INPRO Dialogue Forum on Nuclear Energy Innovations

# Main driving factors for India's long term nuclear energy strategy

Arun Srivastava
Department of Atomic Energy, Mumbai

1-4 February 2010, IAEA, Vienna

# Presentation Outline

- Social and macroeconomic Factors
- Energy Resource Position
- Nuclear Energy Strategy

# Aspiration to be among the top !!

For the size and complexity of a country like India, which has

- 21 languages and cultures,
- a history going back to 10,000 years,
- 17% of the world population,
- 2.2% of the land mass,
- 2.4% of the world's GDP (i.e. 97.6% buying power outside India) or 6.6% of the world’s GDP in PPP terms.
- only 0.6% of the world's trade! (i.e. 99.4% of world trade is outside India)

# India's Macro Economic Indicators (March 2009)

- Population about 1,112 Million
- GDP 2008-09: US $ 1179.8 bn at current prices
- Per capita GDP(PPP) (2005 est.) – US $3,400
- GDP growth rate 2005-06 : 9.5%, 2006-07: 9.7%, 2007-08: 9% and 2008-09: 6.7% (provisional)
- Composition of GDP 2008-09:
  - Service: 57.3%
  - Industry: 25.7%
  - Agriculture : 17%
- FDI 2008-09 : US $ 33.6 billion
- Average literacy rate – 64.84%
- Life expectancy for male: 63.87 yr female: 66.91 yr

# India - Select Indicators for 2007

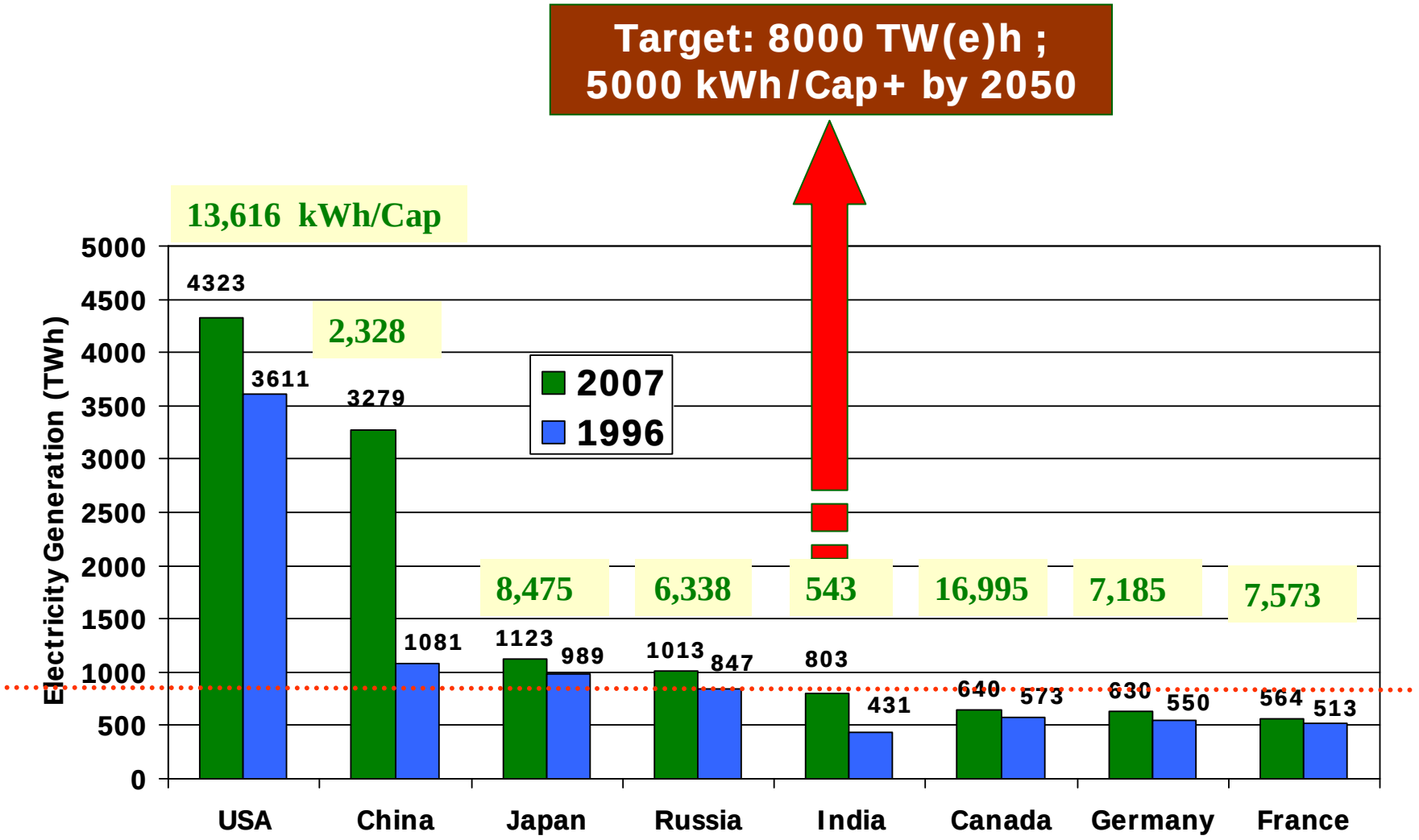
| Population (million) | GDP (billion 2000 US$) | GDP (PPP) (billion 2000 US$) | TPES (Mtoe) | Elec. Cons. (TWh) | CO 2 Emissions (Mt of CO 2) | GDP (PPP) / Pop US$ | Per capita Elec. Cons (kWh) | Per capita CO2 Emission (te) |
|---|---|---|---|---|---|---|---|---|
| 1123.32 | 771.09 | 4024.89 | 594.91 | 609.74 | 1324.05 | 3583 | 543 | 1.18 |

