

**A NEW PROCESS FOR PRODUCING MOTOR  
FUEL PRODUCTS FROM OIL SHALE**

**Kent Hatfield, Ralph Coates,  
Douglas Smoot**

**COMBUSTION RESOURCES, INC.**

Provo, Utah

# KEY PROCESS OBJECTIVES:

- **EXPERIMENTAL DATA AND  
COMMERCIAL EXPERIENCE PROCESS  
BASIS**

- **PROCESS THE OIL SHALE WITH  
COMMERCIALY AVAILABLE  
EQUIPMENT**

- **ELIMINATE CO2 EMISSIONS FROM OIL SHALE PROCESSING**

- **GASIFY COAL FOR PROCESS ENERGY AND HYDROGEN**

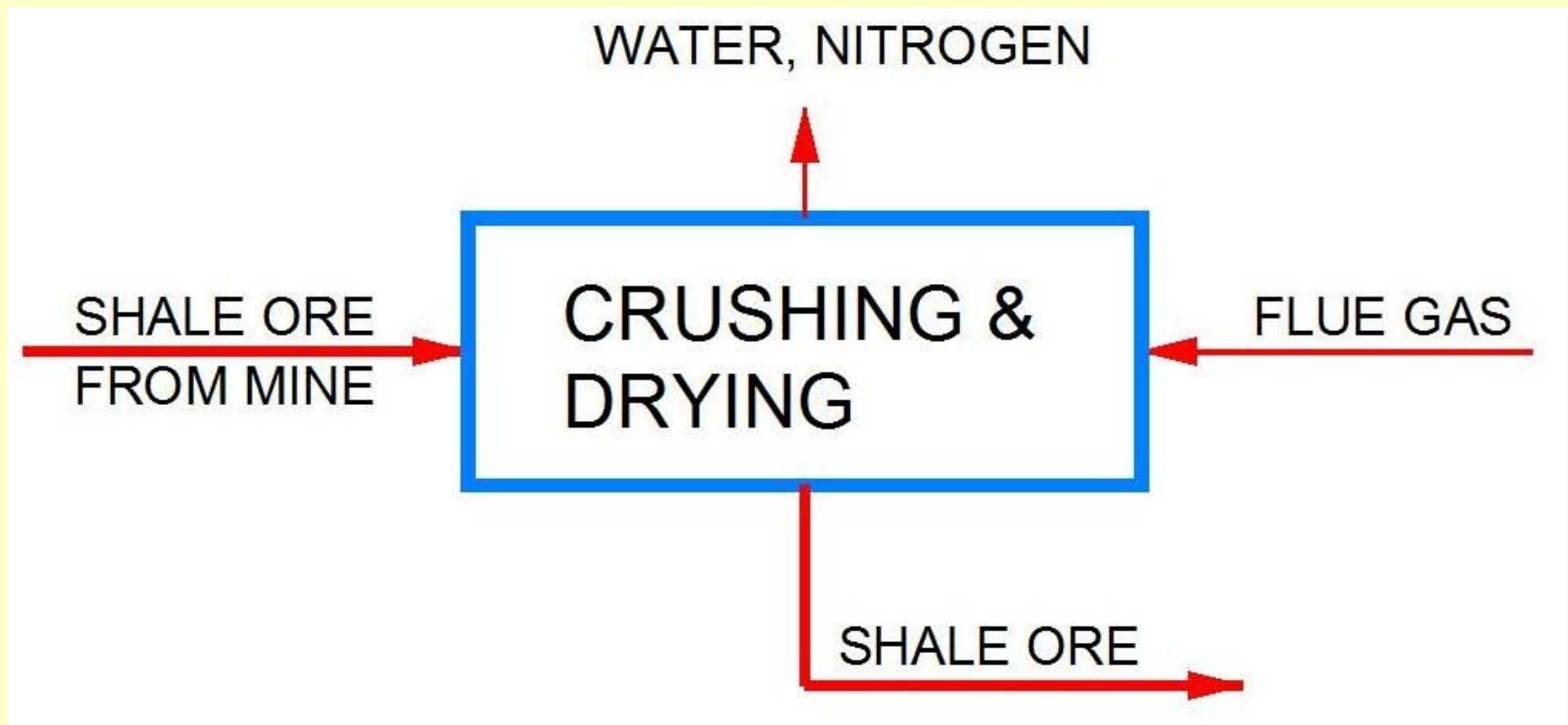
- **PRODUCE MARKETABLE MOTOR FUELS ON THE SAME SITE WHERE THE OIL SHALE IS PROCESSED**

