CLAIMS:

What is claimed is:

1. A hydrocarbon upgrading process, comprising:

heating a hydrocarbon feed and combining the hydrocarbon feed with an aqueous fluid to produce a heated mixture comprising hydrocarbon and steam, wherein the heating is carried out before, during, and/or after the hydrocarbon feed is combined with the aqueous fluid;

separating, from the heated mixture, a vapor phase product and a liquid phase product;

catalytically cracking at least a portion of the liquid phase product in the presence of a fluidized catalyst to produce a catalytically cracked effluent;

separating a light hydrocarbon product and a bottoms product from the catalytically cracked effluent, wherein the light hydrocarbon product comprises a first C_2 hydrocarbon;

steam cracking at least a portion of the vapor phase product to produce a steam cracker effluent;

separating, from the steam cracker effluent, a tar product and an upgraded steam cracker effluent, wherein the upgraded steam cracker effluent comprises a second C_2 hydrocarbon;

hydroprocessing at least a portion of the tar product with at least a portion of the bottoms product to produce a hydroprocessed product, the at least a portion of the bottoms product and the at least a portion of the tar product being combined before and/or during the hydroprocessing; and

combining at least a portion of the first C_2 hydrocarbon and at least a portion of the second C_2 hydrocarbon, and recovering at least a portion of the combined C_2 hydrocarbon.

2. The process of claim 1, wherein

(i) the hydroprocessing is carried out under the pre-treater hydroprocessing conditions to produce a pretreated tar product;

(ii) the pre-treater hydroprocessing conditions include hydroprocessing the tar product at a temperature (T_{PT}) of 400°C or less, a weight hour space velocity ($WHSV_{PT}$) of ≥ 0.3 hr^{-1} based on a weight of the tar product that is subjected to the pre-treater hydroprocessing conditions, a total pressure (P_{PT}) of ≥ 6 MPa, and in the presence of molecular hydrogen supplied at a rate (SR_{PT}) of less than 534 standard cubic meters per cubic meter of the tar product that is subjected to the pre-treater hydroprocessing conditions,

(iii) the pre-treated tar product comprises a vapor potion and a liquid portion;

(iv) the hydroprocessed product is obtained by hydroprocessing the pre-treated tar product under bottoms product hydroprocessing conditions which include hydroprocessing the pre-treated tar product at a temperature (T_{BP}) of ≥ 200°C, a weight hour space velocity ($WHSV_{BP}$) of ≥ 0.3 hr^{-1} based on a weight of the pre-treated tar product, a total pressure (P_{BP}) of ≥ 6 MPa, and in the presence of molecular hydrogen supplied at a rate (SR_{BP}) of ≥ 534 standard cubic meters per cubic meter of the pre-treated tar product; and

(v) $WHSV_{BP}$ is less than $WHSV_{PT}$.

3. The process of ~~claims~~ claim 1 ~~or 2~~, further comprising (i) pretreating the liquid phase product upstream of the catalytic cracking, and (ii) heating or cooling the liquid phase product upstream and/or downstream of the pretreating, wherein the pretreating includes one or more of desalting, hydroprocessing, and particulate removal.

4. The process of ~~any of claims 1-3~~ claim 1, further comprising pretreating the light hydrocarbon product before combining the first and second C_2 hydrocarbons, wherein the pretreating includes removing from the light hydrocarbon product at least a portion of one or more of molecular hydrogen, methane, ammonia, carbon dioxide, arsine, mercury, hydrogen sulfide, carbonyl sulfide, mercaptans, and carbon disulfide, oxygenates and water.

5. The process of ~~any of claims 1-4~~ claim 1, wherein (i) the light hydrocarbon product further comprises a first C_3 hydrocarbon; (ii) the upgraded steam cracker effluent further comprises a second C_3 hydrocarbon; (iii) the process further comprises combining at least a portion of the first C_3 hydrocarbon and at least a portion of the second C_3 hydrocarbon, and recovering at least a portion of the combined C_3 hydrocarbon; and wherein the process further comprises one or more of (a) comprises recovering propylene from at least a portion of one or more of the first C_3 hydrocarbon, the second C_3 hydrocarbon, and the combined C_3 hydrocarbon, and (b) recovering ethylene from at least a portion of one or more of the first C_2 hydrocarbon, the second C_2 hydrocarbon, and the combined C_2 hydrocarbon.

6. The process of ~~any of claims 1-5~~ claim 1, further comprising:

separating ~~a bottoms product and~~ a naphtha from the catalytically cracked effluent;

hydroprocessing at least a portion of the naphtha to produce a hydroprocessed naphtha;

reforming the hydroprocessed naphtha to produce a reformate and molecular hydrogen; and

~~combining the bottoms product and the tar product before and/or during the tar hydroprocessing, and hydroprocessing the bottoms product with the tar product; and~~

utilizing at least a portion of the molecular hydrogen for at least one of the tar product hydroprocessing and the naphtha hydroprocessing.

7. The process of ~~any of claims 1-6~~ claim 1, wherein the hydrocarbon feed comprises medium hydrocarbon and/or heavy hydrocarbon.