- 3rd Largest GDP in PPP terms (after USA and China)
- 10th largest in GDP terms
- 4th in TPES (Mtoe) (after USA, China and Russian Federation)
- 5th in Electricity generation/consumption (after USA, China, Japan and Russian Federation)
- 111th in terms of Per capita electricity consumption

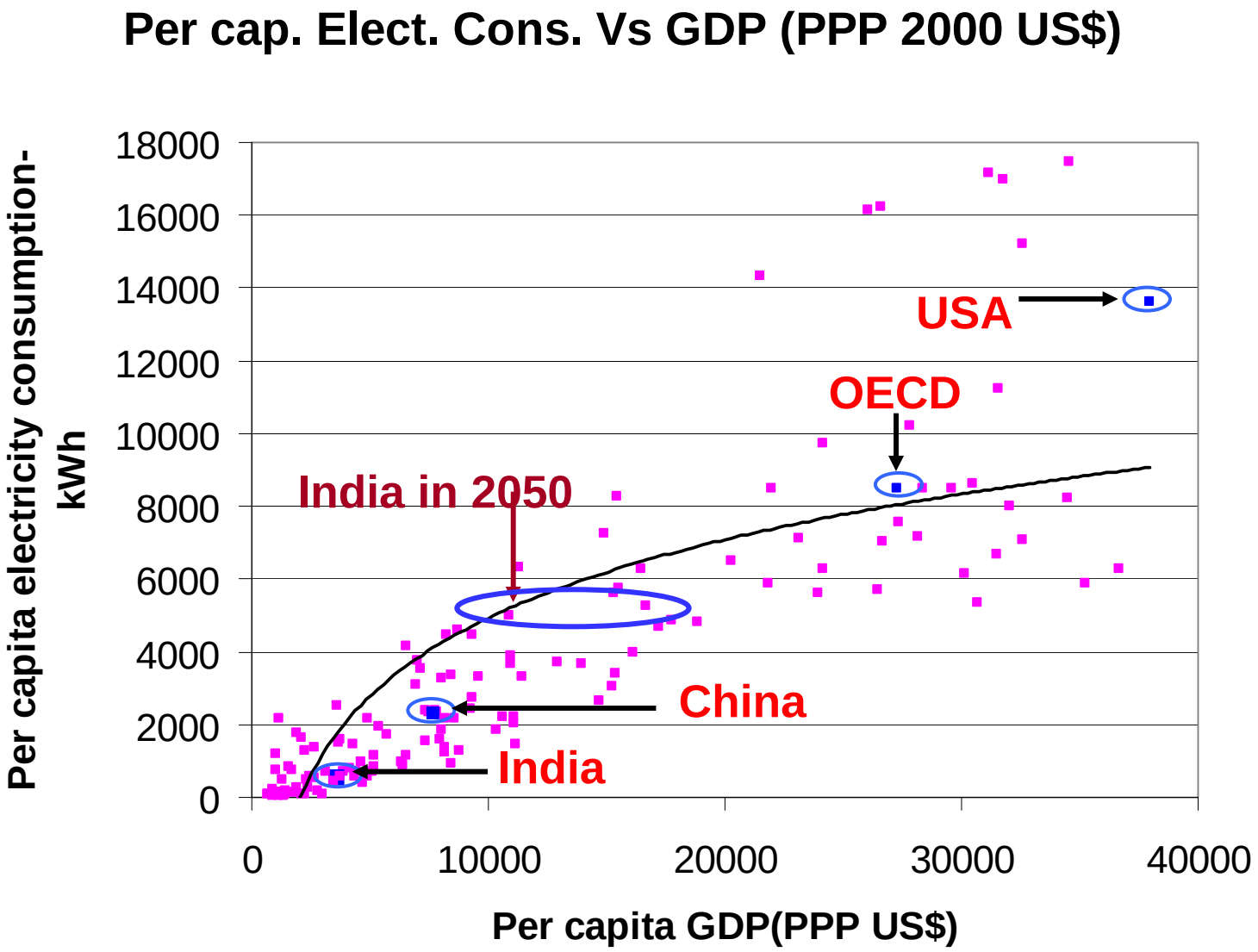
Source : IEA 2009 Key World Energy Statistics