- **ULTRA-LOW WATER USE**

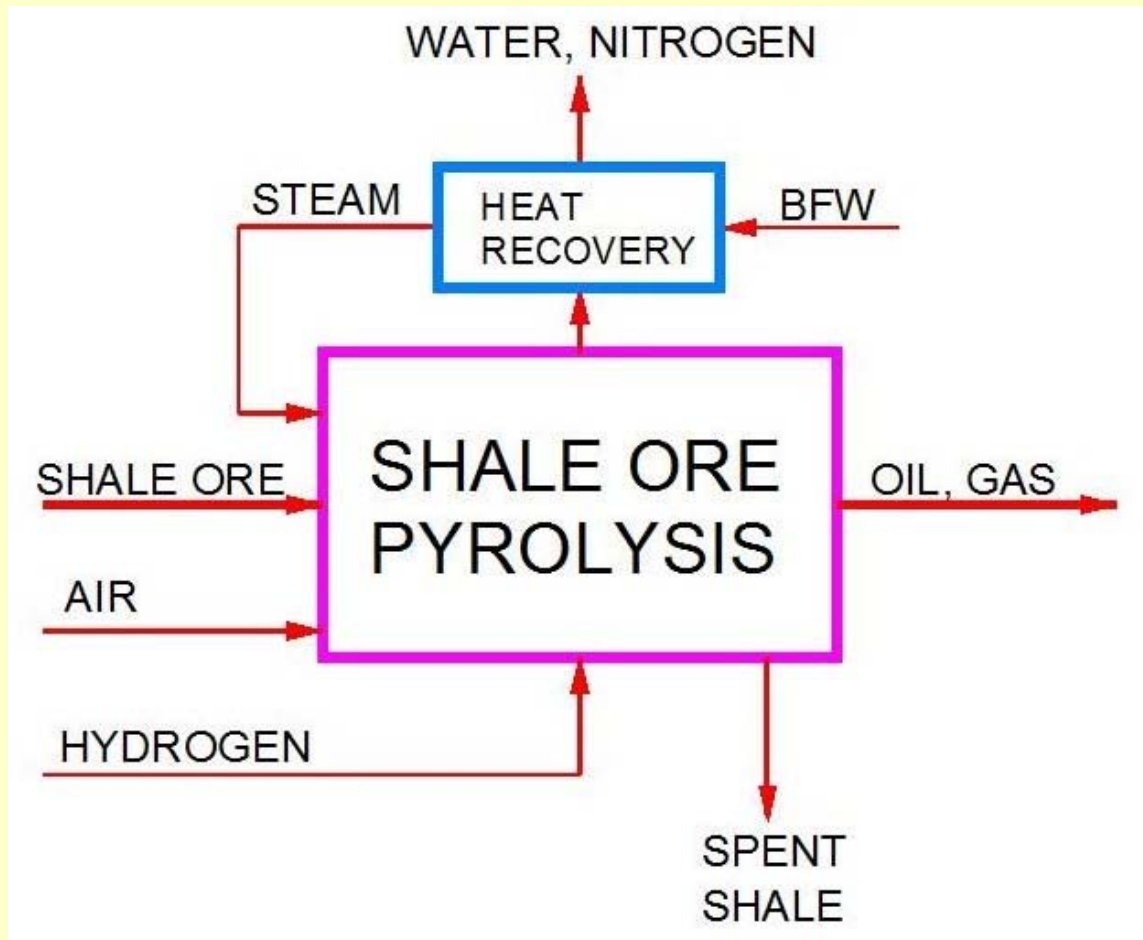


- **FAVORABLE ECONOMICS**

