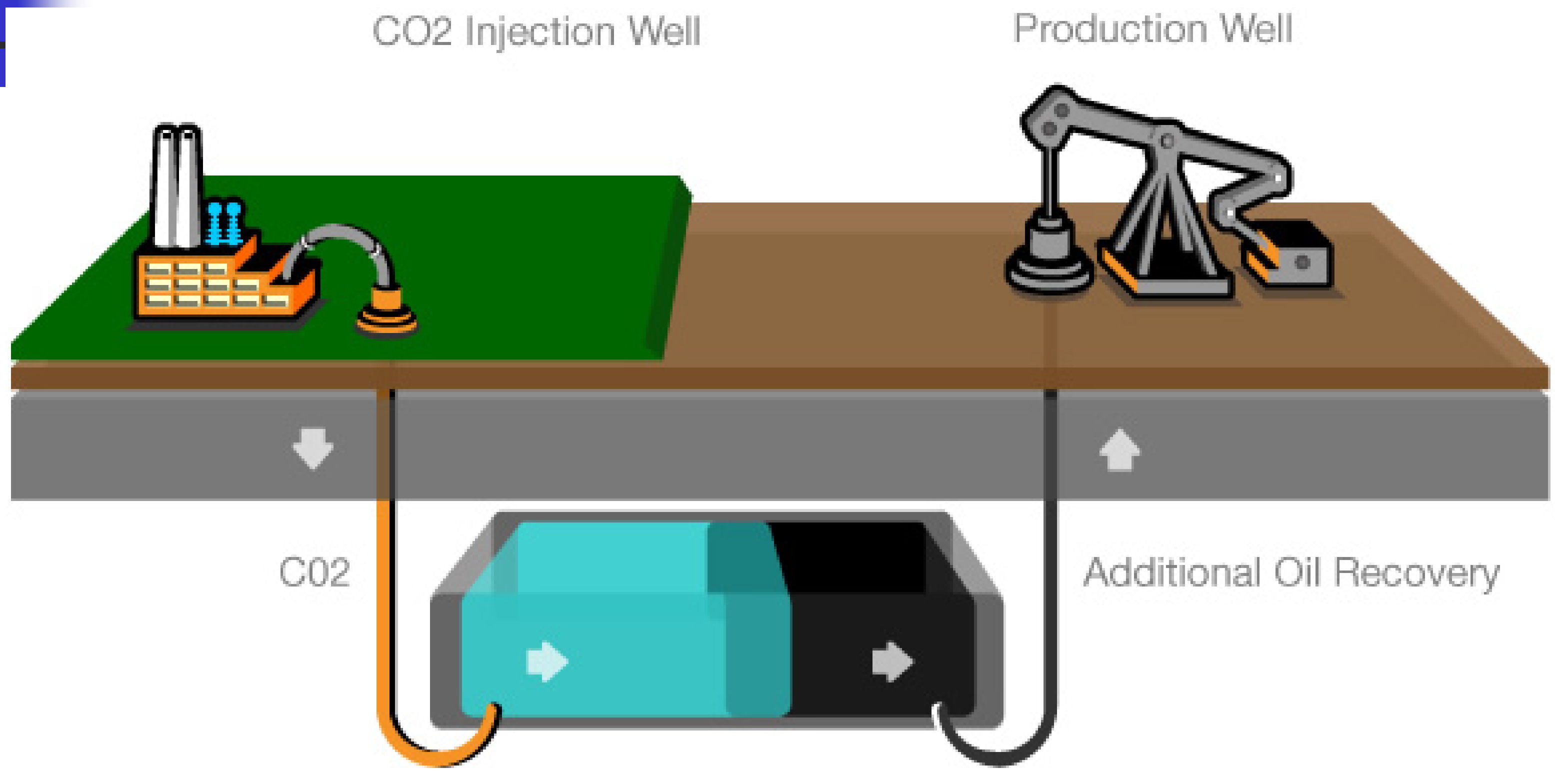
Tako pucaju molekularne veze u ugljenu i pari čime nastaju ugljik, vodik, sumpor, dušik i ostalo tvoreći sirovi plin