# Indian target - in global context

*(Source of data: BP Statistical Review of World Energy 2007 for 1996 data and IEA 2009 'Key World Energy Statistics' for 2007 data)*



# Correlation between Electricity Consumption & GDP




Source: IEA 2009, Key World Energy Statistics

# India's Energy Resource Base

| | Amount | Electricity Potential¤ GWe-yr |
|---|---|---|
| **Coal** (Economically mineable) (Total Resource 255 BT) | 98.2 –BT* | 19,457 |
| Hydrocarbon | 12 –BT# | 5,833 |
| Uranium-Metal | 61,000 -T | |
| - In PHWR | | 320 |
| - In Fast Breeders | | 42,000 |
| Thorium-Metal (In Breeders) | 2,25,000 –T | 155,000 |
| Hydro | 150 -GWe | 69 GWe-yr / yr |
| Non-conv. Ren. | 100 -GWe | 33 GWe-yr / yr |

¤ Assuming entire resource is used for generating electricity.

# Currently known resources (including coal bed methane) are 3 BT. However, MP&NG has set a target of locating at least 12 BT as per Vision Hydrocarbon-2025.

# Renewal Energy Resources

| Resources | Unit | Present | Potential | Basis of Accessing Potential |
|---|---|---|---|---|
| Hydro-power | MW | 30936 | 1,50,000 | Total potential assessed is 84000 MW @ 60% of load factor or 1,50,000 MW at lower load factors |
| Bio-mass | | | | |
| Wood | Mtoe/year | 140 | 620* | Using 60 million Ha wasteland yielding (20) MT/Ha/year |
| Biogas | Mtoe/year | 0.6@ | 4 | In 12 million family sized plants |
| | | 0.1 | 15 | In community based plants if most of the dung is put through them. |
| Bio-Fuels | | | | |
| Bio-diesel | Mtoe/year | - | 20* | Through plantation of 20* million Ha of wasteland or 7* million hectares of intensive cultivation |
| Ethanol | Mtoe/year | <1 | 10 | From 1.2 million hectares of intensive cultivation with required inputs. |
| Solar | | | | |
| Photovoltaic | Mtoe/year | - | 1200 | Expected by utilising 5 million Ha wasteland at an efficiency level of 15 percent for Solar Photovoltaic Cells |
| Thermal | " | | 1200 | MWe scale power plants using 5 million Ha |
| Wind Energy | Mtoe/year | <1 | 10 | Onshore potential of 65000 MWe at 20 percent load factor |
| Small Hydro-power | Mtoe/year | <1 | 5 | |

@ based on 50 percent plants under use

* The availability of land and inputs for getting projected yields is a critical constraint

**Source:** Respective Line Ministries

**Ref: Integrated Energy Policy, Dec 2005, p39**

# Energy Development Policy

- Consume as much as possible the non- carbon energy (Full Hydro potential by 2025, ~50% Non-conventional potential by 2020 and balance by 2050)
- Energy - Imports as low as possible (restrict to present level of ~30%)
- Energy conservation and efficiency emphasis
- Social Dimension – Provide for minimum basic commercial energy need to even the lowest economic group

# Trends in Demand and Supply of Primary Commercial Energy (in Mtoe)

| | 1960-61 | 1970-71 | 1980-81 | 1990-91 | 2000-01 | 2006-07 |
|---|---|---|---|---|---|---|
| Domestic production of Commercial Energy | 36.78 | 47.67 | 75.19 | 150.01 | 207.08 | 259.56 |
| Net Imports | 6.04 | 12.66 | 24.63 | 31.07 | 89.03 | 131.07 |
| **Total Commercial Energy** | **42.82** | **60.33** | **99.82** | **181.08** | **296.11** | **391.53** |
| Non-Commercial Energy | 74.38 | 86.72 | 108.48 | 122.07 | 136.64 | 147.56 |
| **Total Primary Energy** | **117.20** | **147.05** | **208.3** | **303.15** | **432.75** | **539.09** |
| **Non-C E as % of TPE** | **63.64%** | **58.97%** | **52.08%** | **40.27%** | **31.57%** | **27.37%** |
| **Import as % of TCE** | **14.11%** | **20.98%** | **24.67%** | **17.16%** | **30.07%** | **33.48%** |