# OIL SHALE DELIVERED FROM MINE IS CRUSHED AND DRIED

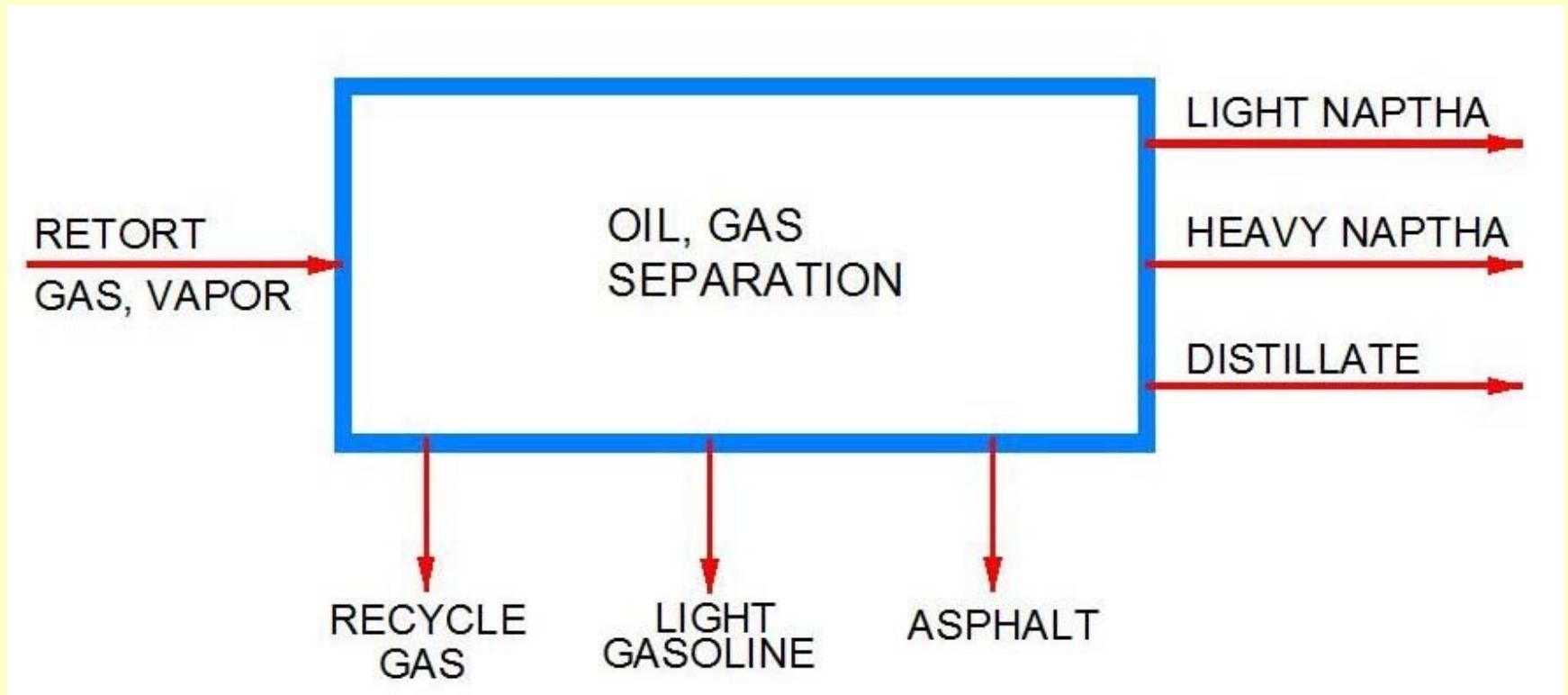