8. The process of ~~any of claims 1-6~~ claim 1, further comprising (i) providing a crude oil, wherein the hydrocarbon feed comprises a first portion of the crude oil, (ii) distilling at least a second portion of the crude oil in at least one atmospheric distillation zone and/or at least one vacuum distillation zone, (iii) conducting an atmospheric bottoms product away from the atmospheric distillation zone, (iv) conducting a vacuum bottoms product away from the vacuum distillation zone, and (v) combining with the liquid phase product at least a portion of the atmospheric bottoms product and/or the vacuum bottoms product.

9. The process of claim ~~6~~ 1, wherein the upgraded steam cracker effluent further comprises benzene and/or toluene, and wherein the process further comprises (i) recovering at least a portion of the toluene and/or at least a portion of the benzene and (ii) combining with the reformate at least a portion of the recovered benzene and/or at least a portion of the recovered toluene.

10. The process of claim ~~6~~ 1, wherein the upgraded steam cracker effluent further comprises benzene and/or toluene, and wherein the process further comprises (i) recovering at least a portion of the toluene and/or at least a portion of the benzene, and (ii) alkylating a portion of the recovered benzene and/or at least a portion of the recovered toluene to produce one or more of additional toluene, ethylbenzene, and xylene.

11. A hydrocarbon upgrading process, comprising:

heating a hydrocarbon feed and combining the hydrocarbon feed with an aqueous fluid to produce a heated mixture comprising hydrocarbon and steam, wherein the heating is carried out before, during, and/or after the hydrocarbon feed is combined with the aqueous fluid;

separating from the heated mixture a vapor phase product and a liquid phase product;

catalytically cracking the liquid phase product in the presence of a fluidized catalyst to produce a catalytically cracked effluent;

separating a light hydrocarbon product and a bottoms product from the catalytically cracked effluent, wherein the light hydrocarbon product comprises methane, a first C_2 hydrocarbon, a first C_3 hydrocarbon, and a first C_4 hydrocarbon;

separating from the light hydrocarbon product, at least a portion of the first C_4 hydrocarbon to produce ~~and~~ an upgraded light hydrocarbon product;

demethanizing at least a portion of the upgraded light hydrocarbon product by at least contacting that portion of the upgraded light hydrocarbon product with a first portion of the first C_4 hydrocarbon, and recovering (i) a raffinate comprising methane and (ii) an extract comprising C_2, C_3, and C_4 hydrocarbon;

steam cracking the vapor phase product to produce a steam cracker effluent;

separating from the steam cracker effluent a tar product and an upgraded steam cracker effluent, wherein the upgraded steam cracker effluent comprises a second C_2 hydrocarbon; a second C_3 hydrocarbon, and a second C_4 hydrocarbon, wherein the second C_4 hydrocarbon is richer in butadiene in comparison with the first C_4 hydrocarbon;

hydroprocessing at least a portion of the tar product with at least a portion of the bottoms product to produce a hydroprocessed product, the at least a portion of the bottoms product and the at least a portion of the tar product being combined before and/or during the hydroprocessing;

removing butadiene from the second C_4 hydrocarbon to produce an upgraded C_4 hydrocarbon; and

combining at least a portion of the extracted C_4 hydrocarbon with at least a portion of the upgraded C_4 hydrocarbon.

12. The process of claim 11, further comprising recovering ethylene from at least a portion of the extracted C_2 hydrocarbon and/or a portion of the second C_2 hydrocarbon.

13. The process of ~~claims~~ claim 11 ~~or 12~~, further comprising pretreating the light hydrocarbon product before combining the first and second C_2 hydrocarbons, wherein the pretreating includes removing from the light hydrocarbon product at least a portion of one or more of molecular hydrogen, methane, ammonia, carbon dioxide, arsine, mercury, hydrogen sulfide, carbonyl sulfide, mercaptans, and carbon disulfide, oxygenates and water.

14. The process of ~~any of claims 11-13~~ claim 11, further comprising (i) combining at least a portion of the extracted C_2 hydrocarbon and at least a portion of the second C_2 hydrocarbon, (ii) recovering at least a portion of the combined C_2 hydrocarbon, and (iii) recovering ethylene from at least a portion of the combined C_2 hydrocarbon.

15. The process of ~~any of claims 11-14~~ claim 11, wherein the process further comprises (i) combining at least a portion of the extracted C_3 hydrocarbon and at least a portion of the second C_3 hydrocarbon, and recovering at least a portion of the combined C_3 hydrocarbon; and/or (ii) comprises recovering propylene from at least a portion of one or more of the extracted C_3 hydrocarbon, the second C_3 hydrocarbon, and combined C_3 hydrocarbon.

16. The process of ~~any of claims 11-15~~ claim 11, further comprising:

separating ~~a bottoms product and~~ a naphtha from the catalytically cracked effluent;

hydroprocessing at least a portion of the naphtha to produce a hydroprocessed naphtha;

reforming the hydroprocessed naphtha to produce a reformate and molecular hydrogen; and

~~combining the bottoms product and the tar product before and/or during the tar hydroprocessing, and hydroprocessing the bottoms product with the tar product;~~

utilizing at least a portion of the molecular hydrogen for at least one of the tar product hydroprocessing and the naphtha hydroprocessing.