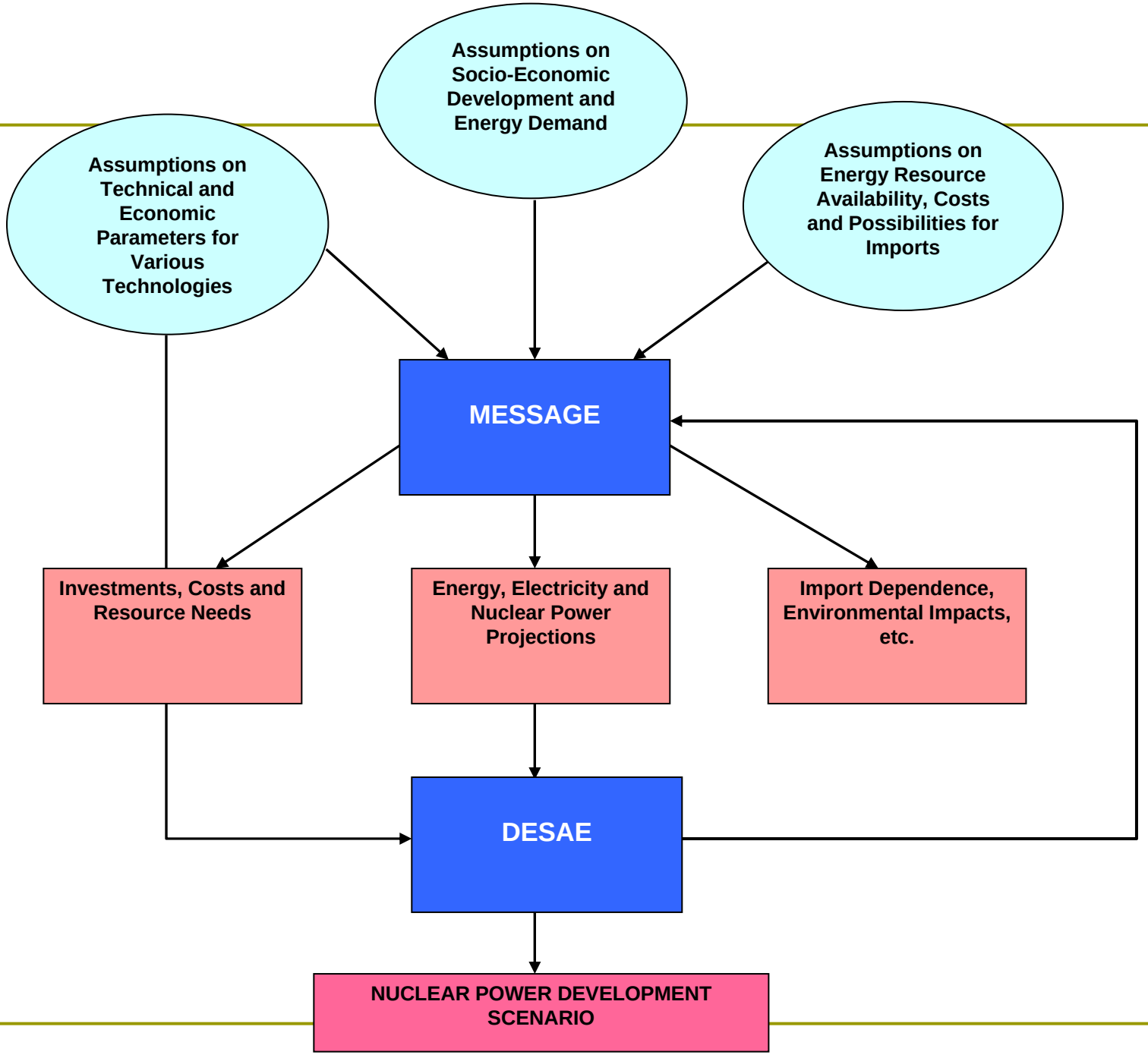
**Non-Commercial Energy: fuel wood, crop residue, cow dung, biogas etc**



Source: Draft report of the Steering Committee on Energy for the XI five year plan (2007-12)