# **HYDROGEN PRODUCED ON SITE IS USED TO RETORT SHALE OIL**

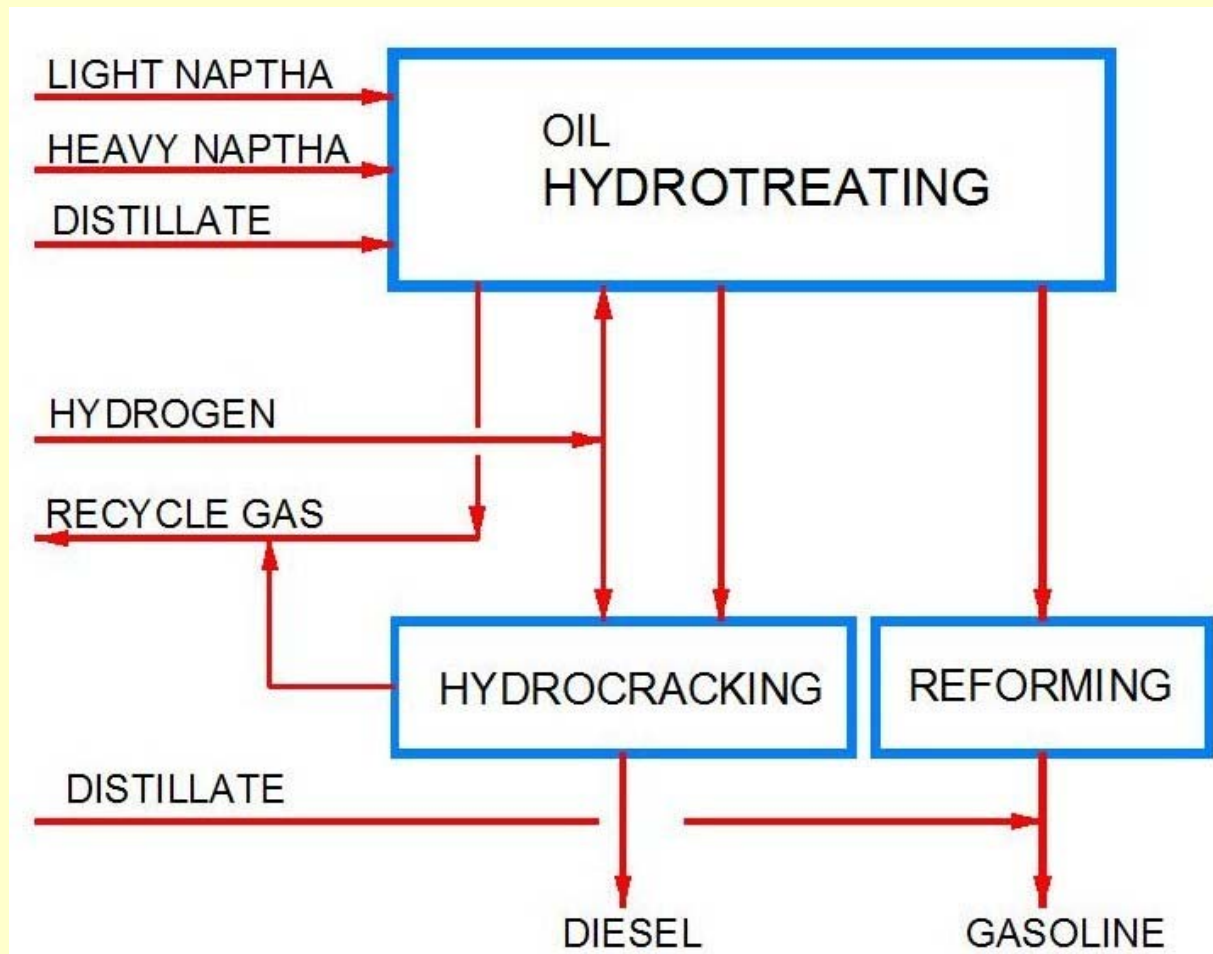


PATENT PENDING