17. The process of ~~any of claims 11-16~~ claim 11, wherein the hydrocarbon feed comprises medium hydrocarbon and/or heavy hydrocarbon.

18. The process of ~~any of claims 11-16~~ claim 11, further comprising (i) providing a crude oil, wherein the hydrocarbon feed comprises a first portion of the crude oil, (ii) distilling at least a second portion of the crude oil in at least one atmospheric distillation zone and/or at least one

vacuum distillation zone, (iii) conducting an atmospheric bottoms product away from the atmospheric distillation zone, (iv) conducting a vacuum bottoms product away from the vacuum distillation zone, and (v) combining with the liquid phase product at least a portion of the atmospheric bottoms product and/or at least a portion of the vacuum bottoms product.

19. The process of claim ~~16~~ 11, wherein the upgraded steam cracker effluent further comprises benzene and/or toluene, and wherein the process further comprises (i) recovering at least a portion of the toluene and/or at least a portion of the benzene and (ii) combining with the reformate at least a portion of the recovered benzene and/or at least a portion of the recovered toluene.

20. The process of claim ~~16~~ 11, wherein the upgraded steam cracker effluent further comprises benzene and/or toluene, and wherein the process further comprises (i) recovering at least a portion of the toluene and/or at least a portion of the benzene, and (ii) alkylating a portion of the recovered benzene and/or at least a portion of the recovered toluene to produce one or more of additional toluene, ethylbenzene, and xylene.

~~21. The combined C_2 hydrocarbon product of any of claims 1-10.~~

~~22. The combined C_4 hydrocarbon product of any of claims 11-20.~~

~~23. The additional toluene, ethylbenzene, and xylene products of claim 20.~~

~~24. An apparatus for producing at least unsaturated hydrocarbon, the apparatus comprising:~~

~~a heater configured to heat a hydrocarbon feed;~~

~~a mixer configured to combine the heated hydrocarbon feed with an aqueous fluid;~~

~~a separator configured to remove from the heated mixture at least a vapor phase product and a liquid phase product;~~

~~a riser reactor configured to catalytically crack at least a portion of the liquid phase product in the presence of a fluidized catalyst to produce a catalytically cracked effluent;~~

~~a separator configured to separate a light hydrocarbon product from the catalytically cracked effluent, wherein the light hydrocarbon product comprises a first C_2 hydrocarbon;~~

a steam cracker configured to pyrolyse at least a portion of the vapor phase product to produce a steam cracker effluent;

a separator configured to separate from the steam cracker effluent a tar product and an upgraded steam cracker effluent, wherein the upgraded steam cracker effluent comprises a second C_2 hydrocarbon;

a hydroprocessor configured to hydroprocess at least a portion of the tar product to produce a hydroprocessed product; and

a mixer configured to combine at least a portion of the first C_2 hydrocarbon and at least a portion of the second C_2 hydrocarbon.

25. An apparatus for producing at least unsaturated hydrocarbon, the apparatus comprising:

a heater configured to heat a hydrocarbon feed;

a mixer configured to combine the heated hydrocarbon feed with an aqueous fluid;

a separator configured to remove from the heated mixture at least a vapor phase product and a liquid phase product;

a riser reactor configured to catalytically crack at least a portion of the liquid phase product in the presence of a fluidized catalyst to produce a catalytically cracked effluent;

a separator configured to remove a light hydrocarbon product from the catalytically cracked effluent, wherein the light hydrocarbon product comprises methane, a first C_2 hydrocarbon, a first C_3 hydrocarbon, and a first C_4 hydrocarbon;

a separator configured to remove from the light hydrocarbon product at least a portion of the first C_4 hydrocarbon to produce and upgraded light hydrocarbon product;

a demethanizer configured to (i) remove at least a portion of the upgraded light hydrocarbon product by contact of that portion of the upgraded light hydrocarbon product with a first portion of the first C_4 hydrocarbon, and (ii) recover (a) a raffinate comprising methane and (b) an extract comprising C_2, C_3, and C_4 hydrocarbon;

a steam cracker configured to pyrolyse the vapor phase product to produce a steam cracker effluent;

a separator configured to separate from the steam cracker effluent a tar product and an upgraded steam cracker effluent, wherein the upgraded steam cracker effluent comprises a second C_2 hydrocarbon; a second C_3 hydrocarbon, and a second C_4 hydrocarbon, wherein the second C_4 hydrocarbon is richer in butadiene in comparison with the first C_4 hydrocarbon;

~~a hydroprocessor configured to hydroprocess at least a portion of the tar product to produce a hydroprocessed product;~~

~~a separator configured to remove butadiene from the second C_4 hydrocarbon to produce an upgraded C_4 hydrocarbon; and~~

~~a mixer configured for combining at least a portion of the extracted C_4 hydrocarbon with at least a portion of the upgraded C_4 hydrocarbon.~~