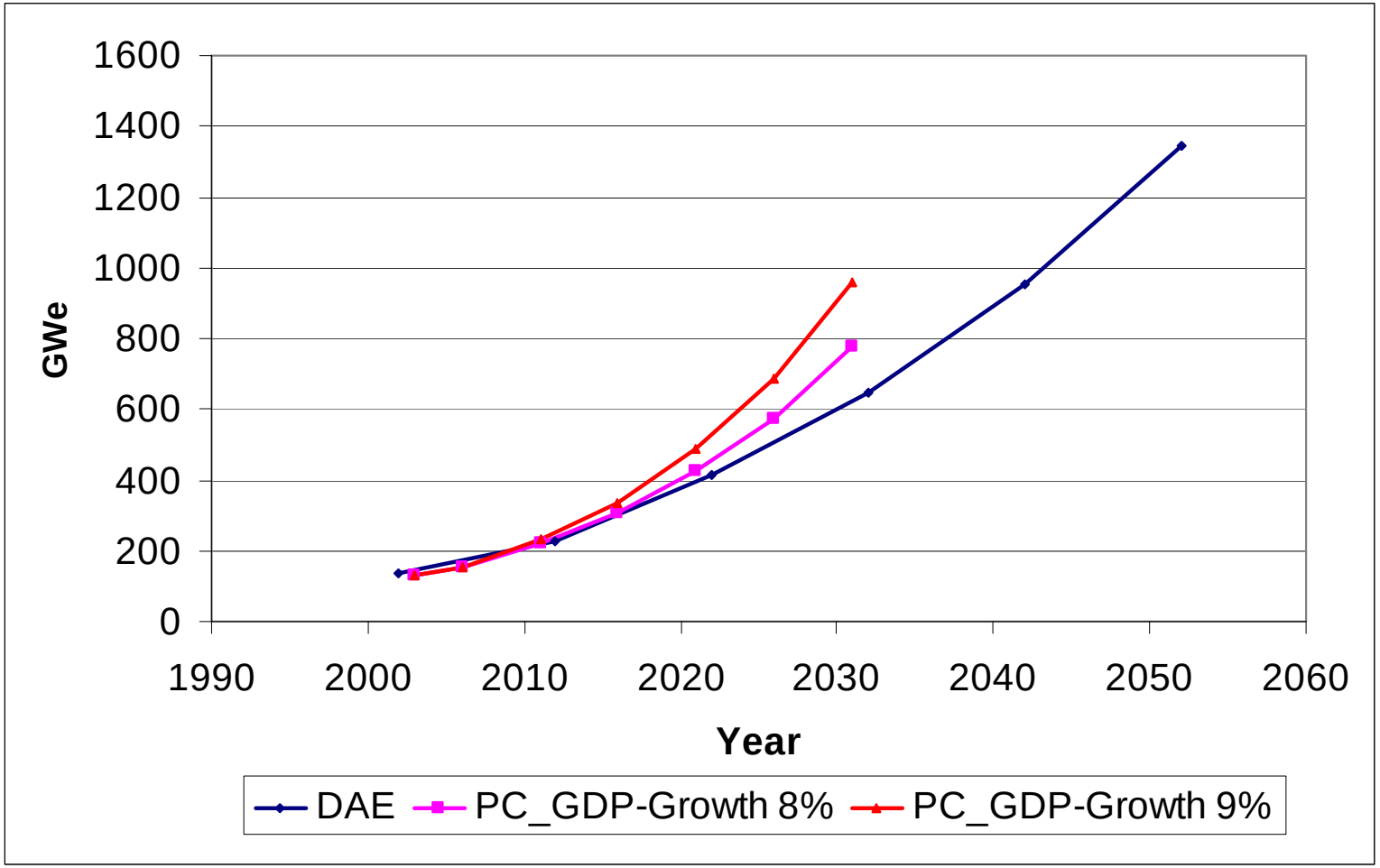
# Tools Used

- **MESSAGE:** Model for Energy Supply Strategy Alternatives and their General Environmental Impacts
  - **Optimisation study on use of resources**
  - **Developing scenarios**
- **DESAE:** Dynamics of Energy System – Atomic Energy
  - **Quantitative assessment of nuclear energy systems.**
- **ISED:** **Indicators for Sustainable Energy Development**
  - **Social, Economic & Environmental**
  - **Energy & Development**
  - **Import independence**
  - **Resource diversity (fuel type, region & country)**


Assumptions on Socio-Economic Development and Energy Demand
Assumptions on Technical and Economic Parameters for Various Technologies
Assumptions on Energy Resource Availability, Costs and Possibilities for Imports
MESSAGE
Investments, Costs and Resource Needs
Energy, Electricity and Nuclear Power Projections
Import Dependence, Environmental Impacts, etc.
DESAE
NUCLEAR POWER DEVELOPMENT SCENARIO