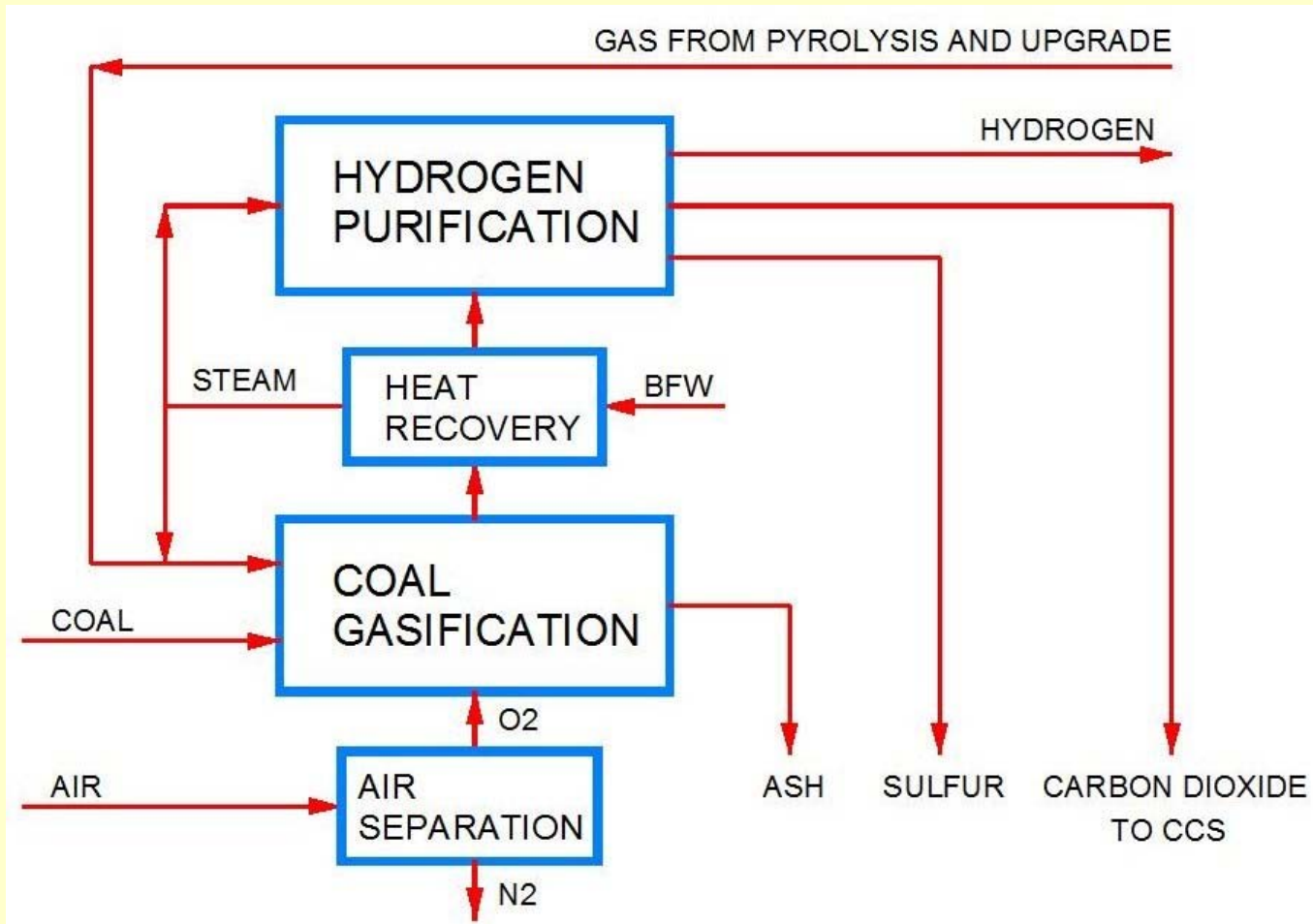
# RETORT GAS AND VAPOR IS SEPARATED PRIOR TO UPGRADING