- 18000 tona ugljena (lignita) dnevno koristi se u reaktorima za isplinjavanje .
- Para i kisik ubacuju se u dno reaktora da dođe do intenzivnog izgaranja (temp. 1200°C),
- Tako pucaju molekularne veze u ugljenu i pari čime nastaju ugljik, vodik, sumpor, dušik i ostalo tvoreći sirovi plin koji izlazi iz reaktora,
- sirovi plin se hladi,
- Primjese (katran, ulja, fenoli, amonijak) se odvajaju,
- Metan nastaje prolaskom pročišćenog plina preko nikl katalizatora tako što ugljični monoksid i ugljični dioksid reagiraju s vodikom tvoreći metan,
- preostali ugljični dioksid se odvaja, komprimira i odvodi plinovodom do potrošača
- Metan se hladi, komprimira i odvodi u plinovod.

Carbon Capture and Storage – tehnologija prikupljanja i skladištenja CO_2 - CO_2 se ne ispušta u atmosferu



Iskoištavanje CO_2 za povećanje iscrpka nafte (EOR)



Stanje i perspektiva CCS postrojenja u Svijetu

	Location	Capacity (MW)	Year	Comments
FutureGen	USA	275	2012	FutureGen is a public-private partnership to build a first-of-its-kind coal-fired, near-zero emissions power plant. The project will cost approximately US$ 1.5 billion to develop and will test the feasibility of producing low-cost electricity and hydrogen from coal with near-zero CO_2 emissions.
ZeroGen	Australia	530	2015	ZeroGen is a joint State Government/coal industry project to build a commercial scale 530 MW (gross) IGCC plant with up to 90% CCS. The Mitsubishi Corporation and Mitsubishi Heavy Industries have joined the project, with the latter to provide ZeroGen with both the IGCC and carbon capture technologies. Pre-feasibility and feasibility studies are expected to be completed by September 2011 enabling construction to commence in 2012 and commissioning in late 2015.
GreenGen	China	650	2015	GreenGen is a joint government-industry alliance with project leaders including Peabody Energy. The planned IGCC plant will capture CO_2 for enhanced oil recovery.
SaskPower	Canada	100	2015	SaskPower's Boundary Dam project will use low-sulphur lignite with post-combustion capture or oxyfuel technology. The project will use the CO_2 for enhanced oil recovery in the region.
Powerfuel	UK	900	2014	The Powerfuel IGCC CCS project is to be located at the Hatfield Colliery (South Yorkshire). The colliery is owned and operated by Powerfuel.
E.ON	UK	450	Post-2012	The E.ON IGCC project will be built alongside their existing gas-fired power plant in Killingholme. The first phase of the project would be the construction of the power plant with CCS being added in a second phase.
E.ON	Netherlands	1 100	Post-2012	E.ON Benelux and the Rotterdam Climate Initiative plan to develop the project on the Maasvlakte, with a view to implementing CCS at a new fleet of power stations from 2020 onwards.
RWE	Germany	400-450	2014	The first of the RWE proposals will use IGCC technology. This project will be able to separate hydrogen after gas treatment and cleaning to use directly as an energy source or in synthetic fuel production.
RWE nPower	UK	1 000	2016	The second of the RWE proposals will investigate supercritical technology combined with post-combustion CCS.
ScottishPower	UK	3 390	2014	ScottishPower plans to demonstrate CCS at its 3 390 MW Longannet coal power station using a full-scale carbon capture unit from 2014 onwards, following initial testing of a prototype unit which began in 2009.
Vattenfall	Germany	250	2015	Vattenfall has been operating a 30 MW CCS pilot plant at Schwarze Pumpe since 2008. This plant will provide a platform for the R&D required in order to build a 250 MW Oxyfuel demonstration plant at Jänschwalde, with construction scheduled to start in 2011, for completion in around 2015.