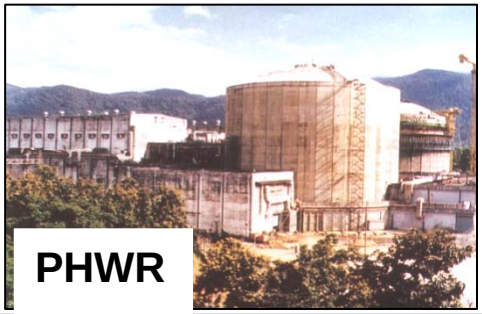
# Scenarios for Total Installed Power Capacity in India

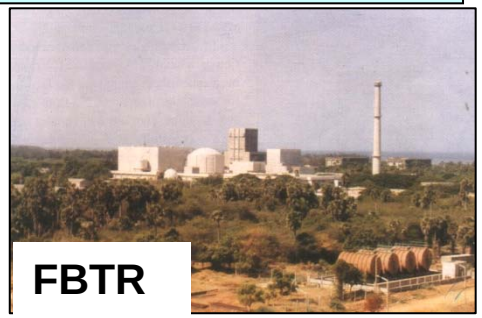
## (DAE-2004 and Planning Commission-2006 studies)

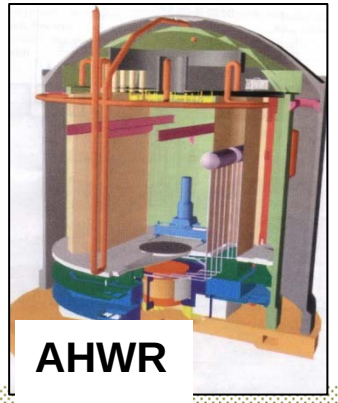


# Three Stage Indian Nuclear Programme

## Thorium in the centre stage




Nat. U

U fueled PHWRs

320 GWe-Year

Electricity

Dep. U

Pu

Th

42000 GWe-Year

Pu Fueled Fast Breeders

Electricity

$U^{233}$

Pu

Th

155000 GWe-Year

$U^{233}$ Fueled Reactors

Electricity

$U^{233}$

Power generation primarily by PHWR
Building fissile inventory for stage 2

Stage 1

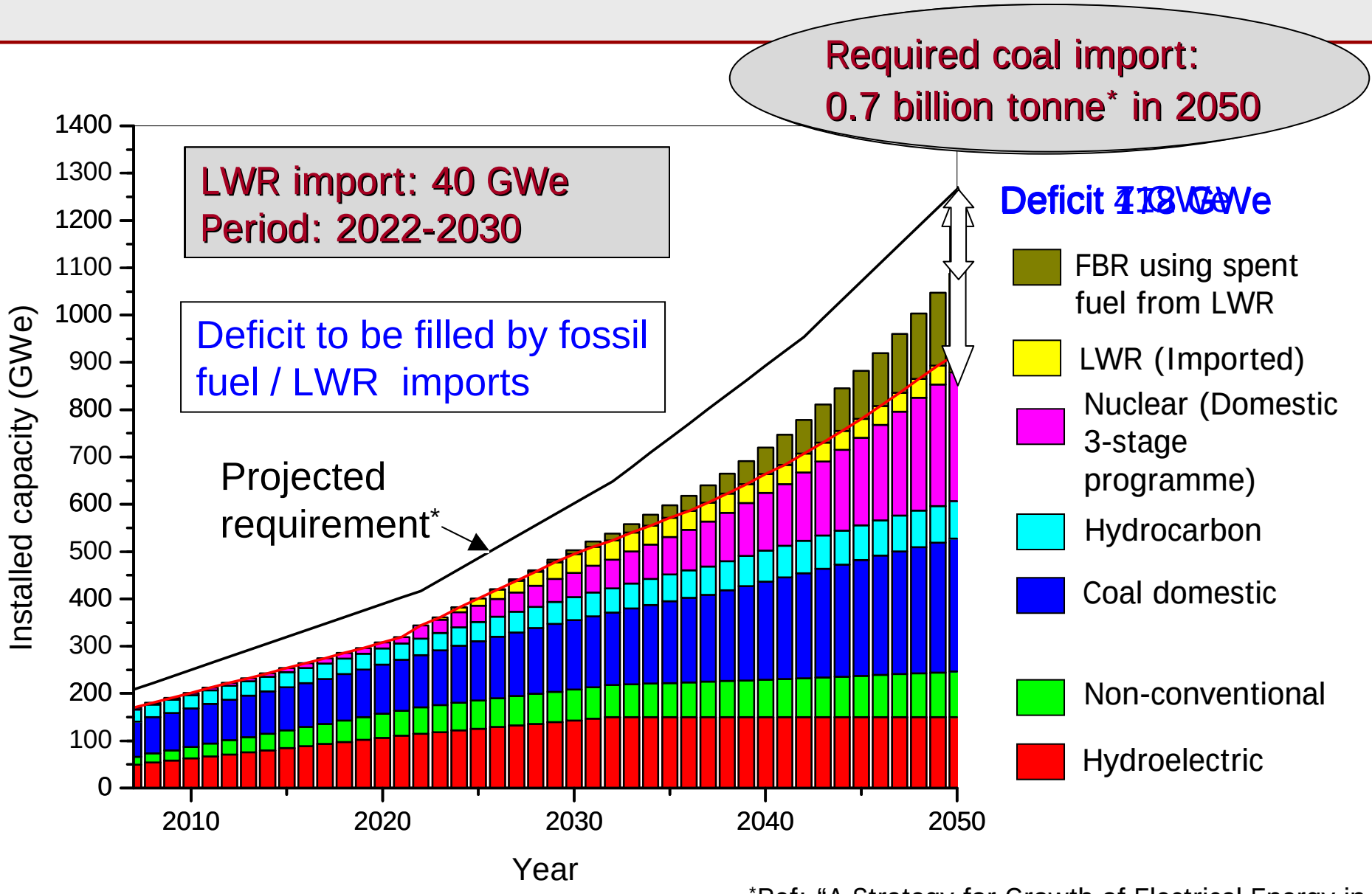
Expanding power programme
Building $U^{233}$ inventory