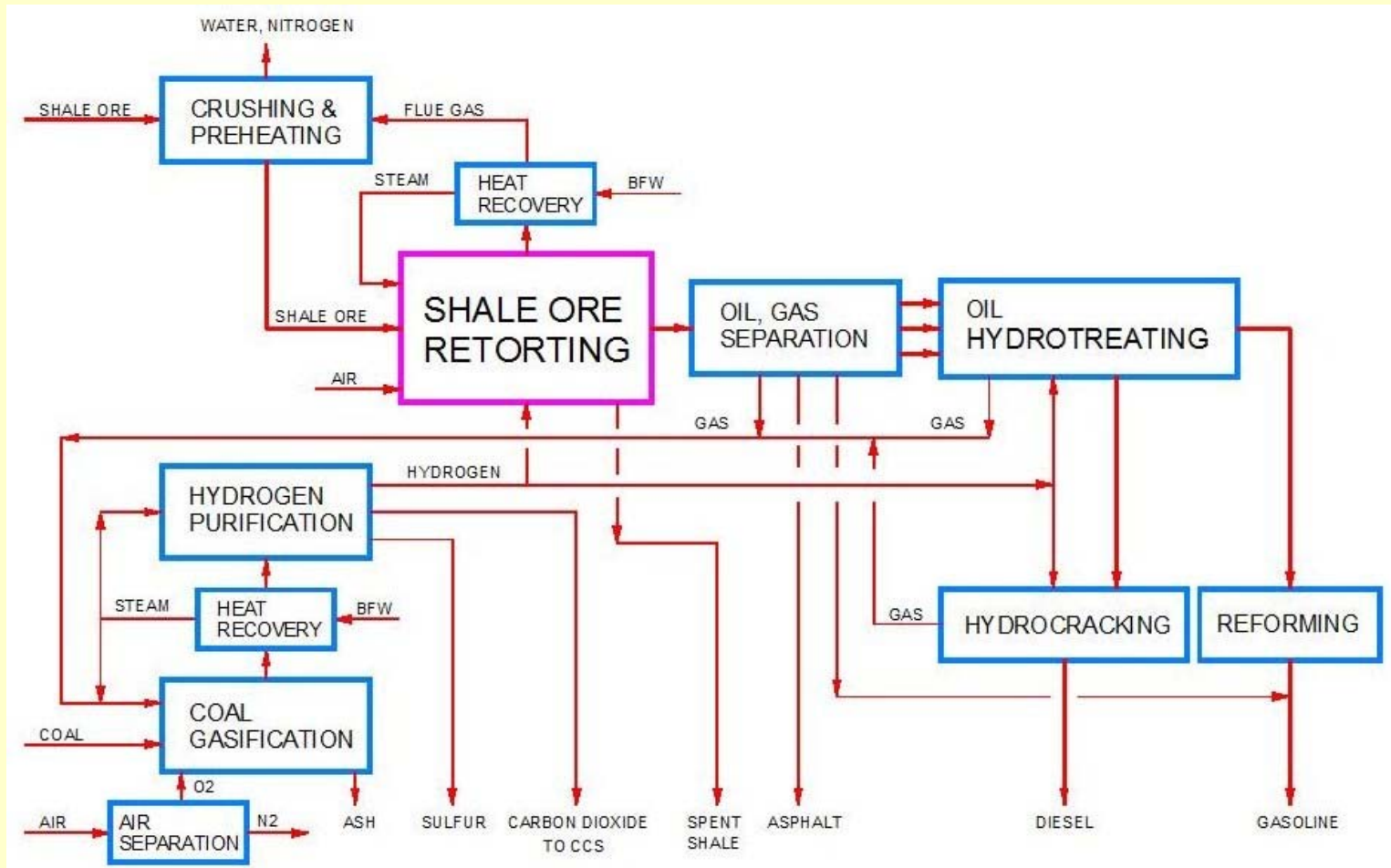
# HYDROGEN IS USED TO PRODUCE MOTOR FUELS