Stage 2

Thorium utilisation for
Sustainable power programme

Stage 3

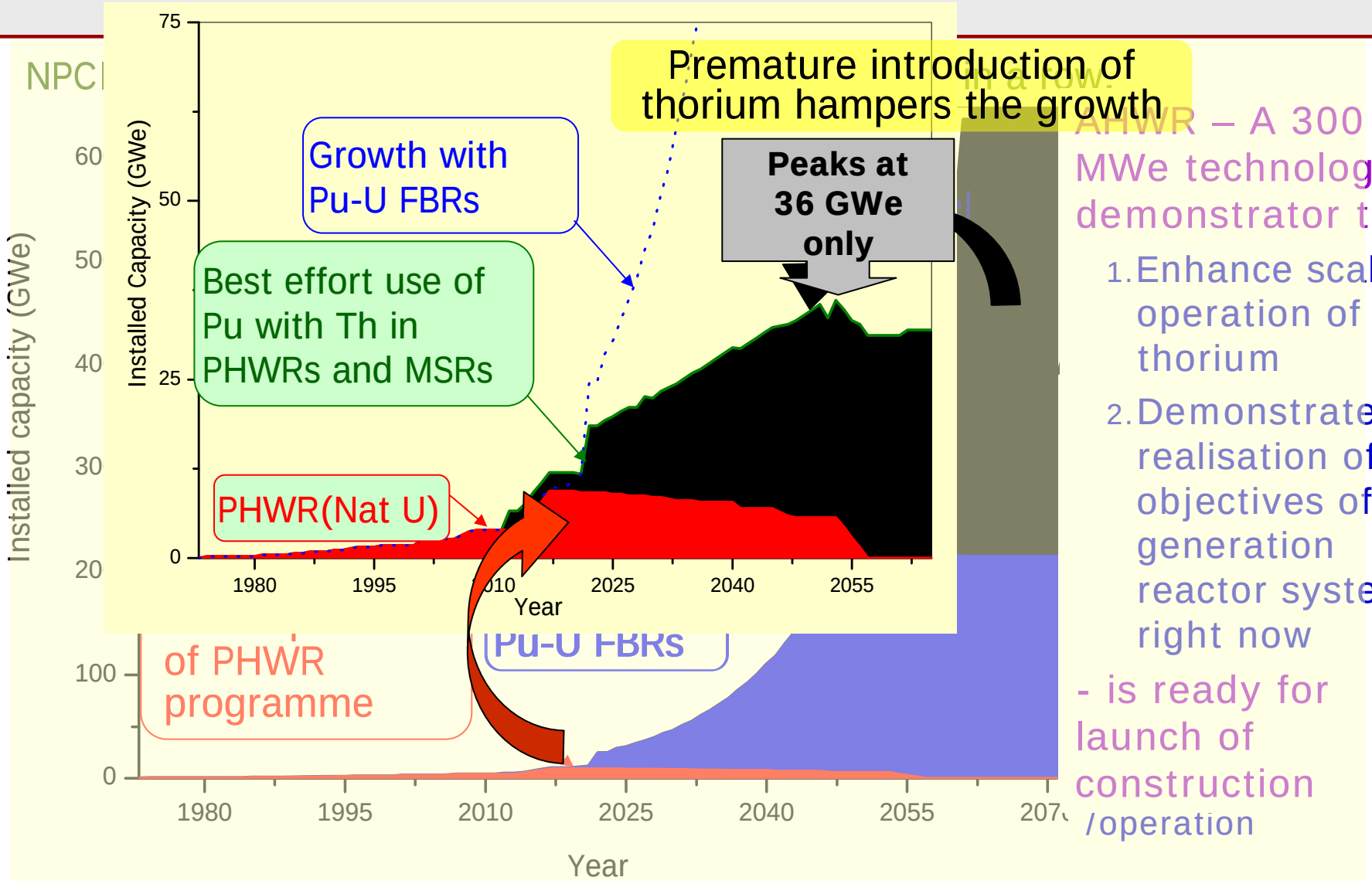
# Strategies for long-term energy security




* - Assuming 4200 kcal/kg

*Ref: "A Strategy for Growth of Electrical Energy in India", document 10, August 2004, DAE

# Strategies for optimum use of domestic nuclear resources




AHWR – A 300 MWe technology demonstrator to -

1. Enhance scale of operation of thorium
2. Demonstrate realisation of objectives of 4th generation reactor systems right now

- is ready for launch of construction /operation

Results for a scenario with current domestic Uranium resources and assuming short doubling time FBRs from 2021

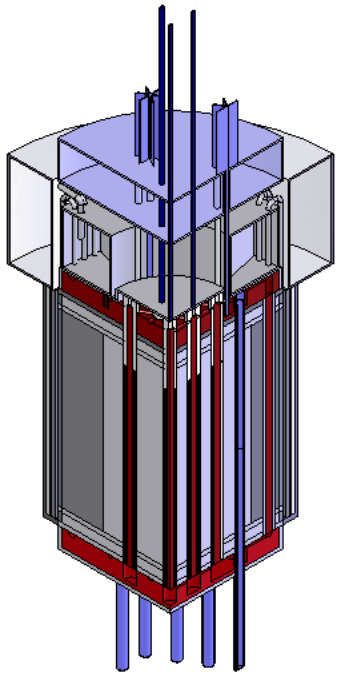
# Advanced Energy Technologies: Thorium and beyond

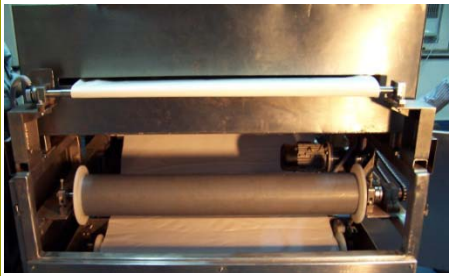
## New technology

- Metallic fuel
- Molten salt
- Liquid heavy metal
- High power accelerators
- High temperature materials
- Hydrogen production
- Hydrogen utilisation
- Fusion

## Deliverables

- Short doubling time FBR
- ADS for isotope production
- ADS for power production
- Compact high temperature reactor
- IHTR (for commercial $H_2$ production)
- ITER



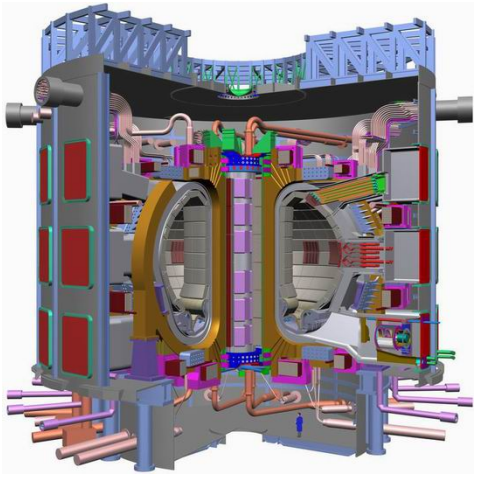


## Spin-offs

Solar tower

Desalination

Fuel cells

# Concluding Remarks

- Energy as well as electricity consumption per capita has to increase to ensure continued high GDP growth.
- Augment energy resources and supply in a sustainable manner. Non-fossil resources needs to be augmented.
- Reduce energy requirement through energy efficiency and conservation. Reduce T&D losses
- Encourage renewable and local solutions
- Enhance energy security (Nuclear power)
- Promote adaptation of clean coal technologies for future power plants
- Decrease in non-commercial use in Rural areas by providing cleaner energy options to them thereby reduce health related problems
- Rural economy needs to be strengthened so as to increase the affordability of rural people and arrest the migration from rural to urban areas.

# Thank You