# HYDROGEN IS PRODUCED ON SITE FROM COAL



# SIMPLIFIED FLOW DIAGRAM OF CR PROCESS



PATENT PENDING

# CR PROCESS DESIGN ECONOMICS

- **6,000 BBL/DAY DEMONSTRATION PLANT**
  - CONCEPTUAL DESIGN, HEAT AND MATERIAL BALANCES
  - STANDARD CHEM ENG ESTIMATING METHODS
  - VENDOR CONTACTS FOR KEY COMPONENT COSTS
  - GASIFICATION COSTS FROM RECENT DOE STUDIES
  - NETL METHODS AND CONTINGENCY
- **A KEY OPERATING COST**
  - SHALE ORE \$9/TONNE
- **PRODUCT REVENUE ASSUMPTIONS (w/o tax)**
  - GASOLINE \$1.60/GALLON
  - DIESEL \$2.10/GALLON



# DEMONSTRATION PLANT FLOWS

MATERIAL	TONNES/DAY
INPUT SHALE ORE	6,000
INPUT COAL	588
OUTPUT SPENT SHALE	5,160
SHALE OIL	750
SHALE GAS	90
CO2 TO SEQUESTRATION	1,620
HYDROGEN TO PYROLYSIS	49
HYDROGEN TO UPGRADING	51
PRODUCT ASPHALT	80
DIESEL	426
GASOLINE	246

# 6,000 B/D DEMONSTRATION PLANT ESTIMATED CONSTRUCTION COSTS

	\$, MILLIONS
SHALE PROCESSING	123
COAL GASIFICATION	60
SYNGAS PROCESSING	85
SHALE OIL UPGRADING	115
GENERAL PLANT	68
CONTINGENCY	163
TOTAL	614

# 6,000 B/D DEMONSTRATION PLANT ESTIMATED OPERATING COSTS (310 DAYS/YEAR)

<b>PLANT OPERATIONS</b>	<b>\$, MILLIONS</b>
RAW MATERIALS	24
LABOR, MAINTENANCE	26
UTILITIES, MISC.	30
<b>TOTAL</b>	<b>80</b>
<b>PLANT REVENUES</b>	
DIESEL	88
GASOLINE	47
ASPHALT	20
CARBON DIOXIDE CREDIT	15
<b>TOTAL</b>	<b>170</b>

# CONCLUSIONS FROM CR STUDIES

- COMBUSTION OF SPENT SHALE IS NOT ESSENTIAL FOR ECONOMIC PROCESS PLANT OPERATIONS
- HYDROGEN CAN BE ECONOMICALLY GENERATED ON SITE FOR SHALE PYROLYSIS AND OIL REFINING
- VERY LOW CO<sub>2</sub> EMISSIONS CAN BE ACHIEVED
- COMMERCIAL EQUIPMENT TO BE USED FOR OIL SHALE PROCESS
- 6,000 B/D DEMONSTRATION PLANT DESIGN DEMONSTRATES POTENTIAL FOR ECONOMIC PROFITABILITY

# NEXT STEP

## CR PROCESS DEVELOPMENT

- DESIGN, CONSTRUCT, OPERATE CONTINUOUS 5 TPD SCALE UNIT
- HEAT TRANSFER AND THROUGHPUT FACTORS
- SHALE OIL AND GAS PROPERTIES
- PROPERTIES OF BOILING POINT FRACTIONS
- PRODUCE SMALL QUANTITIES OF MOTOR FUEL
- 18 MONTHS, \$2 MILLION